Physiology - Laboratory and Clinical Research

PROSPECTIVE STUDY OF PATIENTS WITH FOOT BURNS IN SAMARKAND

BABUR M. SHAKIROV, M.D.

NOVA

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NOVA BIOMEDICAL

New York

LIBRARY OF CONGRESS CATALOGING-IN-PUBLICATION DATA

Library of Congress Control Number: 2012939758
ISBN: 978-1-62257-024-9

Published by Nova Science Publishers, Inc. † New York

CONTENTS

PREFACE

This monograph is based on the practical work of the Samarkand Inter-Regional burn Center and Burn department of RSCUMA and literary data, the regulations of scientific and practical achievements in the treatment of foot burns and their consequences have been analyzed.

The problems and tasks in the field of scientific research and the treatment of foot burns have been interpreted in detail and systematically.

Particular attention has been paid to necrectomy, the application of biological coverings and autodermoplasty. Treatment of thermic injuries of bones and joints and the clinical principles of the elimination of different deformations, localized in the foot area, have been described.

Simultaneously, typical methods of foot joint mobilization, all degrees of movement and localization of impairments have been described, opportunities for reconstructive surgery have been shown, and new theoretical generalizations concerning the principles and possibilities of deformation elimination and their classification have been made.

Scientific treatment of burns, foot deformations and the principles of functional treatment after operations have been described in detail. Direct and follow-up treatment results depending on severity of injuries have been shown.

This treatise is illustrated by colored figures and schemes, making the material more understandable.

There are 105 figures, 19 tables and this monograph is of great interest among combustiologists, traumatologists, orthopedists and surgeons, performing reconstructive surgery.

INTRODUCTION

The problem of the rehabilitation of patients suffering from burns deserves close attention. In the conditions of Uzbekistan, foot burns make up 15% of all burns, among them, 40% of the patients are early age children, with high specific gravity of contact injuries (sandal burns), accompanied by especially severe course.

Absence of a scientifically proved and reliable system of registration and control of patients discharged from inpatient department, programs of dispensary care, conservative and surgical treatment of burn consequences, result in malformations due to fatal secondary changes in osteoarticular apparatus, relative shortening of tendons, vessels and nerves, lagging behind of limb during growth, invalidity and complete disability in the future. Moreover, there are no specialized departments for rehabilitation of a patient who underwent foot burns.

In medical literature and public health practices particularly important problems of the rehabilitation of a patient with foot burns are not reflected. Specifically, a system of surgical rehabilitation including dispensary care of patients who underwent foot burns has not been developed; the employed methods of conservative rehabilitation are not effective. There are no effective classifications of the cicatrical contractures of ankle joints and feet, contributing to the choice of the operative methods. It is unknown what methods of plastic surgery operations result in better outcomes among patients.

What correlation must be between functional and ethical factors in the choice of the plastic method?

Establishment of terms and consequences of conservative and surgical treatment is not clear.

All these facts substantiate the expediency of publication of the presented book. Significant material is accumulated by the author during a period of more than 15 years of medical practice at the Samarkand Interregional Burn Center and Burn department of RSCUMA.

More than 400 clinical observations and also the experience of more than 250 reconstructive operations in the foot area permit the author to have a critical approach to earlier suggested methods of foot burn treatments and their outcomes and to give his own suggestions on the elimination of burn deformations in the foot area.

The work is based on keeping patients with burns and post burn deformations of the ankle joint and foot under observation for many years in Samarkand Inter-Regional Burn Center and in the Burn department of RCSUMA.

The authors of the presented book aim to show contemporary characteristics of burns and post burn complications in the foot area; to develop their classification; to determine the principles of their treatment, to improve rehabilitation and plastic surgery operations and make their modest contribution to the determination of this complex multifaceted problem.

PART I: BURNS OF THE FOOT

Chapter 1

PROBLEMS AND AIMS OF THE SCIENTIFIC INVESTIGATIONS OF FOOT BURNS

Burn trauma brings about serious medical, social and economic problems [1]. Development of heavy industry and chemical industry as well as wide use of electrical energy in everyday life contributes to significant increase in the frequency of burn injuries.

The findings of publications reveal that a substantial number of patients suffering from burn trauma make from 5 to 12 percent of peace time traumas.

Burns take 2^{nd} – 3^{rd} place in a common structure of traumatic injuries. Thus in the United States almost 2 million people suffer from burns every year; approximately 100,000 persons with burns need hospitalization and about 4.000 deaths result from house fires and 1,250 result from other sources, including motor vehicle and aircraft crashes, contact with electricity, chemicals and other sources of fire or flames [4].

Every year 400-500 patients with burns are registered in Russia and a fourth of them need hospitalization [5]. In Uzbekistan 7,500 patients with burns are treated every year [6].

Over the last 30 years the foundation of burn units, the development of new methods of the correction of homeostasis and the wide use of active surgical tactics with the employment of skin grafts made it possible to significantly increase the survival of patients with deep, extensive and critical burns and to shorten the terms of their treatment [7, 8].

According to the findings of different authors [9], foot burns take 4^{th} – 5^{th} place in distribution of location; however their epidemiology and the peculiarities of surgical tactics, the prevention and treatment of functional and

cosmetic injuries and their effect on life quality have not been studied yet, in spite of a high percent of invalidism.

In publications [10, 11], accessible to us, it is noted that the most frequent causes of burn foot traumas appeared to be: hot water, fire and various substances used in high temperature industrial processes.

The cases of foot burns occur rather frequently. As a casuistic one, is the case of feet burns in Saudi Arabia, which was described in 12 persons, 8 of them were ill with diabetes who received burns of the foot plantar surface during a holiday mass [12].

Technological processes, the production of building material, can be considered as dangerous industrial factors that can cause foot burn traumas. Thus, in Egypt, where the cement industry is considered to be an important component of the economy the number of people who had suffered from foot burns in only one plant with a total number of 3.200 workers during the period from 1991 to 1995 was 155 people. They got burns during their contact with hot cement powder [13, 14].

An effective but potentially dangerous heating system, sandal, is still used in some regions of Middle Asia. A sandal is an ancient, primitive heating device that is used by both poor and rich people. Even today this traditional system is used, especially in the mountain areas, for heating the lower part of the human body.

In cold weather, people of all ages sit around the table, called a sandal, with their feet under the blanket, talking, drinking tea, and eating. In those cases, when children sit side by side with adults, they are not endangered. However, children, especially toddlers, when left unsupervised, can crawl under the blanket and fall into the coals. As a result, they can suffer severe burns followed by serious complications, such as contractures and amputations [15, 16].

It is necessary to note that 70 percent of the patients, who had suffered from foot burns, needed rehabilitation and 26,6 – 47,7 percent operative treatment. Of all the patients 30 - 40 percent are under 14 years of age [17, 19].

It must be agreed that based on the information of the total progress in treatment of burns, scientific investigation concerning the rehabilitation of foot burns is lagging behind. The absence of a scientifically based and verified registration system and control of discharged patients' condition, the programs of dispensary care, conservative and surgical treatment of burn consequences, result in malformations due to irreversible secondary changes of the osteoarthritic apparatus, relative shortening of tendons, vessels and nerves,

delayed growth of extremities, invalidism and working disability in the future. The situation is intensified by the fact that specialized rehabilitating departments for patients suffering from foot burns are absent.

That is why the increase in the numbers of disabled people due to deep and extensive foot burns presents a difficult social and economic problem on the one hand and brings up a number of tasks to improve the organization and rehabilitation methods on the other hand. In public health literature and practice there is a deficiency of information resources for the rehabilitation of patients with foot burns. There is also no developed system of surgical rehabilitation, including dispensary care for patients suffering from foot burns; and methods of conservative rehabilitation are not carried out effectively.

There are no effective classifications of cicatrical contractures of ankle joints and feet contributing to the choice of surgical techniques. It is unknown which methods of plastic surgery operations result in the best outcomes in patients; what the correlation must be between functional and aesthetic factors in choosing and in fixing the conditions and outcomes of performing surgical and conservative treatments.

The work is based on the medical care provided for several years in patients with burns and post burn deformations of ankle joints and feet that were treated at the Samarkand Burn Center and the Burn department of RSCUMA. The authors of the presented work aim to introduce a contemporary description of burns and post burn complications in the foot area; to develop their classification; to determine the principles of their treatment, to improve restorative and plastic surgery operations and to make their modest contribution for settling this complex, multifaceted problem.

REFERENCES

[1] Artz, C. P. (1970). Historical aspect of burn management. – *Surg. Clin. N. Amer.*, *50* (6), 1193 – 1200.

[2] Papini, R. P. et al. (1995). Wound management in burns centers in the United Kingdom. Br// *J. Surg*, vol.*82*, No. 4, 505-509.

[3] Saffle, J., Davis, B. & Williams P. (1995). // *J. Burn Care Rehabilitation*, Vol. *16*, N. 3, 19-32.

[4] Herndon, D. N. (2001). Total burn care // 2nd edition, W.B. Saunders.

[5] Azolov, V. V. et al. (2004). Epidemiology of burns and condition of care to suffered people in Russia // Nizhnegorod Medical journal appendix:

The problem of treatment of severe thermal trauma. Mat. of the VIII All – Russia conference. N. Novgorod, 27-28.

[6] Fayazov, A. D. & Hadjibaev A. M. (2008). The condition of specialized Care to people with burns in the Republic of Uzbekistan. Bulletin of Urgent Medicine, No4, 8-9.

[7] Haberal, M. (2008). Burn Care facilities at the Baskent University burn and Fire Disaster Institute in 2007. // The 14th Congress of the International Society for Burn Injuries. Montreal, Canada, September 7–11, Abstract Book, 180.

[8] Alexeev, A. A. et al. (2005). Problems of organization and condition of specialized medical care to people with burns in Russia/The 1st Congress of combustiologists in Russia. Materials of the Congress. Moscow, 3-4.

[9] Kuran, I., Turgut, G. & Bas L. (2000). Comparison between sensitive and nonsensitive free flaps in reconstruction of the heel and plantar area // *Plas Reconst Surg*, No2, 575-580.

[10] Shaw J, H., His, W. L., Ulbrecht, J. S. (1997). The mechanism of plantar unloading in total contact casts: implications of design and clinical use // *Foot & Ankle*, Vol.*18*, 809-817.

[11] Al-Qattan, M. M. (2000). The «Friday Mass» burns of the feet in Saudi Arabia // *Burns*, Vol.*26*, 102-105.

[12] Al-Qattan, M. M. (2000). Car-tyre friction injuries of the foot in children // *Burns*, Vol.*26*, 399-408.

[13] El-Megeed, H. S. A., El-Din, S. M. A., Kotb, S. A., El-Oteify, M. A. A. (1999). Study of burns among workers in Assiut cement factory, Egypt, 1998 // *Annals of Burns and Fire Disasters*, March, Vol. *XI*, n.l, P.3-7.

[14] Shan, B. R. (2002). Burns of the feet. Clin Pediatric Med Surg, *19*(1), 109-123.

[15] Shakirov, B. M. (2004). Sandal Burns and Their Treatment in Children // *J. Burn Care Rehabilitation (USA)*. November/December, Vol. *25*, N6, 501–505.

[16] Shakirov, B. M. & Tursunov, B. S. (2005). Treatment of severe foot burns in children // *Burns*. November, Vol. *31*, Issue 7, 901–905.

[17] Hemington-Gorse, S. et al. (2007). Foot burns: Epidemiology and management // *Burns*, *33* (8), 1041-1045.

[18] Merz, J., Schrand, C. & Mertens, D. et al. (2003). Wound care of the pediatric burn patients // *AACN Clin Issues*, *14*, 429–41.

[19] Suchanek, I., Rihova, H. & Kaloudova, Y. et al. (2004). Reconstructive surgeries after extensive burns in children. // *Acta. Chir. Plast*, *45*, 139–43.

Chapter 2

ANATOMY OF THE SKIN AND FOOT

The skin of the foot has a rather complex structure with its own features. The skin is usually subdivided into two types – thick and thin which is associated with the different thicknesses of the epidermis. The thick skin covers the plantar surface of the foot by 2mm thickness according to the data of V. Shpaltegolts 1 cm by Soutwood, up to 4mm by B. Petrov. It is characterized by a thick epidermis with a special powerful keratin layer and thin derma on its external surface. The dorsal surface of the foot has a relatively thin epidermis and its corneal layer is also comparatively thin. In children and elderly persons the skin is thinner than in adults. In children in the first two years of life the average thickness is 1 mm, from 3 to 7 years it is 1-1.5 mm; from 7 to 15 years – 1.5-2 mm and only by 20-25 years does it reach 3 mm.

The integument system consists of two major layers: the epidermis and the dermis. The epidermis varies from 0.07 mm to 0.12 mm in thickness with the deepest layers found on the soles of the feet. Although the epithelial layer is subdivided into five separate layers, each with their own functions, the most important layers are the stratum corneum and the stratum germinativum. The stratum corneum is composed of dead keratinized cells and surrounding lipids that inhibit the passage of physical, chemical and noxious agents found in the environment. This layer also protects the body against the invasion of micro-organisms. The innermost layer of the epidermis, the stratum germinativum, is responsible for the reproduction of new epithelial cells that migrate toward the surface to replace the outer layers.

The dermal layer ranges in thickness from 1 mm to 2 mm and lies below the epidermis. This layer is composed primarily of connective tissue and

collagenous fiber bundles and provides a nutritional supportive bed for the epidermis. Within the dermis is a highly vascular network, called the rete subpapillare, which is composed of venules and capillaries that nourish the avascular epidermis. Nerve fibers, called Meissner's corpuscles, also originate in the dermis and are specific to the sensation of touch.

Additionally, the corpuscles of Vater-Pacini (pressure), Ruffini (heat), and Krause (cold) are located in the dermal and underlying subcutaneous layers. Of particular note in the dermal layer are the sweat glands and hair follicles, which, with their epithelial lining, serve in the re-epithelialization of partial thickness wounds.

Beneath the dermis is the hypodermis, which contains the fat, smooth muscle, and areolar tissue. This layer is irregular in shape, varies in thickness from one part of the body to another, and is anchored by the connective tissue originating in the dermis. The hypodermis acts as a heat insulator, shock absorber, and nutritional depot that are mobilized during starvation (Figure 1).

FOOT ANATOMY

The skeleton of the foot begins with the talus, or ankle bone, which forms part of the ankle joint. The two bones of the lower leg, the large tibia and the smaller fibula come together at the ankle joint.

The two bones that make up the back part of the foot (sometimes referred to as the hind foot) are the talus and the calcaneus, or heel bone. The talus is connected to the calcaneus at the subtalar joint. The ankle joint allows the foot to bend up and down. The subtalar joint allows the foot to rock from side to side.

Down the foot from the ankle is a set of five bones called tarsal bones that work together as a group. There are multiple joints between the tarsal bones. When the foot is twisted in one direction by the muscles of the foot and leg, these bones lock together and form a very rigid structure. When they are twisted in the opposite direction, they become unlocked and allow the foot to conform to whatever surface the foot is contacting.

The tarsal bones are connected to the five long bones of the foot called the metatarsals. The two groups are fairly rigidly connected, without much movement at the joints.

Finally, there are the bones of the toes, the phalanges. The joint between the metatarsals and the first phalanx is called the metatarsal phalangeal joint

(MTP). These joints form the ball of the foot, and movement in these joints is very important for a normal walking pattern.

Not much motion occurs at the joints between the bones of the toes. The big toe, or hallux, is the most important toe for walking, and the first MTP joint is a common area for problems in the foot (Figure 2).

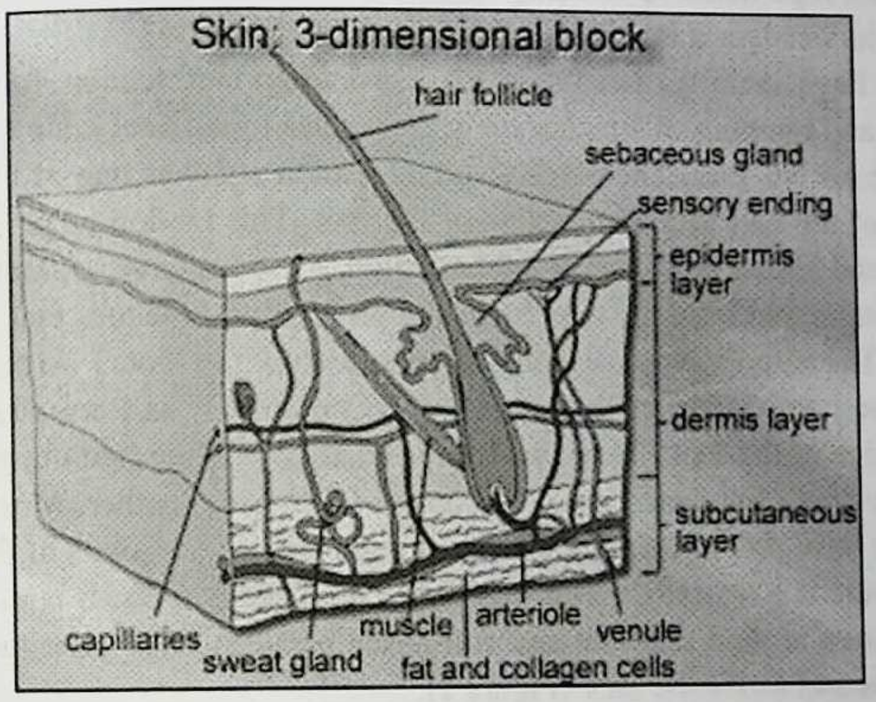


Figure 1.Anatomy of the skin.

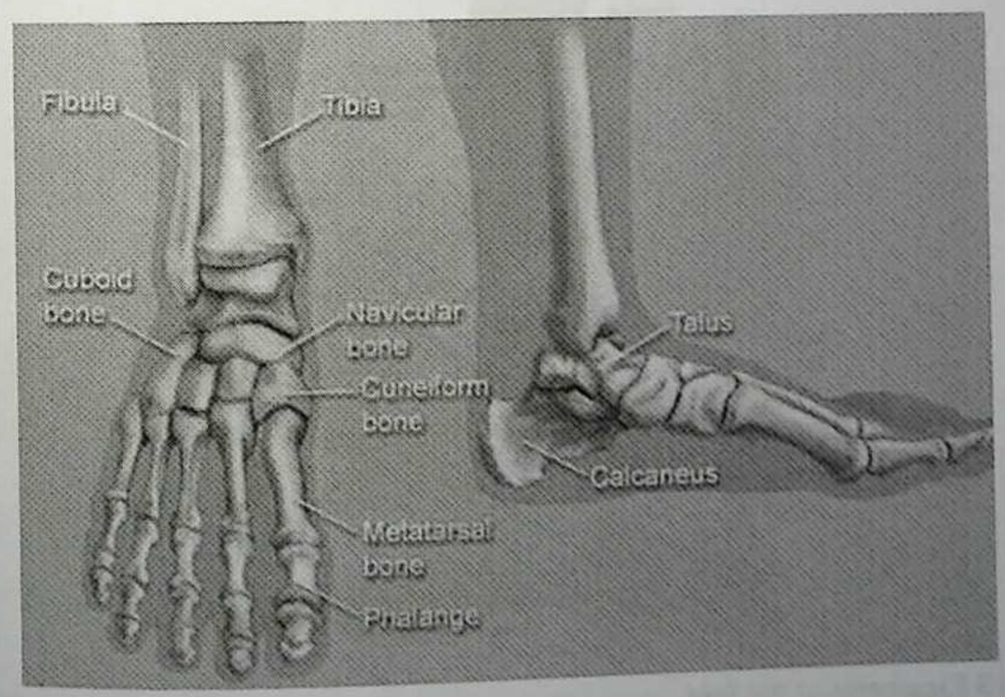


Figure 2.Skeleton of the foot.

Ligaments, Muscles and Blood Vessels are the soft tissues that attach bones to bones. Ligaments are very similar to tendons. The difference is that tendons attach muscles to bones. Both of these structures are made up of small fibers of a material called collagen. The collagen fibers are bundled together to form a rope-like structure. Ligaments and tendons come in many different sizes like a rope made up of many smaller fibers. The thicker the ligament (or tendon) the stronger it is.

The large Achilles tendon is the most important tendon for walking, running, and jumping. It attaches the calf muscles to the heel bone to allow us to rise up on our toes. The posterior tibial tendon attaches one of the smaller muscles of the calf to the underside of the foot. This tendon helps to support the arch and allows us to turn the foot inward. The toes have tendons attached on the bottom that bend the toes down and on the top of the toes that straighten the toes. The anterior tibial tendon allows us to raise the foot. Two tendons run behind the outer bump of the ankle (lateral malleolus) and are attach to the outside edge of the foot. These two tendons help to turn the foot outward.

Many small ligaments hold the bones of the foot together. Most of these ligaments form part of the joint capsule around each of the joints of the foot. A joint capsule is a watertight sack that forms around all joints. It is made up of the ligaments around the joint and soft tissue between the ligaments that fills in the gaps and forms the sack (Figure 3).

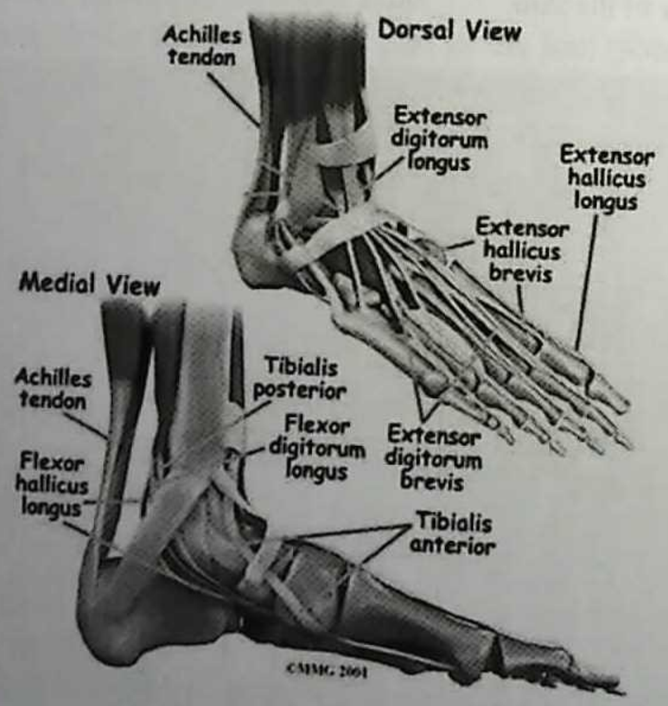


Figure 3.Ligaments of the foot.

Most of the motion of the foot is caused by the stronger muscles in the lower leg whose tendons connect in the foot. Contraction of the muscles in the leg is the main way that we move our feet to stand, walk, run, and jump (Figure 4).

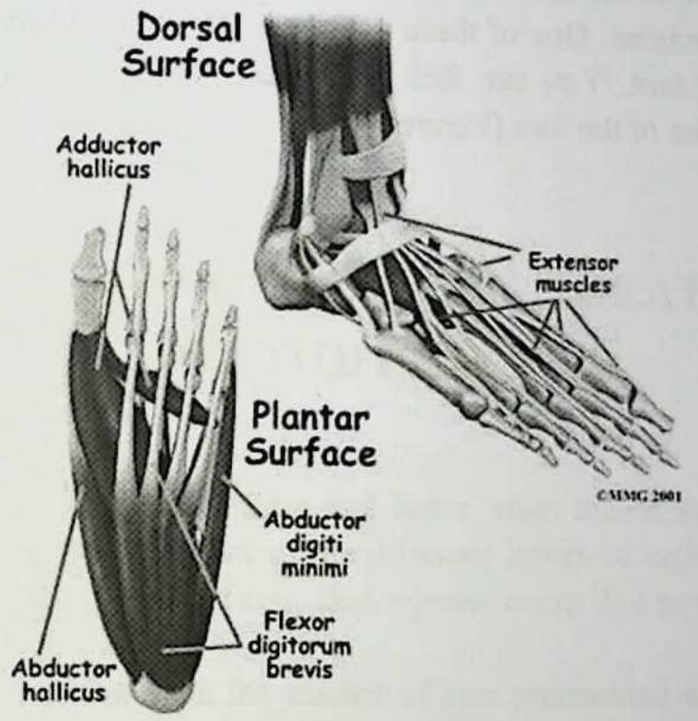


Figure 4.Muscles in the foot.

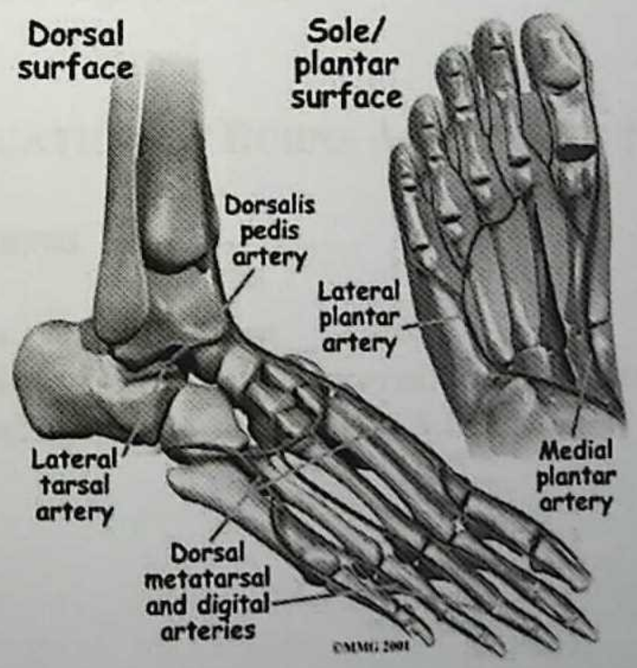


Figure 5. Blood supply to the foot.

There are numerous small muscles in the foot. Most of the muscles of the foot are arranged in layers on the sole of the foot. These muscles move the toes and provide padding underneath the sole of the foot.

The main blood supply to the foot, the posterior tibial artery, runs right beside the nerve of the same name. Other less important arteries enter the foot from other directions. One of these arteries is the dorsal pedis that runs down the top of the foot. You can feel your pulse where this artery runs in the middle of the top of the foot (Figure 5).

Chapter 3

A Simple Guide to Burn Treatment of the Foot

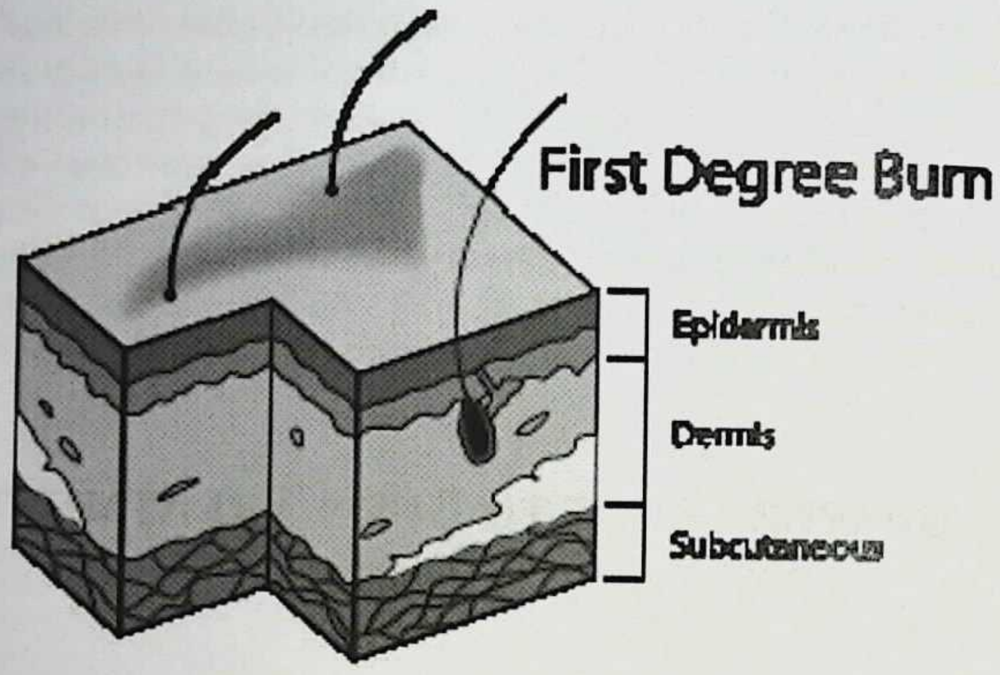
Burns or thermal injuries of the foot occur when scalds, contact burns or flame burns destroy some or all of the different layers of cells that form the human skin. For traditional reasons, skin injuries occur due to the sandal, ash, chemicals and electricity.

Burn depth depends upon the amount of heat transmitted to the skin. This depends upon two elements: the temperature of the flame, hot liquid or solid body and the duration of exposure. Burns are classified according to depth and are identified by four degrees of burn.

Classification of Burns According to Depth

First Degree Burns

Clinical Signs: painful erythema.
Histology: epidermis is partially destroyed; basal membrane is intact.
Prognosis: healing in a few days. (Figure 3.1 and 3.2)



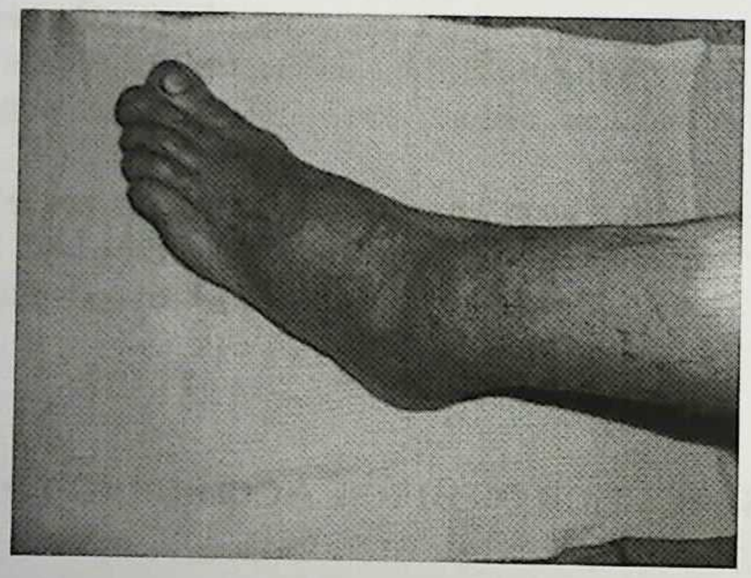


Figure 3- 2. Patient A, a 69 –year-old women, was hospitalized in the Burn department of RSCUMA. Diagnosis: First degree thermal burns of the left shin and foot. Patient's foot on the second day after getting burn trauma.

Second Degree Burns (Superficial)

Clinical Signs: erythema, blisters, underlying tissue blanches with pressure

Histology: basal membrane is partially destroyed.

Prognosis: healing in ten-fifteen days (Figure 3. 3. and 3. 4).

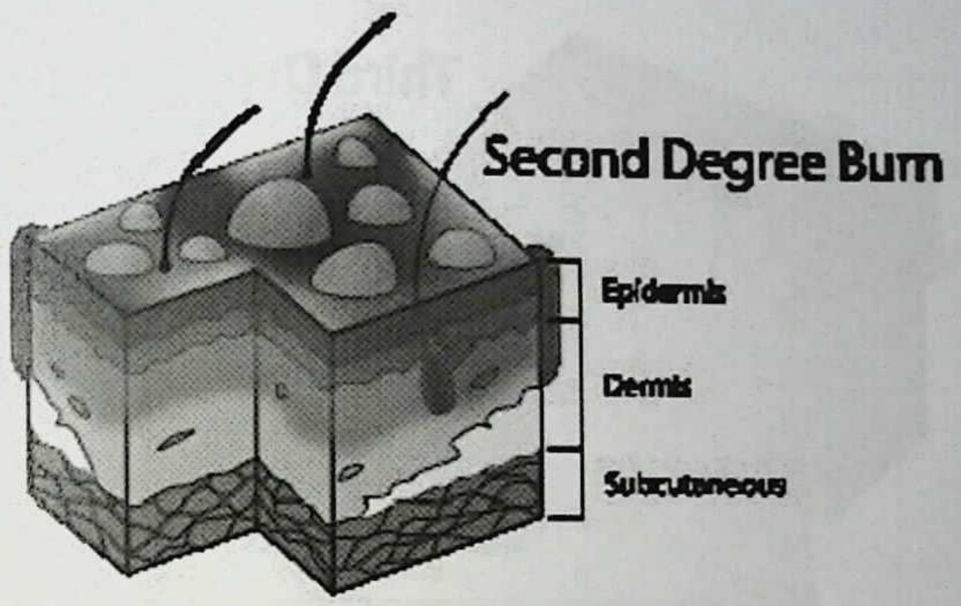


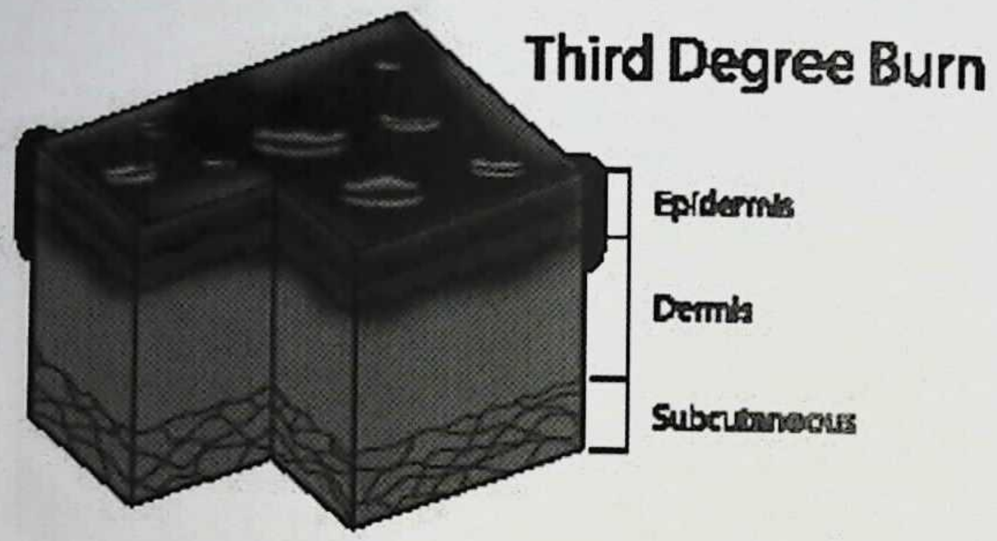
Figure 3.4.Patient B, a 1. 7 year old girl was hospitalized at the Burn department of RSCUMA. Diagnosis: Thermal burns of the right dorsal surface of the foot of the II degree. Patient's foot on the second day after getting burn trauma.

Third Degree Burns

Clinical Signs: erthyema, blisters, underlying tissue does not blanche with pressure

Histology: basal membrane is entirely destroyed; dermis partially destroyed, epidermal cells still present around hair follicles.

Prognosis: healing in three – four weeks, or there is no healing, in which case it may require grafting (Figure 3.5, 3.6, 3.7).



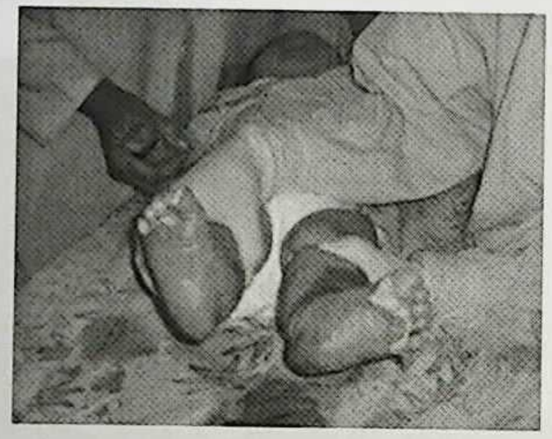


Figure 3.6.Patient C, a 1.2 year old girl, was hospitalized in the Burn department of RSCUMA with diagnosis: Thermal burns of both feet IIIA degree. Four days after getting burn trauma.

Figure 3.7. Patient D, an 11 –year-old girl, was hospitalized to the Burn department of RSCUMA diagnosis: Third degree thermal burns of both shins and feet. The patient after getting burn trauma.

Fourth Degree Burns

Clinical Signs: brown, black or white; no blister, no sensitivity.

Histology: epidermis and dermis are totally destroyed; subcutaneous tissue no more or less injured.

Prognosis: no healing with the exception of edges. Grafting is required (3.8.).

Figure 3.8. Patient F, a 9 month old girl, was hospitalized in the Burn department of RSCUMA. Diagnosis: Thermal burns (sandal burns) of IIIB-IV degree of both shins and feet. The patient twelve days after getting burn trauma.

Figure 3.9. Patient M, a 24 year old girl, was hospitalized at the Burn department of RSCUMA. Diagnosis: Thermal burns of both left shin and foot and right foot of IIIB-IV degree. Seven days after getting the burn trauma. (Contact burn).

Depending on the location of the affected deep tissues, course and complication of the following classifications of foot burns was proposed in our clinic:

According to the depth:

I. *Superficial damages of the foot of I-II degree:*
   1. Burns of dorsal surface of the foot.
   2. Burns of plantar surface of the foot.
   3. Circular burns of the foot.

II. *Dermal foot burns of IIIA degree:*
   1. Burns of dorsal surface of the foot.
   2. Burns of plantar surface of the foot.
   3. Circular burns of the foot.

III. *Deep burns of the foot of IIIB-IV degree:*
   1. Deep foot burns with impairment of the tendon
   2. Deep foot burns with impairment of metatarsophalangeal joints.
   3. Deep foot burns with impairment of foot bones.

Corresponding to the series of:

1. Without impairment of the toes functions
2. With impairment of the toes functions
3. With impairment of the finger functions
4. With exarticulation of the toes:

A. Exarticulation of Shapartov joint
B. Lisfranc
C. Ankle joint
D. Exarticulation on the level of the toes

Complications:
1. Bleeding
2. Osteomyelitis
3. Arthritis
4. Luxations

Chapter 4

FOOT BURNS: EPIDEMIOLOGY AND MANAGEMENT

This is a retrospective study of the epidemiology and treatment of isolated foot burns at the Samarkand Inter-Regional Burn Center and the Burn department of RSCUMA. This study suggests a protocol for the initial management of acute foot burns. This protocol states immediate referral of all foot burns to the burn center, admission of these burn patients for leg elevation, regular wound cleansing with change of dressing and prophylactic antibiotics.

INTRODUCTION

Only rare papers on the problem of foot burns can be found in available foreign and national scientific literature [1, 2]. Insufficient coverage of this problem in scientific literature and frequent post-burn complications that result in disabilities impelled us, the staff members of the Burn department of RSCUMA and Inter-Regional Burn Center, to carry out this study.

Foot burns involve a specialized area of function and although they involve a small total body surface area (3.5%), they can cause a significant degree of morbidity. This is caused by the fact that foot burns often require prolonged bed rest. Time lost from work along with the length of hospitalization and a high risk of complications result in a high financial as well as emotional cost to the individual [3, 4].

Burns to the feet usually occur in all ages, both in children and the elderly and result in disability [5, 6]. Burns to children's feet are often due to a sandal, and hot water, as an infant's skin is thinner and hence more susceptible to a full-thickness injury [7, 8].

Treatment of foot burns depends on the depth of the burn. The aggressive management of superficial partial thickness foot burns to prevent infection may prevent the progression of a superficial partial thickness burn into a deep partial thickness burn which is known to occur with infection [9].

Treatment of a full thickness burn is usually performed by eschar excision and wound coverage by a skin graft [10]. The skin on the sole of the foot is highly specialized and thick and even though foot burns are often initially clinically assessed as full thickness burns in some cases it may heal in conservative treatment due to the skin characteristics. It was documented in pediatric foot burns that conservative treatment should be the treatment of choice for all pediatric burn wounds and if healing has not occurred within 3 weeks, only then should excision and grafting occur [11]. Early complications such as infection, cellulitis, delayed wound healing, graft loss and late complications such as dryness, hyperkeratosis, ulceration, keloid and hypertrophic scarring, scar contractures, decreased range of movement, altered gait patterns and complex regional pain syndrome were documented in the literature [12].

PATIENTS AND METHODS

This database includes the admission date, the name and age of all hospitalized patients as well as the total body surface area, depth of burn and mechanism of injury. The data about each patient was collected and includes: demographics, etiology of the burn, occupation of the patient, location of the accident, co-morbidities, characteristics of the burn, treatment, complications, outcome, admission, swab results, prophylactic antibiotic use, and presentation of delay and length of stay. Three hundred and sixty –seven patients were identified by the database with isolated foot burns. 138 patients were included in the study. 87 patients were classified as pediatric (less than 14 years old with 48 males and 39 females. 51 patients were classified as adults (older than 14 years), with 24 males and 27 females.

RESULTS

I. Burn Depth

Burns were classified as superficial partial thickness, deep dermal, full thickness or mixed. 30.43% of the patients (42) were classified as having superficial partial thickness pedal burns, 27.53% of the patients (38) had deep dermal burns, 18.85% of the patients (26) had full thickness burns and 23.19% of the patients (32) had mixed depth pedal burns.

II. Etiology Compared in the Adult and Pediatric Groups

The adult group included 53 patients, of these patients the most common etiology was a scald in 58.49% of the (31) patients, sandal burns in 26.41% of the (14) patients, chemical burns in 7.55% of the (4) patients and electrical burns in 7. 55% of the (4) patients. The pediatric group included 75 patients and sandal burns was the most common etiology (77.33% of the (58) patients, scald in 16.0% of the (12) patients, and hot ash and asphalt burns in 6.67% of the (5) patients (Table 4.1).

Most of them were children under three years of age who fell into sandal heaters. In these cases, the sandal burns caused especially deep and severe injuries to tissue due to immediate contact with the burning agent.

III. Place of injury

The most common place of injury was at home in 77. 54% of the patients (107), followed by work, 17. 39% of the patients (24), and finally "other" cases in 5.07% the patients (7) (Table 4.2).

IV. Management

All 138 patients underwent stationary treatment. The length of hospital stay varied and ranged from 4 to 39 days, with an average stay of 11 days.

The management of isolated foot burns was divided into conservative and surgical treatment. 41.30 % of the patients (57) were managed conservatively with dressings and strict elevation to manage edema for at least 24 hours and 58.70 % of the patients (81) also underwent surgical treatment, in addition to dressings and elevation. All the 81 patients having surgical management underwent necrotomy -10 (12.35%), necrectomy -29 (35.8%), tangential excision -26 (32. 0%) of their burn and split skin grafting and 16 patients (19. 75%) underwent exarticulation (one patient underwent amputation below the knee and 15 patients underwent toe exarticulation) (Table 4.3).

Table 4.1. Etiology of burns in isolated foot burns in the adult and pediatric groups

Etiology of burn	Adult patients	Pediatric patients
Scald	31 (58. 49%)	12 (16. 0%)
Sandal	14 (26. 41%)	58 (77. 33%)
Chemical	4 (7. 55%)	-
Electrical	4 (7. 55%)	-
Hot ash and asphalts	-	5 (6. 67%)
Total	53 (100%)	75 (100%)

Table 4.2. Place of injury

Home	107 (77. 54%)
Work	24 (17. 39%)
Other cases	7 (5. 07%)
Total	138 (100%)

Table 4.3. Management

Conservative management	57	41.3%
Surgical management	81	58.7%
• necrotomy	10	12.35%
• necrectomy	29	35.8%
• tangential excision	26	32.0%
• exarticulation (amputation)	16	19.75%

COMPLICATIONS

Complications occurred in 35.51% of the patients (49), with this 7.97% of the patients (11) had more than one complication. The most common complication was hypertrophic scarring that was documented in 13.77% of patients (19) - 21.74% of the patients (30) with burnt contracture were children below 16 years of age. The second most common complication was graft loss/delayed healing which occurred in 10.14% of the patients (14). Wound infection occurred in 6.52% of patients (9). The most common infectious organism was Staphylococcus aureus, other infections included Pseudomonas aeruginosa.

I. Antibiotics use

Prophylactic antibiotics were given in 87.68% patients (121). 66.1% patients (80) were given ceftriaxone, 17.4% patients (21) were treated with amikacin, 10.7 % patients (13) with gentamicyni and 5.8% patients (7) had a combination of the above.

II. Microbiology

Most patients had combinations of bacteria, but the results clearly show that Staphylococcus aureus was the most common organism isolated. Not included in the table due to the small number was the isolation of streptococcuspneumonia, Klebsiella and Candida. However swab results have been found to be useful in guiding antibiotic treatment if the wounds subsequently become infected (Table 4. 4).

Table 4.4. Results from admission swabs in isolate foot burns

Bacteria	
Staphylococcus aureus (gram + ve cocci, aerobic)	31 (22.46%)
Staphylococcus aeroginosa (gram + ve cocci, aerobic)	24 (17.39%)
Staphylococcus epidermidis (gram + ve cocci, aerobic)	19 (13. 77%)
No growth	53 (38. 41%)
Other	11 (7. 97%)
Total	138 (100%)

III. Follow-up Period

60. 1% percent (83) of patients with isolated foot burns were discharged within 6 months and 24.64% (34) after 6 months. 15.22% (21) of the patients did not attend follow up appointments.

DISCUSSION

In modern clinical surgery the treatment of deep burns is considered to be one of the more complex problems having not only medical but also social and economic significance. According to the registration date_foot burns comprised 5 to 14% of all burns and they can be explained by the mechanisms of the burn taking place in part due to risk factors caused by footwear (shoes, boots, etc.).

The increase of burn trauma incidences in these countries may be associated with the high development of the power and chemical industries and also with a high level of road accidents. In Central Asia, and particularly in Uzbekistan, many instances of burns take place in homes due to the use of sandal heaters.

Isolated foot burns in the pediatric group are caused most frequently by sandal usage at home. Our results are compared with previous studies [14]. Scald burns are almost as common as sandal foot burns in the pediatric group.

Seventy-five (75%) percent of the isolated foot burns were treated conservatively with dressings and again these results are comparable to previous studies. To date no randomized control trial has been carried out comparing conservative therapy verses grafting in certain scald and sandal foot burns. Foot burns are often colonized with infections from the surrounding skin, which can account for the multiple systemic antibiotics which were given to most foot burns treated either in or out of our patient departments and this could account for the lower infection rate.

CONCLUSION

Treatment of patients with foot burns is still one of the important tasks of modern combustiology because of the functional significance of the studied joint segment.

Rehabilitation of patients with deep foot burns is done by means of complex treatment measures both medical and surgical, which are intended to correct the general somatic state, prophylactics against the development of joints osteoarthritis and foot phlegmon. Providing an adequate regenerative process in the burn zone and cutting dead joint segments prevents the development of contractures. To sum up the above mentioned reasons, the investigation of consistent methods for the treatment of deep foot burns is considered to be of great importance today. There is no confusion when dealing with deep burns; the only method of treatment is surgery.

We suggest an aggressive initial management protocol for foot burn injuries:

- Immediate referral to a burn center is essential.
- Admission for at least 24 hrs with strict foot elevation to reduce the swelling.
- Regular wound cleansing with Flamazine, Bactigras or Aquacel Ag and an assessment of burn depth and follow up treatment.
- Prophylactic use of antibiotics to prevent infection.
- We consider this aggressive immediate management of foot burns helps to reduce the progression of the burn depth, hence decreases the complication rates and the need for surgical intervention.

REFERENCES

[1] Brigham, P.A. & Mc Loughlin, E. (1996). Burn incidence and medical care in the United States: estimates, trends and sources. *J. Burn Care Rehabil*, *17*, 95-107.

[2] WHO Report. (2002).*The Injury Chart Book: a graphical overview of the global burden of injuries*, 27-34.

[3] Zachary et al. (1987). Burns to the feet. *J. Burn Care Rechab*, *8*(3), 192-194.

[4] Shah, B. R. (2002). Burns of the feet. *Clin Paediatr Med Surg*, *19*(l), 109-23.

[5] Hemington-Gorse, S. et al. (2007). Foot burns: Epidemiology and management. *J. Burns*, *33*(8), 1041-1045.

[6] Barret, J. P. & Herndon, D. N. (2004). Plantar burns in children: epidemiology and sequelae. *Ann Plast Surg*, *53*(5), 462-4.

[7] Shakirov, B. M. (2004). Sandal Burns and their Treatment in Children // *J. Burn Care Rehabilitation*, *25*, 501-505.

[8] National Burn Care Review Committee. (2001). National Burn Care Review Offer GJ (2003). Evidence based medicine as applied to plastic surgery.

[9] Kanat, V.R. (1985). Burns: a review of the pathophysiology, treatment, and complications of thermal injury. *J Foot Surg*, *24*(5), 373-82.

[10] Cooper, R. & Lawrence, J. C. (1996). The isolation and identification of bacteria from wounds. J. Wound Care, *5*(7), 335-40

[11] Caruso, D. M., Foster, K. N., Blome-Eberwein, S. A., Twomey, J. A., Herndon, D. N. & Luterman, A. et al. (2006).Randomized clinical study of hydro fiber dressing with silver or silver sulfadiazine in the management of partial-thickness burns. *J Burn Care Rehabilitation*, *27*, 298 -309.

[12] Shakirov, B. M. & Tursunov, B.S. (2005). Treatment of severe foot burns in children // *J. Burns*, Vol.31, No7, 901-905.

[13] Shakirov, B.M., Tursunov, B.S. & Tagaev, K.R. (2006). Treatment of sandal burns in children. British trauma society annual clinical meeting / *Abstract book*, October 12-13, 0145.

Chapter 5

COMMON PRINCIPLES IN THE TREATMENT OF FOOT BURNS

FIRST AID

These recommendations are intended as a guide for "first responders", i.e. informed bystanders, health clinic workers, paramedics and other medical emergency medical personnel:

1. Remove heat source.
2. Look for associated trauma.
3. Remove non – sticking garments.
4. Cool the burn with cold water (best between 8°-23°) as soon as possible. Cold water relieves the pain, removes the heat and lowers the temperature in the injured tissues. This prevents further injury to the skin, and increases the chances of survival of damaged but still living cells. Cooling can be effective for thirty – sixty minutes after injury, and can be continued until pain no longer returns after cooling stops. The water must be "clean" but sterility is of no concern.
5. Estimate burned surface area and burn depth.
6. Apply first aid dressing: if a hospital or clinic is near, simply wrap up the wound in a clean towel and transport. Otherwise:
   I. clean the burn with an alcohol free antiseptic solution or with soap and water.

II. Dress the burn.
III. Separate toes with layers of dressing.

7. Take the patient to a medical care facility for treatment.

Ambulatory Care of a Burn patient

- Give tetanus prophylaxis.
- Clean the foot burn with an alcohol free antiseptic solution or with soap and water.
- Dress the burn wound by applying one layer of gauze impregnated with petroleum jelly and cover it with several layers of absorbent gauze. Keep toes separated.
- Give written instructions to patients to come back before the end of the third day in case of fever, or if the dressing soaks through, is malodorous or is disrupted.
- Local treatment in the foot area begins with a cleansing of the burn injuries. The cleansing is carried out in a clean dressing room, following aseptic rules after anesthesia has been administered. The injured areas of the foot are washed with soap and warm water or weak solutions of antiseptics; remove dead tissues using swabs soaked in a solution of antiseptics, warm water or detergent. Visible mud is removed by a swab soaked in betadine or iodopyrine. Foreign bodies or thickenings are carefully removed from the burnt surface with a gauze pad soaked in a solution of above mentioned antiseptics. Ruptures of the epidermis and cysts are excised by sterile scissors. The burnt surface is then irrigated with a 3% solution of hydrogen peroxide or furacilline. Intact cysts of small and middle size are not processed but the large ones are undercut at the base and their content is released. After this the biological layer prevents the burn surface from trauma. The pain is decreased by bandaging which creates favorable conditions for epithelization.

Local Conservative Treatment

Local conservative treatment of burn injuries in the foot area is based on the peculiarities of inflammation in injuries of various depths. In order to prevent the development of purulent inflammation in the burn injury of the

foot area or to stop its development in the shortest time it is necessary to carry out an adequate conservative treatment, contributing to rapid rehabilitation of the flat skin covering the foot and preventing the development of hypertrophic cicatrical and post burn contractures of the foot. Proceeding from this, the main problems associated with the treatment of purulent injuries are the following:

The first stage of wound processing:

- Suppress the wound infection;
- Normalize the local homeostasis (liquidation of hyperemia, acidosis, excessive proteolysis)
- Activation of the rejection of necrotic tissues, absorption of toxic discharge from the injury and the prevention of microbes and tissue destruction.

The second and third stage preparations must be the following:

- Prevent secondary contamination with simultaneous suppression of the residual micro flora growth;
- Provide a protective environment for regenerating tissues;
- Provide directed stimulation of reparative processes in the wound
- Provide activation of metabolic processes in tissues and improvement of local blood flow.

The extent of knowledge about the regularity of the healing of burn injuries in the foot area resulted in different treatment protocols of burns depending on the depth of injury in the foot area. The presence of a superficial layer of dead tissues, marked by impairment of microcirculation and also the whole structure of cellular and biochemical changes are specific for superficial and border burns of the foot.

It is known that the foot burn is characterized by irregular damage (dorsal surface, sole surface or combined damage); because deep necrosis can be intermixed with superficial damage and so the depth of the injury will not be the same in the burned area.

Local treatment in superficial and border burns must be targeted to the creation of favorable conditions for their healing in the shortest period of time and must provide protection for the injuries from impairments and infection

and if necessary to carry out an effective treatment of any infection and a stimulation of the reparative processes.

In the early stages immediately following a burn of the foot it is reasonable to use antibacterial treatments. If inflammation develops it is necessary to use preparations to which wound vegetating microorganisms are most sensitive. Preparations with an antimicrobial effect must be used in all stages of the wound process, but the dosage is not the same:

- Fluid dosage forms;
- Soft dosage forms (they are provisionally subdivided into the following groups: ointments, creams and aerosols);
- Solid dosage forms.

If there is no marked suppuration of the wound, rebandaging is done every 2-3 days. If there is wound suppuration of IIIA degree, the burn treatment must be started with a wet to dry dressing protocol that contributes to the development of a thin, crust, consisting of necrotizing layers of skin and fibrin. Iodine preparations (1% solution of iodopyrone, iodopovidone and betadine), and multicomponent combined ointments (levomycol, levosin, vascopan with levomycol and others) contributes to the development of thin crust.

The IIIA degree burns may be healed without suppuration. If epithelization of the IIIA degree burns is prolonged, stimulators (aloe, vitamins, and anabolic) are used. It is necessary to underline that, at present in the treatment of IIIA degree burns; the quickest drying crust is used in order to prevent infection. Drying of dead tissues is achieved by physical methods of treatment (Figure 5.1, 5.2, 5.3).

Removal of Dead Tissue

Deep foot burns of IIIB-IV degree will not heal by them so treatment must focus on a quick cleansing of dead tissues and preparation for plastic surgery. The phase of the injury process and the character of the injury are determined. The preparations used for the rejection of necrotic tissues from the surface of the burn injuries must have an osmotic, antibacterial, necrolytic effect. They must contribute to the cleansing of nonviable tissues and outflow of exudates from the surface to the bandage and also suppress micro flora in the wounds.

Figure 5.1. Patient Y, 34-year-old man was hospitalized at the Samarkand Inter - Regional Burn Center with diagnosis: Thermal burn (IIIA-IIIB degree) of left shin and foot. The patient's third day after getting burn trauma.

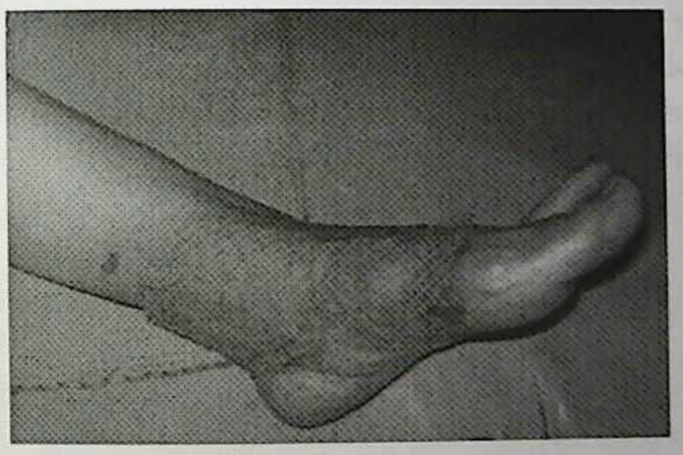


Figure 5.2. Patient's foot during the dressing with iodopovidone.

Figure 5.3. The patient before discharge.

The other important issue in the treatment of deep foot burns is to speed up the rejection of dead tissues. Detritus is the nutritional medium for the development of microorganisms; dead tissues prevent the development of granulation and epithelization of wounds. Burn crust is the source of possible septic complications. Spontaneous rejection of necrotic tissues may prolong the recovery by 4-6 weeks and thus the tactics of the local treatment of burn wounds was focused on the quickest methods of cleansing necrotic tissues from the wounds.

The rejection of a wet crust occurs quicker. However toxic conditions are more pronounced and the development of pathogenic flora and a generalized infection of the wound are more likely, as this is connected with the failure of the protective barriers. It is explained by the above method to turn a wet necrosis into dry, although the dry method is rejected more slowly. So measures must be taken to quicken the burn crust rejection.

Enzymatic debridement (trypsin, chymotrypsin, terrilitin) have a necrolytic effect. Methods that employ the use of immobilized proteolytic enzymes in combination with a 10% solution of urea deserve attention.

A combination like this makes it possible to speed up the rejection of the necrotic mass, to stimulate the cleansing of burn injuries and to prepare the wound for operative closure.

The preparations are dissolved in a hypertonic solution and applied to the injured surface. It must be noted that during the first phase of the inflammatory process an excessive number of proteolytic enzymes are released causing an impairment of the leucocytes of the tissues and microbes.

Due to this fact the employment of proteolytic enzymes is indicated in the development of secondary necrosis in the wound area.

During the development and evolution of the research to make local treatment more effective we have included semiconductor laser therapy into the therapeutic protocols (Figure 5.4).

After a comparative evaluation of helium neon lasers (in 17 patients) and semiconductor lasers (in 21 patients) used in medicine currently, we prefer to use semiconductor lasers. They are more mobile and can work in an ever-changing medical protocol and still provide sufficient therapeutic power.

Showing even more therapeutic potential is a combined use of semiconductor laser therapy and a local application of both naturally and biologically active preparations such as propolis. In our practice (in 14 patients) we subsequently used various propolis preparations: starting with a 5-10% combined preparation of propolis ointment and collagen, to immobilize

the propolis in polyfunctional napkins called "Coletex". These napkins contain enzymes that have a binary effect and are immobilized on a textile material.

Combinations of proteolytic enzymes such as trypsin, chymotrypsin or collagen in addition to metal composites, act like a biological scalpel, "melting" the necrotic tissues by activating the plasmine and producing an anti-inflammatory effect. Due to the use of the penicillinase enzymes, bacteria activity decreases and the impairment of their fibrine membrane resistance for pyogenic microflora also decreases. Due to this process the burn surfaces can be prepared more rapidly for plastic surgery approximately 18-22 days after receiving the burn trauma.

We placed skin grafts on the granulated tissue, when the wound was completely ready for an autograft closure. The wound surface, when prepared for plastic surgery, is bright pink, neat, moist, with little bleeding, and without edema. It should be covered with a thin layer of tender, granulated tissue without fibroses, suppurative and necrotic films. It should have a marked border of epithelization without any inflammation and with minimal micro flora (Figure 5.5).

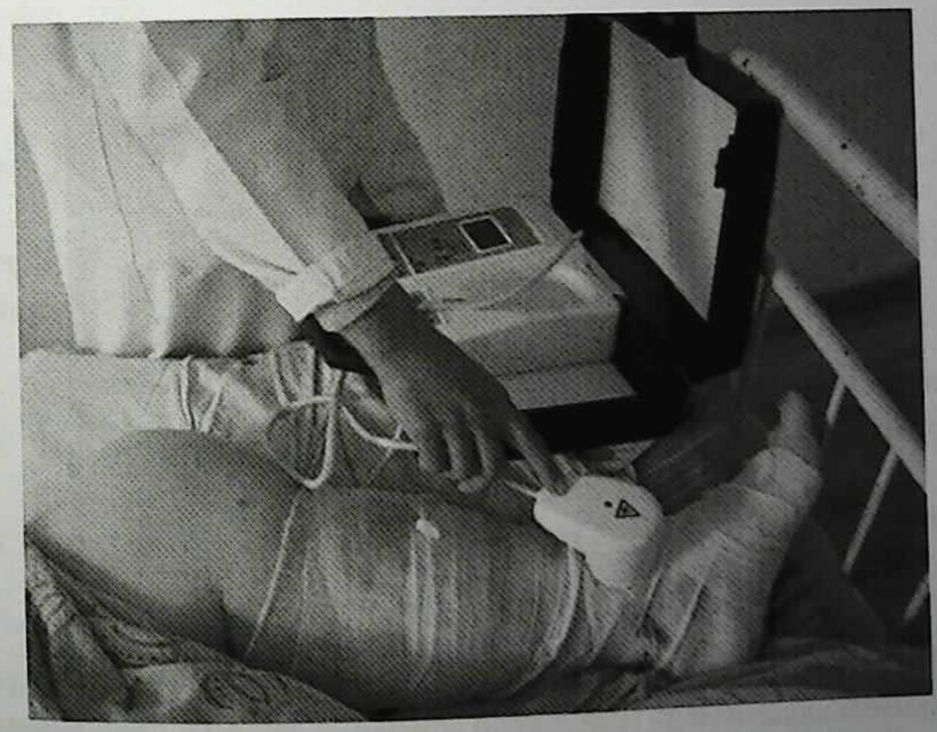


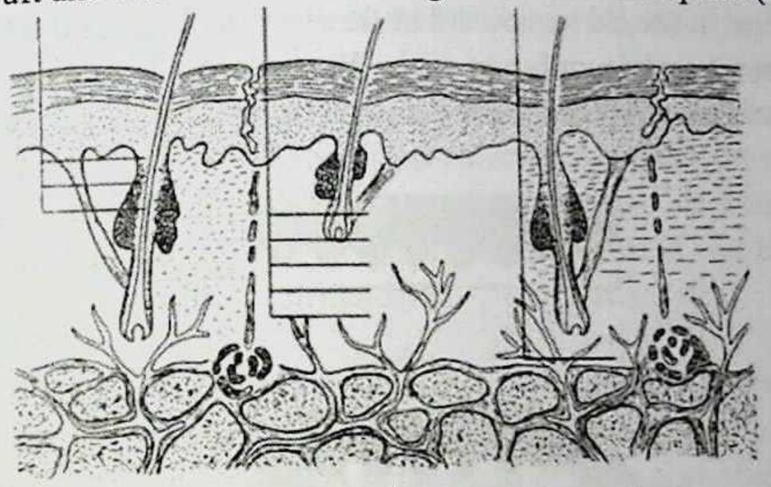
Figure 5.4. Laser therapy, provided by MILTA-F apparatus.

Figure 5.5. Patient Z, 1.4-year-old boy was hospitalized at the burn department of RSCUMA with a thermic burn (IIIA-IIIB degree) of the left shin and foot. The patient's feet 21 days after getting trauma.

Figure 5.6. Patient V, 1.1-year-old boy was hospitalized in the burn department of RSCUMA with a thermic burn (IIIB degree) of both feet. Patient's feet 20 days after trauma.

WOUND COVERAGE

Skin transplantation is the most widespread method for treatment of skin defects. There are three types of free skin transplants: split thin skin graft, split thick skin graft and whole skin thickness graft or thick transplant (Figure 5.7).



a b c

a – split skin grafts;
b – split thick grafts;
c – whole skin thickness grafts.

Figure 5.7. (a, b, c) Types of free skin transplant grafts.

A split thin skin graft for closure of granulating skin defects is used for the following reasons:

1) Nutrition of thin grafts is easier and they heal better than thick ones;
2) The donor area, the place where the thin grafts were taken heals quicker;
3) Hypertrophic scars and keloids often develop on the area where thick grafts are taken in predisposed patients.

In order to take transplants we used Brown's electro-dermatome and dermatomy disk. The use of electro-dermatomes makes it possible to obtain thin skin grafts in some areas which contain only a superficial layer of epidermis (Figure 5.8 a,b,c).

For technical reasons the margins of such transplants do not form at right angles to the skin (Figure 5.8a) and have the form of a transplant on a transverse incision (Figure 5.8b). The form that the transplant takes with the

use of dermatome is shown in the picture. Transplantation of the skin graft was mainly performed on granulated tissue.

The width of the grafts range from 3 to 5 cm. Their length depends on the location of the donor site. The thickness of the grafts range from 0.2 to 0.3 mm. Grafts from the external and internal surfaces of the hip were normally used. However, it should be noted that for successful engrafting, transplanted skin must be placed in order to cover the area of the wound completely, without constraints, compression or tension (Figure 5.9).

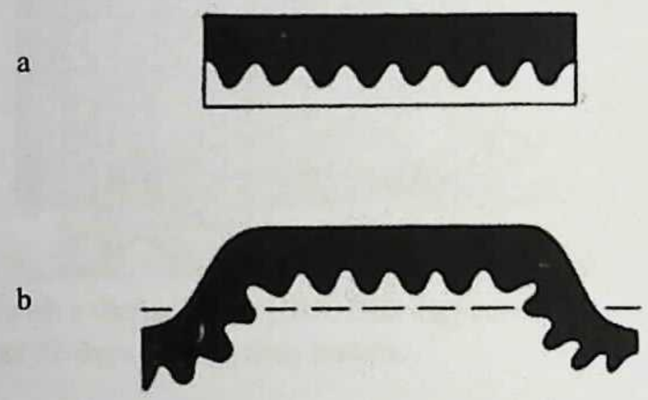


Figure 5.8. (a, b, c) Transverse incision of a skin transplant.

Figure 5.9. The patient on the 19th day after admittance to the hospital, the patient's foot after necrectomy, the wound is ready for the skin graft.

Patient A. was a 7-year-old boy admitted to the burn department of RSCUMA with the diagnosis of a: thermal burn (full thickness) of the left shin and foot (sandal burn) of the III-IV degree. The patient was examined on the 3rd day after recovering from burn shock. At the time of the patient's admission to the Burn Center his general condition was satisfactory. His skin and visible mucosae were pale. His nasal breathing was easy. His heart sounds were muffled his pulse rate was 118-120 beats/min, and his blood pressure was 90-60 mm Hg. His abdomen was soft. He was not passing urine and had no bowel movements. Examination of the patient showed that the epidermis on the foot was disrupted and covered with a black material, the wound base was pale, and there was no sensitivity. The results of a blood test on admission were: hemoglobin, 120.0; hematocrit, 51.0; leukocytes, 10.3; blood coagulability, 3-4.

Treatment of the foot burn started with a Novocaine ring block (0.5%, 25 ml) which made it possible to put the burned extremity into a bath with a detergent solution without any pain to the patient. The pieces of necrotic tissue were then removed with scissors and the burnt surface was treated with Rivanol and a Furacillin solution (1:5000). The wound was covered with a sterile dressing and the patient was given some molecular and crystalloid solutions for hemodynamic stabilization, anti-toxification medications, antibiotics and analgesics.

On the fourth day an exarticulation of all five left toes and a partial necrectomy were performed under general intravenous anesthesia.

Figure 5.10. The patient's foot after plastic surgery with a perforated skin graft.

On the 12th day after the burn trauma, a partial necrectomy of the patient's foot was performed and on the 15th day, a total necrectomy was performed. The patient had also undergone a blood transfusion and a plasma and other blood substitute transfusion.

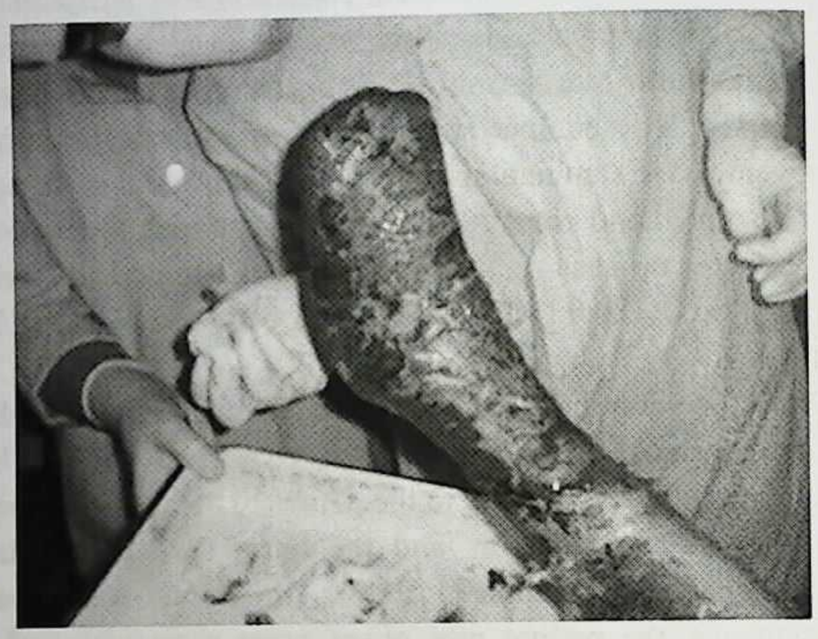


Figure 5.11. The results about 20 days after the plastic surgery.

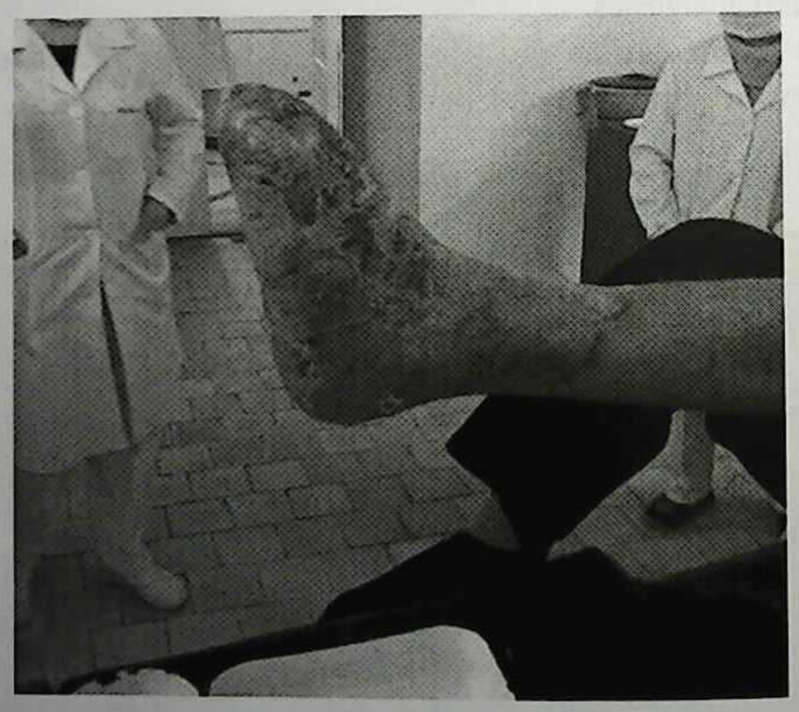


Figure 5.12. The results 6 months after the operation.

On the 20th day granulated tissue formed in the wound on the heel and the ball of the foot and in the arch area the wound healed naturally. Then plastic surgery was performed and a graft was taken from the external surface of the left hip of the patient and placed on the granulated wound. A examination was made on the 3rd day after the plastic surgery. The skin was engrafted and the patient was discharged from the hospital in satisfactory condition for outpatient treatment. Physiotherapy was advised for the patient. The second examination was performed 25 days later and the patient was in satisfactory condition. The transplanted skin had normal color and the foot sensitivity was good. The patient was advised to continue physiotherapy and to avoid putting much pressure on the foot. The third examination was performed a month later and the transplanted skin had a normal pink color and the sole sensitivity was good.

Chapter 6

NECROTOMY OF THE FOOT

The first surgical intervention, which is carried out even during burn shock, is an early decompressive operation. Indications to perform decompressive operations are in the cases of deep foot burns, which lead to the appearance of subfascial edema and the development of Hypertensive Ischemic Syndrome, the result of which can be the loss of material in the zone of paranecrosis. During treatment the formation of a necrotic scab with burns of the III –IV degree occur predominantly in the first two days after the initial injury.

With the performance of a decompressive operation during the period of scab formation there is a high risk of a misdiagnosis of the area with surface foot burns of the II degree, which leads to the damage of healthy tissues and hemorrhages during surgery. This hemorrhaging takes place in the magistral blood stream and that is why it is not diagnosed in a timely manner. As a result of this type of hemorrhaging the foot becomes cold, the areas of the skin having no burn injuries become pale and cyanotic; the arterial pulse gradually weakens and can disappear completely.

Identification of Hypertensive Ischemic Syndrome of the foot is done by using clinical signs and with the aid of instrument study. The clinical signs of Hypertensive Ischemic Syndrome of the extremities are a temperature drop, cyanosis of the intact skin, edema of distal sections and local neurologic symptomatology. For the measurement of Intra Fascial Pressure (IFP) an apparatus is used, which consists of a mercury pressure gauge, PVC tubes, a three–way cock, a syringe and a needle. The needle and PVC tubes, connected with it, are filled with an isotonic solution in the case which overlaps the opening of the crane, which leads to the manometer. Then with the aid of the

crane the needle is inserted and connected with the tube, the filled isotonic solution by means of the syringe raises the pressure in the system to 20 mm Hg this is then transferred by the crane to the position of the manometer needle. If the liquid moves to the needle, then this testifies to the absence of Hypertensive Ischemic Syndrome. In the measurement of pressure cases if the liquid does not move, then the pressure in the system with the aid of the syringe slowly rises and the indications of the manometer which corresponds to the level of the Vacuum Fluorescent Display (VFD) are fixed.

If intra fascial pressure in the fascial compartments of the lower extremities increases to more than 30 mm/Hg it is necessary to perform decompressive operations which are the only way to prevent a secondary tissue necrosis, which develops in burns of the III and IV degree as a result of Hypertensive Ischemic Syndrome.

It was Janet who first recommended (in 1963) to incise the burned skin, subcutaneous tissue and aponeurosis in deep and circulatory burns of the trunk, to prevent the disruption of respiration due to limited respiratory excursion in the chest.

However, controversy still exists regarding the length of the dermatome that is required for adequate decompression of the lower extremities. First some authors have favored limited incisions, claiming low morbidity as an advantage [1, 2]. Others have stated that long skin incisions are required to decompress the affected compartments adequately [3-6].

This study was undertaken to determine the effect of the length of the skin incision in post-traumatic compartment syndromes of the lower extremities treated by fascial decompression.

We performed necrotomy in 32 patients. In 6 patients it was performed 12 hours after getting the burn trauma, in 15 patients on the first day and in 11 patients on the second day after getting the burn (Table 6. 1).

The causes of death were sandal burns in 30 cases and in 2 cases children got burns from hot ash.

Necrotomy was performed under the sterile conditions of the operating room under intravenous anesthesia or after previous compartment anesthesia. When general anesthesia is used it is possible to perform the operation adequately, and to continue on through hemostasis without emotional and psychological disturbances for the patient. The most important moment in performing decompression necrotomy is the whole length of incision of the burn injury of only the dead tissues without damaging the viable ones (Figure 6.1).

The operation technique: The operative area is processed with an alcohol and iodine tincture. Incision of the necrotic tissues to the whole depth of the injury is performed with a scalpel in a longitudinal direction across the area until the appearance of small capillary bleeding. In this way the incisions on the foot and toes are performed along the lateral surfaces of each phalange with interspaces in the structure of the inter-phalangeal joints. There must be no less than two necrotomic incisions on the dorsal surface of the foot in the I and IV projection of interdigital interspace and one incision in the structure of the median bed of the sole surface. The line of incision must coincide with the longitudinal axis of the extremity. With this incision, the edges of the wound separate and a slightly bleeding subcutaneous tissue bulges from it. There is no significant bleeding during this process. In performing the incision above the joints it should be noted that the developing scar will have a more favorable direction (along the lateral surfaces). The area is then covered by a sterile bandage. The operation for necrotomy is less traumatic and does not complicate further treatment. The clinical signs of necrotomy effectiveness are an improvement of the microcirculation in the foot, disappearance of paleness and cyanosis, an increase of the skin temperature of 1-2ȯ, a decrease of edema and absence of local neurological symptoms.

Table 6.1. The age of studied patients

Under 1 years	9	28.1%
1-3 years	17	53.1%
Older than 3 years	6	18.8%

Figure 6.1.Thermic burn of the IIIB-IV degree of the right sole surface of the foot. Necrotomy was performed on the second day to illustrate decompression of the four fascial compartments using the double-incision technique.

In addition, incision of burn crust during early periods accelerates its demarcation and following rejection. In performing early necrotomy a favorable effect and the absence of a secondary necrosis were observed in all patients (Figure 6.2).

DISCUSSION

Prompt surgical decompression is the only means of preventing the late secondary occurrence of an ischemic contracture in post-traumatic compartment syndrome. In circumferential burns of the foot, the skin is identified as the primary constricting envelope, and liberal escharotomy is the treatment of choice [7, 8]. However, in the traumatized foot, it is the strong fascial compartment boundaries which are the least responsive to internal pressure gradients, and all authors agree on the need for a wide fascial release. Controversy exists only with regard to the length of the skin incisions.

The proponents of limited dermotomy (4 to 8 cm) cite the advantages of a decreased risk of infection, a shorter healing time, less scarring, and an easier secondary wound closure. Long incisions have been said to cause more bleeding and to affect the distal circulation in the limb by damaging the collateral vessels.

Figure 6.2. Thermic burn of the IIIA,B degree of the right shin and dorsal surface of the foot. Necrotomy was performed on the third day.

Our study confirms that the skin is a potential contributing factor in compartment syndrome.

Though we cannot predict what would have been the outcome in the foot burn with 'limited' dermotomies, this study documents the potential contribution of the skin envelope in lower extremity compartment syndrome. The use of liberal skin incisions is supported and the need for intra-operative measurement of the compartment pressures in the treatment of this condition is emphasized.

REFERENCES

[1] Gaspar, MR; Treiman, RL; Payne, JH; Rothschild, PD; Gaspard, DJ. Principles of treatment and special problems in vascular trauma. *Surg Clin N Am*. 1968, 48, 1355-64.

[2] Patman, RD; Thompson, JE; Persson, AV. Use and technique of fasciotomy as an adjunct to limb salvage. *South Med J*, 1973, 66, 1108-16.

[3] Matsen, FA III; Winquist, RA; Krugmire, RB Jr. Diagnosis and management of compartmental syndromes. *J. Bone Joint Surg*. [Am] 1980, 62-A, 286-91.

[4] Mubarak, SJ; Hargens, AR. Acute compartment syndromes. *Surg. Clin N Amer*, 1983, 63, 539-65.

[5] DeLee, JC; Stiehl, JB. Open tibia fracture with compartment syndrome. *Clin. Orthop*, 1981, 160, 175-84.

[6] Siverhus, SW; Amis, JA. A practical guide to acute compartment syndromes. *J Musculoskel Med*, 1988, 5, 88-103.

[7] Kaplan, I; White, WL. *Incisional decompression of circumferential burns Plast Reconstr Surg*, 1961; 28, 609-18.

[8] Pruitt, BA; Dowling, JA; Moncrief, JA. Escharotomy in early burn care. *ArchSurg*, 1968; 96, 502-7.

Chapter 7

NECRECTOMY OF THE FOOT

Necrectomy is an excision of dead tissues. In performing necrectomy two main aims are pursued: the excision of the burn crust, which is the source of infections and toxic complications and quicker preparation of the injuries for plastic surgery.

Burn crust is the dead covering tissues of the body due to a thermic effect. Depending on intensity and duration of the etiological factor, its content may include skin, subcutaneous fatty tissue, fascia, muscles and other materials. Dead tissue is a specific nutritious medium for micro-organisms. Together with this, depending on the type of the crust (wet or dry) development, microbe inflammation occurs at various stages. Long ago it was established that the phenomenon of intoxication and microbe inflammation in the case of dry crust were observed to be much lower than in wet necrosis. Nevertheless, only early excision of the crust makes it possible to get rid of these undesirable consequences.

In the surgical treatment of foot burns we used the classification offered by Y.I Turnikova et al. (1998). According to this classification the following types of operations, directed to extract dead tissues and to prepare the wound for plastic surgery are selected.

A. According to the initial condition of the wound.

I. Necrectomy is the excision of the burn wound, localized under the crust.

1. Primary surgical necrectomy (early necrectomy) – is the operation performed before the development of inflammation in the wound (as a rule in the first 5 days after the burn).
2. Postponed surgical necrectomy – the operation is performed after the occurrence of inflammatory signs in the wound area (and as a rule is performed more than 5 days after the initial trauma).
3. Secondary surgical necrectomy – the operation is performed after the primary or postponed necrectomy.
4. Stage by stage surgical necrectomy – the operation is performed part by part (as a rule in extensive skin injuries).

II. Excision of the wound – the method to prepare the burn wound, having no crust.

1. Excision of the wound and the method to prepare the burn wound, is a radical excision of granulations of various maturity and degree.
2. Excision of a purulent, necrotic wound in the prolonged absence of a reparative process (according to the type of trophic ulcer).
3. Excision of a cicatrizing wound.

B. According to an operative technique.

I. Tangentially – the excision of necrotic crust that pathologically exchanges non-viable tissues into viable ones, suitable for plastic surgery closure.
II. Border excision – is an employment of a vertical incision along the wound perimeter within the viable tissues.
III. Combined method.

C. According to excision depth.

I. Dermal – is an excision up to the remnants of the derma ("border line" burns of IIIA-IIIB degree)
II. Fascial – is an excision up to the defined visually viable fascia, keeping it intact
III. Fascial – muscular excision
IV. Osteonecrotomy and osteoectomy (segmentectomy).

D. According to the area of necrectomy

I. Operations on the area up to 5% of the body surface.
II. Operations on the area from 5-7% of the body surface
III. Operations on the area of more than 7% of the body surface

PLANNING OF OPERATIONS

In the process of the preparation of an operative treatment in the foot area it is necessary to solve the following problems:

- to determine the periods of starting the treatment.
- to determine a permissible scale of the operation
- to choose the method of excision.
- to solve the problem of hemostasis methods

Tangential necrectomy prevents excision of the necrosis in layers within one's own skin. This operation is possible in cases when some part of the derma is not affected. It is preferable to perform the operation between 5-7 days after getting a deep foot burn. Delay of excision for more than 8 days makes the operation difficult because the burn surface becomes soft. Hamby's knife is the best surgical tool for operations of this type. The thickness of the excised transplantation is fixed at 0.5mm. The number of the excised layers depends on the thickness of the skin where the excision is performed. One layer of 0.4-0.5 mm. thickness on the dorsal area of the foot is sufficient. Then it will be necessary to cut off several layers on the sole surface.

After tangential necrectomy it is necessary to apply an autodermo transplant, otherwise the wound dries and a crust is formed on it. If it is impossible to perform the autotrasplantation immediately, the wound may be closed for some time with a biological bandage, changed every 5-7 days.

Necrectomy by layers is performed in the total depth of the foot burn. With this method, part of the normal tissue, which could be excised in the case of performing excision up to the fascia, is preserved. The crust is excised by layers in order to cut off all of the dead tissue. If a live layer of derma is not achieved after performing the necrectomy, it is necessary to excise further until all the thrombosed vessels and fatty tissue are excised.

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I. Tangentially – the excision of necrotic crust that pathologically exchanges non-viable tissues into viable ones, suitable for plastic surgery closure.
II. Border excision – is an employment of a vertical incision along the wound perimeter within the viable tissues.
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III. Fascial – muscular excision
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D. According to the area of necrectomy

I. Operations on the area up to 5% of the body surface.
II. Operations on the area from 5-7% of the body surface
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PLANNING OF OPERATIONS

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One of the variants of layer by layer necrectomy is the excision of the dense crust at a later time in sandal burns. In this case excision is performed not to a live layer of intact tissue but to the point of the first capillary bleeding. Due to the irregularity of the burn depth in an excision of this type, a portion of the dead tissue is left on some areas and the wound surface is closed by autotransplant for further future autodermoplasty. It is necessary to note that in a necrectomy, bleeding from the burn surface may be observed. In this case the volume of blood, lost in the process of the excision of the dead tissues, may be decreased by various methods. One of the simple methods is hemodilution, performed in the preoperative period (Henley M, et al., 1993). With this method, due to a preliminary introduction of an excessive amount of fluid into the vascular stream, a specific dilution is achieved and during the operation the patient loses relatively less blood. In order to decrease the blood loss during the excision of the burn crust in the foot area other methods are used as well: one method is to elevate the position of the foot on which the necrectomy is to be performed and the other is an application of a tourniquet. The decrease of intraoperative blood loss may also be achieved by a preliminary infiltration of the foot tissues under the excised crust with an adrenaline solution (Janezic et al., 1995). During the operation traditional methods of hemostasis are also used: diathermocoagulation, bandaging of the vessels on the wound and others.

PATIENT A

Patient A. (Figure 7.1) was a 4-year-old boy admitted to the burn department of RSCUMA with the diagnosis of: Thermal burns (full thickness) of the dorsal surface of the left foot (Flame burn) of a IIIB degree. The patient is examined on the 2nd day after the burn, having recovered from burn shock. At the time of his admission to the Burn Center his general condition was satisfactory. His skin and visible mucosae were pale. His nasal breathing was easy. His heart sounds were muffled, pulse was 118 beats/min, and blood pressure was 90-60 mm/ Hg. His abdomen was soft and he was not passing urine and had no bowel movements. The examination determined that the epidermis on the dorsal surface of his foot was disrupted and covered with a black material, the wound base was pale, and there was no sensitivity. The results of the blood test at the time of admission were: hemoglobin, 120.0; hematocrit, 45.0; leukocytes, 10.3; blood coagulability, 3-4.

Treatment of the foot burn started with a Novocaine ring block (0.5%, 25 ml) which made it possible to put the injured extremity into a bath with a detergent solution without any pain. The pieces of necrotic tissue were removed with scissors and the burnt surface was treated with Rivanol or a Furacilin solution (1:5000) and the wound was covered with aseptic sterile dressing. The patient was then given some molecular and crystalloid solutions for hemodynamic stabilization, anti-toxification medications, antibiotics and analgesics. On the 12th day after the burn, a partial necrectomy of the foot was performed. The patient had undergone a blood and plasma transfusion in addition to other blood substitute transfusions.

On the 17th day granulation tissue had formed in the wound on the heel and the balls of the feet. In the arch area the wound healed naturally and then plastic surgery was performed. A graft was taken from the external surface of the patient's left hip and placed on the granulated wound. An examination was conducted on the 3rd day after the surgery. The skin was engrafted and the patient was discharged from the hospital in satisfactory condition for outpatient treatment. Physiotherapy was recommended for the patient and the second examination was performed 22 days later. The patient was in satisfactory condition, the transplanted skin had a normal color and the sole sensitivity was good. The patient was advised to continue physiotherapy and to avoid putting much pressure on the foot. The next examination was performed a month later, the transplanted skin was a normal pink color and the dorsal sensitivity was good.

PATIENT B

Patient B. (Figure 7.2) was an 18-month-old girl admitted to the burn department of RSCUMA with a diagnosis of: Thermal burns of the left shin and foot of the IIIB degree.

Treatment of the foot burn started with a Novocaine ring block (0.5%, 25 ml) which made it possible to put the patient's extremity into a bath with a detergent solution without any pain. The pieces of necrotic tissue were then removed with scissors and the burnt surface was treated with a Furacilin solution (1:5000). The wound was covered with a sterile dressing and the patient was given some molecular and crystalloid solutions for hemodynamic stabilization, anti-intoxication medications, antibiotics and analgesics. On the 12th day after the burn, a partial necrectomy of the foot was performed. The

patient had undergone a blood and plasma transfusion as well as other blood substitute transfusions.

Figure 7.1. Patient A, was a 4 -year-old boy admitted to the Burn department of RSCUMA with the diagnosis of: Thermal burns (full thickness) to the dorsal surface of left foot (Flame burn) of the IIIB degree during the process of necrectomy.

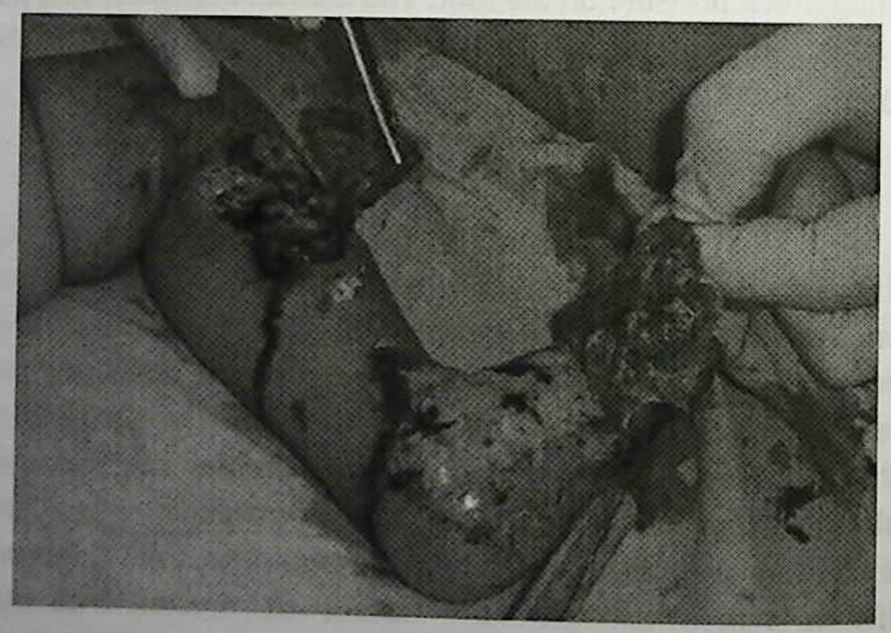


Figure 7.2. Patient B, was an 8 -month-old girl admitted to the burn department of RSCUMA with the diagnosis of: Thermal burns of the left shin and foot of the IIIB degree. During the process of necrectomy.

On the 18th day granulation tissue had formed in the wound on the heel and the balls of the feet. In the arch area the wound healed naturally, then plastic surgery was performed and a graft was taken from the external surface of the left hip and placed on the granulated wound. An examination of the patient was made on the 3rd day after the surgery. The skin was engrafted and the patient was discharged from the hospital in satisfactory condition for outpatient treatment. Physiotherapy was recommended for the patient and the second examination was performed 23 days later. The patient was in satisfactory condition, the transplanted skin had a normal color and the sole sensitivity was good. The patient was advised to continue physiotherapy and to avoid putting much pressure on the foot. The next examination was performed a month later, the transplanted skin was of a normal pink color and the dorsal sensitivity was good.

Chapter 8

APPLICATION OF AN AMNIOTIC MEMBRANE IN THE TREATMENT OF FOOT BURNS OF IIIA DEGREE

The rehabilitation of patients with foot burns is accomplished by means of complex treatment measures both medical and surgical, which are aimed at the correction of the general somatic state, prophylactics to prevent the development of joints osteoarthritis, foot phlegmon, to provide an adequate regenerative process in the burn zone, manage the cutting of dead joint segments and the preventive measures against the development of contractures.

Bacterial invasion is the most common obstacle to the healing process in a burn wound of the foot. It can be overcome in the majority of cases by the strict environmental control maintained in a burn unit, an early excision of the dead skin, and the use of an effective topical antimicrobial agent. Another less recognized factor which impairs the healing of any burn wound is the passive evaporation of water and heat loss, the rate of loss being proportional to the surface area and depth of the burn. At present, synthetic and biological coverings are used for temporary closure of the wounds. The human amniotic membrane is admirably suited for this purpose and has many advantages. An amniotic membrane as a biological dressing for thermal injuries is simple and cost effective.

The human amniotic membrane is formed from the fetal ectoderm; it therefore behaves like skin [1]. The first use of an amniotic membrane was reported by [2] Sabella in 1913, while in 1952 [3] Douglas reported on its use after extensive flame burns. The indications ranged from donor sites [4] to

clean second-degree burns [5]. Experimentally, it was evaluated to be 1000 times more effective than split thickness human skin grafts in decreasing the bacterial levels. The mechanism of the amniotic membrane's antibacterial property is not yet clear [6,7].

According to the data, the application of an amniotic membrane to the wound relieves the pain at once, stimulates granulation growth, contributes to the clearing of the wound and prevents the risk of the development of an infection.

Amnion is a thin, almost transparent membrane and consists of 5 layers: 1. the inner layer, its surface is covered by epithelium; 2. the basal membrane; 3. a compact layer; 4. fibroblasts, and 5. a spongy layer. The cytoplasm of the amnion epithelium cells contains lipids, polysaccharides, aminoglucose and also numerous enzymes such as lipase, peptidase, trypsin and also glycolytic enzymes.

Using a sterile technique, the membrane is separated from the placenta and rinsed three times in a sterile physiological saline solution. In order to dislodge the clots, the membrane is agitated thoroughly during rinsing and occasionally gauze is used to remove the clots between rinses. Next the membrane is rinsed once in a modified 0.025% solution of sodium hypochlorite. The solution rinse is followed by three more rinses with saline. After a surface culture has been taken for initial bacteriological monitoring the membrane is then transferred to a wide mouthed sterile bottle containing physiological saline, labeled, and stored in a refrigerator at 40C. The membranes are then cultured at weekly intervals and those that remain sterile are stored for a maximum period of 6 weeks and with a delivery rate of 250/year, 3-4 membranes are available at all times.

MATERIALS AND METHOD

During the period of July 1998 - May 2002, 55 patients with deep dermal burns of the foot were studied at the burn department of RSCUMA and the Inter-Regional Burn Center, Samarkand, Uzbekistan.

The causes of the burns were as follows: sandal burns in 16 patients (29.1%); flame burns in 14 patients (25.5%), scald burns in 12 patients (21.8%); hot ash burns in 5 patients (9.1%); chemical burns in 3 patients (5.4%); and other burns in 5 patients (9.1%). Among all the cases, 31 patients were under 14 years old and 19 patients were over 14 years old.

The distribution of patients between the different types of burns is presented in Table 8. 1.

Table 8.1.

Etiology of burn	Patients	%
Sandal burns	16	29.1%
Flame	14	25.5%
Scalds	12	21.8%
Hot ash	5	9.1%
Chemicals	3	5.4%
Other	5	9.1%
Total	55	100

For most patients that had deep foot burns caused by sandal heaters [8], an amniotic membrane was usually applied the burned surface of the foot on the 2^{nd} – 3^{rd} day after the trauma occurred. In accordance with the aim and problems of research, patients with dermal burns of the foot were divided into two groups.

- Group I patients are treated without an amniotic membrane dressing.
- Group II patients are treated with an amniotic membrane dressing.

All patients received the same resuscitation protocols and analgesia.

RESULTS

In order to determine the efficacy of the application of an amniotic membrane, morphological and biochemical studies of the blood and the condition of the wound were carried out and a hospital stay was determined.

The patients were divided into two groups: I and II (Table 8. 2).

In a comparison of group A patients that were treated without the application of an amniotic membrane, it has been established in the patients of group B, that the application of an amniotic membrane prevents the decrease of erythrocytes by 15%, of hemoglobin by 19%, of general proteins by 15% and shortens the periods of treatment by 30%

In spite of the subjective character of the evaluation in the application of an amniotic membrane, the patients noted an anesthetic effect and a decrease

of discharge from the wound. As soon as the amniotic membrane engrafted to the wound, its surface was cleansed daily and no other dressings were applied.

Table 8.2. Comparative results of the treatment of III A degree burns by traditional methods (group A) and an application of an amniotic membrane (group B)

No.	Comparative results	Group A (n=26)	Group B (n=29)
1	Hemoglobin	85.6±6.9**	105.6±5.7**
2	Erythrocytes	3.6±0.25**	4.25±0.3**
3	General protein	54±3.9**	63.8±2.4**
4	Healing of burn injuries	15.0±2.7	11.5±3.5
5	Hospital stay	15.0±2.7*	11.5±3.5*

Note: - * - P<0,005 ** - P<0,001– reliable difference of the index from adequate data in the previous group.

The healing of burn wounds of a IIIA degree with the application of an amniotic membrane occurred quicker by an average of 3-4 days (average meaning 11.5±3.5) in comparison with the control group (average meaning 15.0±2.7 days). In addition, the amniotic membrane made it possible to reduce the frequency of purulent complications of the burn wound by more than 2 times.

DISCUSSION

The concept of a physiological dressing dates back to 1869, when a French surgeon Reverdin used a split thickness skin graft from his own arm to cover part of the wound of a patient with an extensive burn [9]. Closure of wound defects in a timely manner is a necessary component of an adequate local treatment of patients with burn trauma. Prolonged continuation of the open area increases the risk of a secondary and serious infection and raises the probability of exhausting the body's adaptable resources due to considerable losses through the injured surface[10]. There is no doubt that the best method is autodermoplasty, which makes it possible to restore the greatest amount of skin coverage and provides favorable outcomes in an operative technique.

However in a number of cases (a severe general condition, extensive deep burns, deficiency of donor resources, unpreparedness of the wound for

autotransplantation and others) it is necessary to perform the closure of defects using different methods.

An amniotic membrane dressing should have a better chance with wider use to provide the maximum benefit to the patients with burn wounds of the foot. It was found to be cost effective as it accelerates wound healing, decreases pain and the usage of analgesics, requires less frequent dressing changes and has a decreased possibility of infections [11].

CASE REPORT

Patient A. was a 5-year old boy admitted to the burn department of RSCUMA with the diagnosis of: Thermal burns of left foot (asphalt burn).

Figure 8.1. Thermal burn of the IIIA degree of the left sole surface of the foot. The condition of the foot 3 days after the trauma.

Figure 8.2. The burn surface is covered with an amniotic membrane.

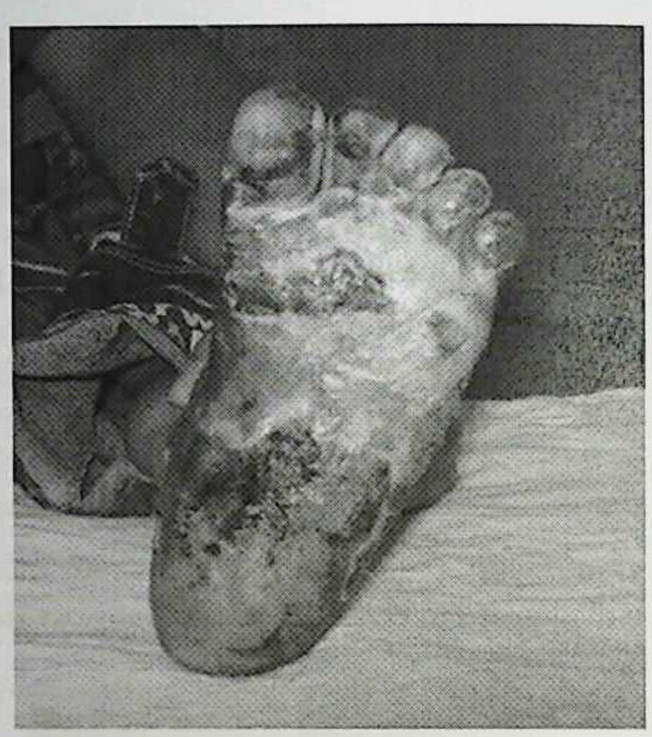


Figure 8.3. The same patient after the healing of the wound on the 10th day after amnioplasty.

REFERENCES

[1] Robert, L.& Ronald, G. (2003). Alternative wound coverage. In: Total burn care 2nd ed., Philadelphia: W.B. Saunders Company,212-7 [chapter 1].

[2] Sabella, N. (1913). Use of fetal membrane in skin grafting. *Med. Rec.* N.Y., *83*, 478-81.

[3] Douglas, B. (1952). *Journal of the Tennessee medical Association, 45*,230.

[4] Kearney J. (1996). Banking of skin grafts and biological dressing. In: "Principle and practice of burns management", John A.D. Settle (ed.), *Churchill Livingstone*, New York, 329-51.

[5] Robson, M.C., Samburg, T.J., Koss, N.& Samburg, J.L. Amniotic membranes as a temporary wound dressing. *Surgery, Gynecology and Obstetrics*, *136*, 904-6, 1973.

[6] Dovi, J., He, L-K. & Dipietro, L. (2003). Accelerated wound closure in neutrophils depleted mice. *J Leucos Biol,73*, 448-55.

[7] Dioguardi, D., De Robertis, M., Di Lonardo, A. (1990). Skin substitutes in burn treatment - our experience. *Annals Medit. Burns Club*, *3*, 265-70.

[8] Shakirov, B.M. (2004). Sandal Burns and Their Treatment in Children // *J. Burn Care Rehabilitation* (USA). Vol. *25*, November/December, N6, 501–505.

[9] Quinby, W.C.& Hoover, H.C. et al. (1982). Clinical trials of amniotic membranes in burn wound care. *Plast. Reconstr. Surg*, *70*, 711-6.

[10] Dino, B. R. et al. (1966). *Journal of the Philippine Medical Association, 42*, 357.

[11] Herndon, D.N. (2001). *Total burn care* // 2nd edition, W.B. Saunders.

Chapter 9

TREATMENT OF SEVERE FOOT BURNS

In Central Asia foot burns are widespread, because many people, especially children, walk barefoot in summer, and because the heated sandal is still used for keeping warm in the winter. At the Samarkand Inter-Regional Burn Center in Uzbekistan, the following method of treatment was developed: an initial surgical debridement of the wound, necrotomy with the application of chymotherapeutic medications and early necrectomy, the removal of the necrotic tissues and the preparation of the wound for early autodermoplasty. This effective method of treatment has contributed to the restoration of foot function in patients, lessened their joint deformities and post-burn contractures/deformities, and also shortened their hospital stay.

INTRODUCTION

The increase in incidences of burn traumas in these countries may be attributed to the high development of the power and chemical industries and also to a high number of road accidents. Scald burns to the feet and lower extremities in children are often described in the literature as the result of forced immersions. Isolated foot burns in pediatric patients were caused most frequently at home due to scalding [1, 2].

In Central Asia, and particularly in Uzbekistan, many burns occur at home due to the use of sandal heaters [3-5]. Despite improvements in the living conditions and public education efforts, the traditional heating device, called a sandal, containing live coals, is still used for heating the lower part of the human body.

Only rare papers on the problems of foot burns can be found in the available foreign and national scientific literature [6]. An insufficient coverage of this problem in the scientific literature and the frequent post-burn complications that resulted in disabilities impelled us, the staff members of the Samarkand Inter-Regional Burn Center, to carry out this study.

MATERIALS AND METHODS

During an 11-year period, (1990-2000), 149 patients with deep foot burns, where the skin did not regenerate on its own and tendons, muscles and bones were not injured (full thickness burn) or when subcutaneous fat, fasciae, muscles, and even bones were exposed (full thickness burn with deep tissue involvement) were treated in the burn department of RSCUMA and at the Samarkand Inter-Regional Burn Center. Of those 149 patients, 89 (59. 73%) patients were under 14 years old and 60 (40. 27%) patients were between 15 and 84 years old.

Most of the patients had deep foot burns that were caused by sandal heaters and most of them were children under 3 years of age who fell into the sandal heaters. In these cases, the sandal burns caused especially deep and severe injuries of tissue because of the immediate contact with the burning agent. Most of the sandal burns were circular foot burns and there were also numerous hot ash and asphalt burns. These burns occurred most often in summer because many children walk barefoot and often step onto or fall into hot ashes or asphalt through carelessness and a lack of awareness. The distribution of the patients between the different types of burns are presented in Table 9. 1.

Table 9.1. Number of patients admitted with different kinds of burns

Kinds of burns	*N*	%
Sandal burns	85	57.05
Hot ash and asphalt burns	22	14.76
Flame burns	20	13.43
Chemical burns	12	8.06
Hot metal burns	5	3.35
Other burns	5	3.35
Total	149	100

The following features characterize the pathogenesis of foot burns. First: sandal and hot ash burns were caused by direct contact between the skin and the thermal agent (live coals or burning firewood). Such burns injured not only all the skin layers, but also the underlying tissues, subcutaneous fat, fasciae, muscles, and even bones. Second, in all cases, edema of the soft tissues of the feet developed during the first 24-48 hrs after the thermal burns occurred. The edema caused vascular and nerve compression and, as a result, secondary necrosis. Because of that, the type of treatment chosen depended on the patient's general condition and also on the extent and depth of the burn trauma. For a proper diagnosis of their condition and the choice of a proper method of treatment, all the patients upon admission were examined for an acid-alkali balance of the blood, blood hemoglobin, glucose, potassium, sodium, and calcium and also for blood coagulability. All patients were also given low molecular (Stabizoli, Refortani, Rheopolyglucin) or high molecular (Polyglucin) blood-substituting solutions in addition to, crystalloid solutions and other medications that were used for hemodynamic stabilization.

Treatment of the foot burns started with a local anesthetic ring block with 0.5 % Novocain, which made it possible to put extremities into a bath of a detergent solution, without any pain (two tablespoons of the detergent "Novost" per 10-12 L. of water at 30-32 °C was used). The scraps of the necrotic tissue were removed with scissors and the burnt surface was treated with Rivanol and a Furacillin solution (1:5000). The wound was then covered with a sterile dressing. Treatment of burns should not be performed until the patient has recovered from burn shock.

The next step in the treatment of foot burns is necrotomy which is performed to prevent a secondary necrosis and to accelerate the rejection of the necrotic tissue and only done after administering a Novocaine ring block on the lower third of the shin. Necrotomy is always performed in a longitudinal direction down to the healthy tissue. After the necrotomy, the wound is covered with chymotherapeutic materials that accelerate the rejection of the necrotic tissue.

At the hospital, we observed 51 patients, whose burn surface areas were treated with chymotherapeutic solutions (Trypsin and Chymotrypsin). The wound dressings were changed every other day and antiseptic medications were used. Necrectomy was performed gradually on a small area at a time and after the initial removal of the damaged tissues, necrectomy was performed on the full depth of the necrosis. A full necrectomy was performed 6-8 days after the burn trauma if the burned surface area did not exceed 5% of the total body surface area of the patients. In the patients with extensive burns covering more

than 10% of their total body surface area, a partial necrectomy was performed. Exarticulations or amputations of toes were done as soon as the non-viability of the toes was determined. The children in those cases had sandal burns and were younger than 3-years-old. Systemic medication, antibiotics, and vitamins were prescribed to all the patients and they had received several transfusions of blood, plasma and other medications.

All these measures were taken to prepare the wound for autodermoplasty. Free skin grafting is performed on the granulated wound when the wound is completely ready for autoplastic closure [7]. The wound surface, when it is ready for plastic surgery, should be bright pink, neat, moist, with little bleeding, no edema and should be covered with a thin layer of tender, granulated tissue and without fibrotic-suppurative and necrotic tissue. The peripheral skin should not be inflamed and the wound should have minimal microflora [8].

When the wound surface was ready for surgery under general anesthesia (Callipsol, Ketamine), grafts of the skin were taken by hand or with the electro-dermatome [9]. The width of the grafts ranged from 3 to 5 cm, their length depended on the location of the donor sites, the thickness of the grafts ranged from 0.2 to 0.3 mm and grafts from the external and internal surfaces of the hip were normally used. It should be pointed out that for successful engrafting, the transplanted skin should be placed in such a way as to cover the wound surface completely, without any constraints, compression or tension. It should be sewn to the healthy skin on the edges with catgut and a splint should be used for immobilization of the foot until the transplanted skin is completely engrafted.

The first bandaging was removed on the 3rd or 4th day after the surgery and if the skin engrafted well, we proceeded with physical therapy after about the 6th day. The patients were then discharged from the hospital for outpatient treatment. It was recommended that they continue with physical therapy and the second examination was conducted 20-25 days after the surgery. After the transplanted skin becomes sensitive and there are signs of restored blood circulation, partial weight placement on the foot was allowed.

Results

The process of healing after the necrectomy was monitored. Extended wound preparation for autografting was observed in patients when chymotherapy medications had not been placed on the wound after the

necrotomy. The wounds were ready for autoplasty in 16. 10% (n=24) of patients on the 16th day, in 19. 46% (n =29) of patients on the 17th day, in 22. 15% (n=33) of patients on the 18th day, in 17. 45 % (n=26) of patients on the 19th day and in 12. 75 % (n =19) of patients on the 20th day after the burn. In 12.08% (n =18) of patients, the wound was ready for autodermoplasty more than 20 days following the burn.

Of all the patients, 78.52% (n=117) were healed after the first autodermoplastic surgery. The second autodermoplastic surgery was performed in 21. 48% (n=32) of the patients because the transplanted skin dissolved in some places which may have been caused by the patient's strong debilitation or more likely because the injured foot suffered some kind of an accidental blow or unintentional pressure.

The surgical methods described in this paper helped to improve the general condition of the patients, contributed to the restoration of their foot function, lessened joint deformities and post-burn contracture deformities and also shortened their stay in the hospital.

Discussion

Patients with deep foot burns require immediate hospital admission, a special treatment protocol and fast preparation of the injured site for skin grafting. In the hospital, we observed patients whose burn surface areas were treated with chymotherapy solutions [9]. Without the use of chymotherapy solutions, the rejection of necrotic tissue usually took 10-14 days after the burn and the wounds were ready for early autografting usually in 17 to 19 days but typically in 20 to 22 days after the burn. The specific characteristic of the sandal burn is that it induces a coagulation necrosis which requires treatment with protein dissolving agents, therefore, the autografting is possible only after necrectomy and the initial stage of granulation. Treatment with Trypsin or Chymotrypsin accelerated the rejection of necrotic tissue by three days and the early autografting was possible 14 to 16 days after the burn trauma.

The treatment of foot sole defects appearing as a result of contact burns has always been a challenge because there is always a lack of soft tissues in the foot area that can be used for free skin plastic surgery. Unlike all the other body parts, the weight bearing side of the foot needs to be covered with tissues which are able to bear up under heavy pressure. The first successful operations of this type were described by London in 1953 [10, 11].

The best materials for the repair of the foot are the parts of the sole skin which were not injured and which can be used as grafts of different sizes. Most of our patients, however, were those with sandal burns or hot ash burns who had the entire sole of their foot injured: a burnt heel, the arch of the foot, the ball of the foot and the toes. In all these cases, we tried to use one graft for covering the entire sole of the foot. The graft was therefore put lengthwise or crosscut without any pressure and was fixed on the edges to the healthy skin with sutures, the extremity was immobilized with a plaster splint until the total engraftment of the transplant was complete [12-13].

During the post-operative period special attention must be paid to the sensitivity of the engrafted skin. The problem with this is, that the transplant engrafted on the sole does not regain its sensitivity for quite a long time. The sensitivity in this area appears gradually and the engrafted skin becomes movable within 4 to 5 months.

The results of the examinations showed that within 3 to 4 years after the operation, the transplanted skin in the area of the heel, the arch of foot and the balls of foot were similar to healthy skin.

We have demonstrated the definite success in the treatment of severe foot burns in the burn department of RCSUMA and the Samarkand Inter-Regional Burn Center due to our organization of specialized medical care services, modern equipment and new medical methods of rehabilitation for burn patients.

Patient A

Patient A. (Figure 9.1) was a 1.2-year-old boy admitted to the burn department of RSCUMA with the diagnosis of: Thermal burn (full thickness) of right shin and foot from a sandal burn of the III-IV degree. The patient is examined on the 4th day after recovering from the burn shock. At the time of his admission to the Burn Center his general condition was satisfactory. His skin and visible mucosae were pale, nasal breathing was easy, heart sounds were muffled, pulse was 128-130 beats/min, and blood pressure was 80-50 mm Hg. The abdomen was soft and he was not passing urine and had no bowel movements. Examination revealed that the epidermis on the sole of the foot was disrupted and covered with a black material, the wound's base was pale, and there was no sensitivity. The results of the blood test taken at the time of admission were: hemoglobin, 130.0; hematocrit, 51.0; leukocytes, 10.3; blood coagulability, 3-4.

Treatment of the foot burn started with a Novocaine ring block (0.5%, 25 ml) which made it possible to put the extremity into a bath with a detergent solution without any pain. The pieces of necrotic tissue were then removed with scissors and the burnt surface was treated with Rivanol and a Furacillin solution (1:5000). The wound was then covered with a sterile dressing and the patient was given some molecular and crystalloid solutions for hemodynamic stabilization, as well as anti-intoxication medications, antibiotics and analgesics.

Figure 9.1. Patient A, was a 1.2-year-old boy admitted to the burn department of RSCUMA with the diagnosis of: thermal burn (IIIB degree) of the right shin and foot (sandal burn). The patient is shown on the 4th day after the burn.

On the 2nd day a necrotomy was performed and on the 10th day after the burn, a partial necrectomy of the foot was performed. On the 14th day a total necrectomy was performed and the patient had undergone a blood and plasma transfusion and also other blood substitute transfusions.

On the 21stday granulation tissue formed in the wound on the heel and the ball of the foot and in the arch area the wound healed naturally. Then autoplastic surgery was performed and a graft was taken from the external surface of the left hip and placed on the granulated wound. An examination of the patient was conducted on the 3rd day after surgery. The skin was engrafted and the patient was discharged from the hospital in satisfactory condition for outpatient treatment. Physical therapy was recommended for the patient and the second examination was performed 25 days later at that time the patient was found to be in satisfactory condition. The transplanted skin had normal color and the sole sensitivity was good. The patient was advised to continue physical therapy and to avoid putting much pressure on the foot. The next

examination was performed after a month, the transplanted skin was of a normal pink color and the sole sensitivity was good (Figure 9.1)

Patient B

Patient B (Figure 9.2, 3) was a 1.5-year-old boy hospitalized in the Burn Center with the diagnosis of : a sandal burn (full thickness) of both the shin and foot of the IIIB-IV degree, and suffering from burn shock. At the time of admission to the Burn Center his general condition was satisfactory. His skin and visible mucosae were pale. His nasal breathing was easy, heart sounds were muffled, pulse was 118-124 beats/min, and blood pressure was 80-50 mm Hg. The abdomen was soft and he was not passing urine and had no bowel movements. Examination of the patient revealed that the epidermis on the sole of the foot was disrupted and covered with a black material, the wound's base was pale, and there was no sensitivity. The results of the blood test taken at admission were: hemoglobin, 130.0; hematocrit, 51.0; leukocytes, 10.3; blood coagulability, 3-4.

Figure 9.2. Patient B, 19 days after burn trauma. The wound is ready for autodermoplastics.

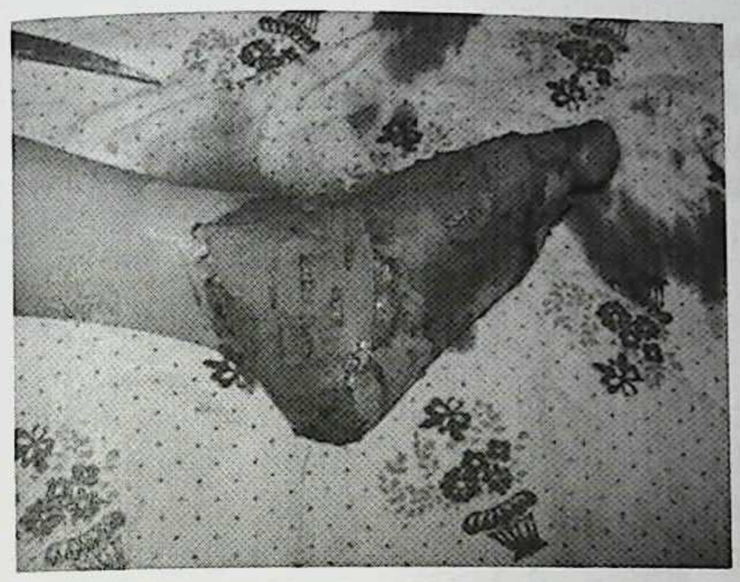


Figure 9.3. Patient B, The patient's wound after autodermoplastics.

Local treatment of the foot burn started with a Novocaine ring block (0.5%, 25 ml) which made it possible to put the extremity into a bath with a detergent solution without any pain. The pieces of the necrotic tissue were removed with scissors and the burnt surface was treated with Rivanol and a Furacillin solution (1:5000). The wound was covered with a sterile dressing and the patient was given some molecular and crystalloid solutions for hemodynamic stabilization, as well as anti-intoxication medications, antibiotics and analgesics.

On the next day a necrotomy was performed and after the necrotomy the wound was covered with a chymotherapeutic material containing Trypsin that accelerated the removal of the necrotic tissue.

On the 7^{th} day after the burn, a partial necrectomy of the foot was performed and on the 10^{th} day, a total necrectomy was performed. The patient had undergone a blood and plasma transfusion and also other blood substitute transfusions.

On the 18^{th} day granulation tissue formed in the wound on the heel and the ball of the foot and the arch area of the wound healed naturally. Then autoplastic surgery was performed and a graft was taken from the external surface of the left hip and placed on the granulated wound. An examination of the patient was conducted on the 3^{rd} day after surgery. The skin was engrafted and the patient was discharged from the hospital in satisfactory condition for outpatient treatment. Physiotherapy was recommended forth patient and the second examination was performed 20 days later. The patient was in a satisfactory condition, the transplanted skin had a normal color and the sole

sensitivity was good. The patient was advised to continue physiotherapy and to avoid putting much pressure on the foot. The next examination was performed after a month, the transplanted skin was of a normal pink color and the sole sensitivity was good (Figure 9.2.3).

Patient C

Patient C. (Figure9.3) was a 68-year-old women admitted to the burn department of RSCUMA with the diagnosis of: Thermal burn (full thickness) of the shin and right dorsal surface of the foot of the IIIA,B degree. The patient is examined on the 2nd day after the burn, having recovered from the burn shock. At the time of her admission to the Burn Center her general condition was satisfactory. Her skin and visible mucosae were pale, nasal breathing was easy, heart sounds were muffled, pulse was 102 beats/min, and blood pressure was 140-90 mm Hg. The abdomen was soft and she was not passing urine and had no bowel movements. Examination of the patient revealed that the epidermis on the dorsal surface was disrupted and covered with a substance, the wound's base was pale, and there was no sensitivity. The results of the blood test at the time of admission were: hemoglobin, 130.0; hematocrit, 51.0; leukocytes, 10.3; blood coagulability, 3-4.

Treatment of the foot burn started with a Novocaine ring block (0.5%, 25 ml) which made it possible to put the extremity into a bath with a detergent solution without any pain. The pieces of necrotic tissue were then removed with scissors and the burnt surface was treated with Rivanol and a Furacillin solution (1:5000). The wound was covered with a sterile dressing and the patient was given some molecular and crystalloid solutions for hemodynamic stabilization, as well as anti-intoxication medications, antibiotics and analgesics.

On the 10th day after the burn trauma, a partial necrectomy of the foot was performed and on the 14th day, a total necrectomy was performed. On the 22nd day granulation tissue formed in the wound on the heel and the ball of the foot and the arch area of the wound healed naturally. Then autoplastic surgery was performed and a graft was taken from the external surface of the right hip and placed on the granulated wound. An examination was conducted on the 3rd day after the surgery. The skin was engrafted and the patient was discharged from the hospital in satisfactory condition for outpatient treatment. Physical therapy was recommended for the patient and the second examination was performed 18 days later. The patient was in a satisfactory condition, the transplanted skin

had a normal color and the sole sensitivity was good. The patient was advised to continue physiotherapy and to avoid putting much pressure on the foot. The next examination was performed after a month. The transplanted skin was of a normal pink color and the sole sensitivity was good (Figure 9.4).

Figure. 9.4. Thermal burn (full thickness) of the shin and dorsal surface of the right foot IIIA,B degree. The patient is shown on the 14th day after the burn.

REFERENCES

[1] Zachary et al. (1987). Burns to the feet. *J. Burn Care Rechab*, *8*(3), 192-194.

[2] Shah, B. R. (2002). Burns of the feet. Clin Paediatr Med Surg, *19*(l), 109-23.

[3] Shakirov, B. M. (2004). Sandal burns and their treatment in children. J Burn Care Rehabil, *25*, 501-505.

[4] Shakirov, B. M., Tagaev, K. R. & Tursunov, B. S. et al. (2007). *Surgical Treatment of Contact Severe Foot Burns in Children* // 12th Congress of EBA, Budapest, Hungary, 12–15 September, 6.

[5] Shakirov, B. M. & Tursunov, B. S. (1992). *Deep foot burns* (based on data from the Samarkand Burn Center). In: Paper presented at the International Conference on Severe Burns, 176-7.

[6] Brigham, P. A. & McLoughlin, E. (1996). Burn incidence and medical care use in the United States: estimates, trends, and data sources. *J Burn Care Rehabil*, *17*, 95-107.

[7] Vikhriev, B. S. & Burmistrov, V. M. (1981). Prognosis of the outcome of burns. *Khirurgia (Moscow)*, *5*, 43-8.
[8] Centers for Disease Control and Prevention. (2001). *Leading causes of death reports*. Available at: webapp.cdc.gov/sasweb/ncipc/leadcaus.html. Accessed October 19.
[9] London, P. S. (1953). The burned foot. *Br J Surg*, *40*, 293-304.
[10] Ariev, T. Y. & Levkevich, G. (1967). *Thermal burns*. Leningrad: Meditsina.
[11] Tursunov, B. S. (1986). *Prophylaxis and surgical treatment of bums in children*. In: Collection of Scientific work. Modern issues of local surgery. Moscow: Meditsina, 199-204.
[12] Bivik, R Shah (2002). *Burns of the feet, Clinics in Podiatric Medicine And Surgery*, Vol. *19*, Issue 1, Pages 109-123.
[13] Atyasov, H. N. (1972). *Plastic surgery*. Moscow: Meditsina.

Chapter 10

EARLY EXCISION AND GRAFTING OF THE FOOT

Only isolated articles on the problem of foot burns can be found in the available foreign and national scientific literature. It is necessary to mention that deep foot burns often occur in Central Asia since many natives still use an ancient means of heating called a 'Sandal' during the winter months. Eighty-four patients with severe foot burns were treated in the burn department of RCSUMA and at the Inter-Regional Burn Center, Uzbekistan. The patients were subdivided into two groups, depending upon the methods of operative intervention.

There was no special allocation of patients to the groups. Criteria for the selections were isolated deep burns of the foot. To characterize the thermic trauma, the area of the deep burn and the severity of the injury, patients from the control and the basic groups were represented.

The first group included 34 patients on whom early excision was done using a skin graft, after anti-shock therapy and 4–5 days after resuscitation. The second group consisted of 50 patients who were treated in the traditional way. The methods used on the first group, described in this article, helped to improve the general condition of the patients, contributed to the restoration of their foot function, lessened their joint deformities and post-burn contracture deformities, shortened their stay in the hospital and also reduced their expenses.

INTRODUCTION

Although researchers [1] had recognized as early as 1947 that prompt eschar removal and immediate wound closure could improve the outcome in burn injuries, application of this approach to large burns had not been practical before the 1970's because of an associated high rate of infection, bleeding complications and wound failure. Many burn units then adopted the excision technique [2], which was a single tangential slice that was intended to remove the superficial layer of second-degree injuries. The application of this tangential excision method to superficial injuries by most surgeons had been frustrated by the excessive blood losses that accompanied its use in large burns and those burns with full-thickness depths. The development of effective topical antimicrobials and systemic antibiotics in the 1960's, combined with hypotensive anesthetic techniques and other blood-conservation measures, allowed prospective, but non-randomized, clinical trials to be conducted. In these studies [3], improvements in the survival rate and length of a patient's hospital stay were seen and as a result of these encouraging outcomes this surgical approach was promoted.

Only isolated articles on the problem of foot burns can be found in the available foreign and national scientific literature [4, 5]. The foot is normally protected by footwear, and thus does not have as high an occurrence of burns as the hands and face. It is necessary to mention that deep foot burns mostly occur in Central Asia since many indigenous people still use an ancient means of heating called a 'Sandal' during the winter months. Sandal burns are always very heavy, severe, deep burns that are followed by serious complications, such as charred bones, especially of the low foot joints [6, 7]. Rehabilitation of these patients with deep foot burns is done by means of complex treatment protocols, both medical and surgical, which are aimed at the correction of the general somatic state, the use of prophylactics to prevent development of joint osteoarthritis and, foot phlegmon, providing an adequate regenerative process in the burn zone, the methods for cutting the dead joint segments and measures to prevent the development of contractures and deformities.

Treatment of these burns with early excision and grafting is reported to have improved burn trauma patient outcomes significantly since its inception. Early excision reduces the mortality rate in burn patients without inhalation injury and shortens the hospital stays for all burn patients [8-10]. Summing up the above-mentioned reasons, the investigation of efficient treatment methods for deep foot burns is of great importance today. There are no options for deep burns; the only treatment method is surgery. Patients with deep foot burns require immediate hospital admission, special treatments and fast preparation of the injured site for skin grafting.

MATERIAL AND METHODS

During a 5-year period, 84 patients with severe foot burns – when the skin was not regenerating on its own and tendons, muscles and bones were not injured (full-thickness burn) – were treated in the burn department of RCSUMA and at the Inter-Regional Burn Center, Uzbekistan. The causes of the burns were as follows: sandal burns, in 56 patients (66.67%); flame burns, in eight patients (9.52%); scald burns, in seven patients (8.33%); hot ash burns, in five patients (5.95%); chemical burns, in three patients (3.57%); and other burns in five patients (5.95%). Among the 84 cases, 41 patients were under 14 years of age and 53 patients were over 14 years of age (Table 10.1).

Most patients had deep foot burns caused by sandal heaters. In these cases, the sandal burns caused especially deep and severe injuries of tissue because of the immediate contact with the burning agent. Most of the sandal burns were circular foot burns. The distribution of the patients subject to burn localization is given in Table 10.2.

In accordance with the aim and problems of research in this area, the patients with deep burns of the foot were divided into two groups, depending upon the methods of the operative intervention. There was no special allocation of the patients to the groups. The criteria for the selections were isolated deep burns of the foot. Patients of the control and basic groups were correlated according to the character of the thermic trauma, the area of deep burn and the severity of the injuries.. For evaluation of the effectiveness of the various methods of surgical treatment, three main indexes were determined: the average term of the rehabilitation of the skin covering, the frequency of postoperative complications (lysis of transplants) and the follow-up results of the treatments. The patients were divided into two groups:

The first group (main group) included 34 patients, admitted during the first 3 days and nights from the moment when the trauma occurred. For the proper diagnosis of their condition and the choice of a proper treatment method, all the patients upon admission were examined for an acid–alkali balance of the blood, blood hemoglobin, glucose, potassium, sodium and calcium levels. After anti-shock therapy for 4–5 days until the period of faster appearance of separation and scab tear away, the early necroectomy was performed on no more than 4–5% of the body area with the help of disk

dermatomy. The depth of the necrotic tissue incision depended upon the burn degree: of a IIIB degree burn within the epidermis adipose tissue, of the IV degree of the fascia or by a cut of the deeper layers of soft tissue. After an early excision, we postponed the immediate non-perforated skin graft. The thickness of grafts ranged from 0.2 to 0.3 mm., and grafts from the external and internal surfaces of the hip were normally used. The first bandage was removed on the 2nd or 3rd day after the surgery. If the skin engrafted well, we proceeded with physical therapy after the 6th day then the patients were discharged from the hospital for outpatient treatment. They were advised to continue physical therapy.

The second control group included 50 patients who were treated in the traditional manner in the burn department of RSCUMA and at Samarkand Inter-Regional Burn Center. From the moment the patients were admitted to the hospital, they underwent the following surgical treatments: a necrotomy was performed to prevent a secondary necrosis and to accelerate the rejection of the necrotic tissue. The necrotomy was always performed in a longitudinal direction down to the healthy tissue and after the necrotomy, the wound was covered with chymotherapeutic materials (trypsin and chymotrypsin) that accelerated the rejection of the necrotic tissue. The wound dressings were changed every other day and after initial removal of the damaged tissues, a necrectomy was performed on the full depth of the necrosis. A complete necrectomy was performed 10 to 14 days after the burn and free skin grafting was performed on the granulated wound once the wound was completely ready for autoplastic closure. The wound surface, when it is ready for plastic surgery, should be bright pink, neat, moist, with little bleeding. The wounds were ready for autoplasty 18 to 22 days after the burn. The thickness of grafts ranged from 0.2 to 0.3 mm. and grafts from the external and internal surfaces

Table 10.1.The distribution of patients with different kinds of burns

Kind of burns	No	%
Sandal burns	56	66.67
Flame burns	8	9.52
Scalds	7	8.33
Hot ash	5	5.95
Chemical burns	3	3.57
Other burns	5	5.95
Total	84	100%

Table 10.2.Burn localization

Burn localization	Deep burn	Total %
Back of the foot	18	21.43
Sole	27	32.14
Combined burn	39	46.43
Total	84	100%

of the hip were normally used. The first bandage was removed on the 3rd or 4th day after the surgery and if the skin had engrafted well, we proceeded with physical therapy about 6 days after the surgery.

RESULTS

In the first group: after an early excision and the placement of an autograft, the development of early infectious complications is prevented, that results in a shorter period of time, only 10 to 15 days, for the skin to recover. Lysis of transplants results not only in the uncovering of already closed wounds and a loss of the transplants, but also in an extension of the injured surface due to the creation of the donor areas. Even a small lysis area can significantly increases the period of rehabilitation of the skin, because they require recurrent autodermoplasty and a prolonged conservative treatment.

The second operation was performed on 3 patients (8.82%) because the transplanted skin had dissolved in some places. Complete rehabilitation of the skin covering provided the engraftment of transplants, donor injuries and the epithelization of superficial burns. As a rule, the skin covering rehabilitation coincided with the patients' discharge from the hospital and our observation of 16.0 9 ± 3.2 days.

In the control group: those who were treated in the traditional manner (50 patients) were to recover the skin cover in 20 to 22 days. The second autodermoplastic surgery was performed on 11 patients (22.0%). The causes of transplant lysis were: suppuration of the injuries, hypoproteinemia, exhaustion and application of high rates of flap perforations. Patients remained in the hospital on average for 25 to 30 days. Complete rehabilitation of the skin covering of the control group provided a 'closure' of cells because perforated flaps were used for these patients.

Analysis of the results from the first group over a period of 1 to 5 years, showed that 7 out of 34 patients came back to the hospital for new surgery

because of the loss of their ability for normal movement of their extremities. From their medical histories, we discovered that the patients did not follow the doctors' postoperative recommendations (physical training, physical- therapy procedure, massage, limiting the amount of weight placed on the foot, etc.). In 4 patients (11.76%) of the main group, contractures of the toes of a I–II degree were observed and they underwent recurrent surgeries.

The second group showed that 16 out of 50 patients came back for new surgery, because of growth and retraction of grafts and foot contractures of the II–III degree. Analysis of the follow-up results in the control group showed that 17 (34.0%) were children with foot contractures of the I–II–III degree that developed due to the growth and retraction of the transplants that required planned operative treatment; in 7 (14.0%) adults, long courses (8–12 months) of conservative treatment were carried out. Comparative analysis of the present and future treatment results of patients with different kinds of burns is presented in Table 10. 3.

The surgical methods, an early excision and immediate skin graft helped to improve the general condition of the patients, contributed to the restoration of their foot functions, lessened their joint deformities and post-burn contractures and deformities, shortened their stay in the hospital and also reduced their expenses.

DISCUSSION

The achievements of science and medical practice during the last few years have contributed much to the treatment of patients with critical and supercritical burns that earlier would have been considered incurable [11]. The expansion of the knowledge on the pathogenesis of burn illnesses and the introduction of new sophisticated medical technologies in diagnostics and treatment have led to a decrease of fatalities among serious patients. It should be mentioned that at present staying alive is not considered to be the only criterion in evaluating treatment, as the number of patients and invalids who need long term care has increased recently [12–15].

Patients with foot burns suffer not only physically but also mentally, they have neuroses which lead to reticence, they live a secluded life and can develop an inferiority complex. This influences their personality and the future social adaptation of the patient. It is necessary to mention that deep foot burns mostly occur in Central Asia during the winter months as many natives still use an ancient means of heating called a 'Sandal'. Sandal burns are

characterized by more severe, deep tissue injuries, and by carbonization of the distal parts of the lower extremities [16].

Table 10.3. Results

No	Results	Group I (P=34)	Group II (P=50)
1	operation term	4.72 ± 0.4*	19.1 ± 2.0*
2	Wound complications	3	11
3	Bed - days	16.09 ± 3.0*	30.3 ± 5.3*
4	Complications in the nearest after operation period	7	16

Note. * - P<0,05– by comparing with control group.

The consequences of thermal burns depend upon the trauma agent and the wound location. The outer defects and a functional breach of the foot depend upon the area and the depth of the burn wounds [17]. Patients with deep foot burns require immediate hospital admission and special treatment. At the early treatment stage of the foot injured by thermal wounds, we used physiotherapy to speed the regeneration process and reduce the inflammatory process, in order to create a condition to block the formation of hypertrophical scars and post burn contractures and deformations. The wide range of rational surgical tactics, medical and physical training and physiotherapy create favorable conditions to reduce the development of foot scar deformations and contractures. The treatment of foot defects appearing as a result of contact burns has always been a challenge because there is always a lack of soft tissues in the foot area that could be used for free plastic surgery. The materials for repairing the foot are the parts of the sole and the dorsum skin which are not injured and which can be used as grafts of different sizes [18-21]. Most of our patients were those with sandal burns with the entire foot injured. In all cases, we tried to use one graft for covering the foot injury. After recovery of the skin cover and discharge from the burn department, the patient must continue with physical therapy on an outpatient basis.

The main purpose of the physical therapy is to rehabilitate the foot function, to prevent the development of contractures and to lower the risk of complications. Physical therapy must be done carefully and individually based on each patients needs and movements must be slow and stretched. Physical training must be done 2 or 3 times a day for 30 or 40 min, and also after discharge from the hospital up to the time of a full growth and formation of the return scar.

We have demonstrated visible success in the treatment of severe burns in the burn department of RSCUMA and at the Samarkand Inter-Regional Burn Center, thanks to our organization of specialized medical services and new medical methods of rehabilitation for burn patients.

Patient A. (Figure10.1) was a 36-year-old women admitted to the burn department of RSCUMA with the diagnosis: Thermal burn to the dorsal surface of the right of the foot of the IIIB degree. The patient is examined on the 2nd day after the burn and having recovered from the burn shock. At the time of admission to the Burn Center her general condition was satisfactory. Her skin and visible mucosae were pale. Her nasal breathing was easy. Heart sounds were muffled, pulse was 90 beats/min, and blood pressure was 100-70 mm / Hg. The abdomen was soft. She was not passing urine and had no bowel movements. An examination revealed that the epidermis on the dorsal surface of the foot was disrupted and covered with a material, the wound's base was pale, and there was no sensitivity. The results of the blood test upon admission were: hemoglobin, 110.0; hematocrits, 45.0; leukocytes, 10.3; blood coagulability, 3-4.

Local treatment of the foot burn started with a Novocaine ring block (0.5%, 25 ml) which made it possible to put the extremity into a bath with a detergent solution without any pain. The pieces of the necrotic tissue were removed with scissors. The burnt surface was treated with Rivanol and a Furacillin solution (1:5000). The wound was covered with a sterile dressing. The patient was given some molecular and crystalloid solutions for hemodynamic stabilization, as well as anti-toxification medications, antibiotics and analgesics.

Figure 10.1. The patient is foot on the 4th day after hospitalization. The foot after an early necrectomy, the wound was ready for autodermoplastic surgery.

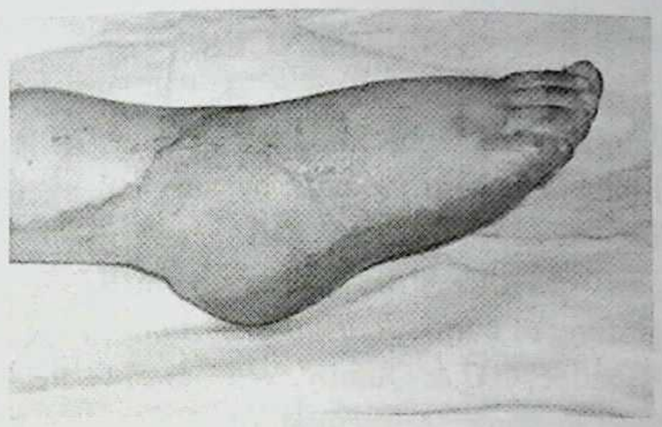


Figure 10.2. After the free autodermoplasty with a non-perforated skin transplant.

On the 4th day after the burn, early necrectomy is performed and the wound is covered by a non-perforated skin transplant. A graft was taken from the external surface of the right hip and placed on the granulated wound. A control examination was made on the 3rd day after surgery. The skin was engrafted. The patient was discharged from the hospital in satisfactory condition for outpatient treatment. Physical therapy was recommended to the patient and the second examination was performed 11 days later. The patient was in a satisfactory condition. The transplanted skin had normal color and the sole sensitivity was good. The patient was advised to continue physical therapy and to avoid putting much pressure on the foot. The next examination was performed a month later. The transplanted skin was of normal pink color and the sole sensitivity was good

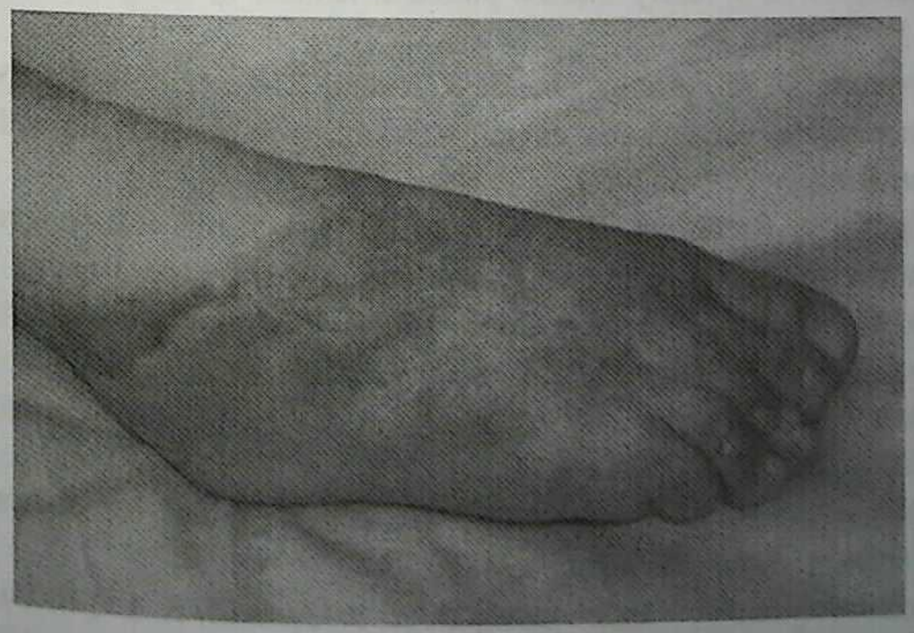


Figure 10.3. 8 months after the operation result.

REFERENCES

[1] Cope, O., Laugohr, H., Moore, F.D.& Webster, R. (1947). Expeditious care of full-thickness burn wounds by surgical excision and grafting. *Annals of Surgery*, *125*, 1-22.

[2] Janzekovic, A. (1970). A new concept in the early excision and immediate grafting of burns. *Journal of Trauma*, *10*, 1103-1108.

[3] Burke, J.F., Bondoc, C.C.& Quinby, W.C. (1974). Primary burn excision and immediate grafting: A method of shortening illness. *Journal of Trauma*, *14*, 389-395.

[4] Brigham, P. A. & McLoughlin, E. (1996). Burn incidence and medical care use in the United States: estimates, trends, and data sources. *J Burns Care Rehabil*, *17*, 95–107.

[5] London, P. S. (1953). The burn foot. *Br J Surg*, *40*, 293–304.

[6] Shakirov, B. M. & Tursunov, B. S. (2005). Treatment of severe foot burns in children. *J Burns*, *31*(7), 901–5.

[7] Shakirov, B. M. (2004). Sandal burns and their treatment in children. *J Burn Care Rehabil*, *25*, 501–5.

[8] Thompson, T., Herndon, D. N., Abston, S. & Rutan, T. (1987). Effect of early excision on patients with major thermal injury. *J Trauma*, *27*, 205-7.

[9] Herndon, D.N., Barrow, R.E., Rutan, R.L., Rutan, T.C., Desai, M.H.& Abston, S. (1989). A comparison of conservative versus early excision: Therapies in severely burned patients. *Annals of Surgery*, *209*(5), 547-553.

[10] Herndon, D. N., Barrow, R. E. & Rutan, R. L. (1989). Comparison of conservative versus early excision therapies in severely burned patients. *Ann Surgery*,*209*, 547–53.

[11] Bogdanov, S. B., et al. (2004). Plastic Q5 by non-perforated skin autotransplants after the early necrectomy. In: Med J (mat. VIII All-Russia Scientific Practical Conference with International Participation. *Problems of Treatment of Severe Thermal Trauma*, 138–9.

[12] Ramzy, P. I., Barret, J. R. & Herndon, D. N. (1999). Thermal injury. *Crit Care Clin*, *15*(2), 333–52.

[13] Paramonov, B. A. et al. (2000). BURNS. Manual for doctors. *Saint-Petesburg: Special Literature*, 488.

[14] Stefanacci, H. A., Vandevender, D. K. & Gamelli, R. L. (2003). The use of free tissue transfers in acute thermal and electrical extremity injuries. *J Trauma*, *55*, 707–12.

[15] Azolov, V. V. et al. (2002). Main tendencies of thermal injury dynamics in Russia and treatment results of burns for the last twenty years. In: Mater. of International. Conference "Actual problems of Thermal Trauma", 28–30.

[16] Kesiktal, E. & Meten, Y. et al. (2006). Use of cross-leg latissimus dorsi free flap for repair of extensive lower leg electrical injury in a child. *J Burns*,*32*, 507–10.

[17] Dmitriev, G. I. & Dmitriev, D. I. (2006). Surgical methods of rehabilitation of patients with burns and its complications. In: First Medical Aid Mater. of International conference. *Actual Problems of Thermal Trauma*, vol. *3*, 228–9.

[18] Shakirov, B.M., Tursunov, B.S.& Tagaev, K.R. (2006). Treatment of sandal burns in children. *British Trauma Society Annual Clinical Meeting/Abstract book*, October 12–13, 0145.

[19] Mooney, J. F., De Fanzo, A. & Marks, M. W. (1998). Use of cross-extremity flaps stabilised with external fixation in severe pediatric foot and ankle trauma. *J Pediatric Orthop*,*18*, 26–30.

[20] Scheflan, M., Nahai, F. & Hartrampf, C. R. (1981). Surgical management of heel ulcers-a comprehensive approach. *Ann Plast Surg*, *7*, 385–406.

[21] Yudenich, V. V. & Grishkevich, V. M. (1986). *Guide to the rehabilitation of burnt patients*. Moscow: Medicine; 324–344.

Chapter 11

SANDAL BURNS OF THE FOOT

The sandal is an ancient, primitive heating device that is still in use by both poor and rich people in mountainous areas of Middle Asia. Sandal burn injuries are a serious health problem. The characteristics of sandal burns of the foot include not only skin injuries of various depths but also injuries to the underlying tissues: subcutaneous fat, fasciae, muscles, and even bones. Sandal burns are characterized by such severe deep injuries because of the close contact of the body with the live coal or the wood. The main goal of this work is to present the most complete information about sandal burns of the foot and discuss the most effective methods of treatment for sandal burns. This treatment is used to accelerate the rejection of the necrotic tissue, to prepare the wound for early autodermoplastic surgery, to decrease the post burn contractures and deformities, and also to shorten the hospital stay for the patients.

INTRODUCTION

An effective but potentially dangerous heating system, the sandal, is still used in some regions of Middle Asia. The sandal is an ancient, primitive heating device that is used by both the poor and rich people. Even today this traditional system is used, especially in the mountainous areas, for heating the lower part of the human body. A hole is made in the floor in the central part of the room, approximately 60 X 60 X 60 cm in. size, for specially prepared live coals (Figure 11.1, 2).

A square wooden table is placed over this hole and covered with a large, warm blanket with the ends trailing on the floor.

In cold weather, people of all ages sit around the table, called a sandal, with their feet under the blanket, talking, drinking tea, and eating (Figure 11.3).

In those cases, when the children sit side by side with the adults, they are not endangered. However, children, especially toddlers, when left unsupervised, can crawl under the blanket and fall into the coals (11. 4).

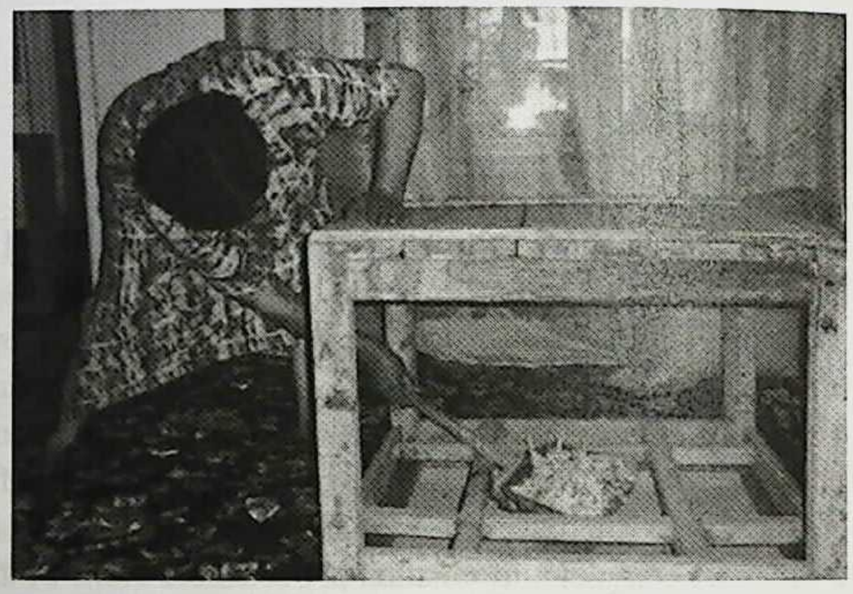


Figure 11.1.

Figure 11.2.

Figure 11.1, 2. Women specially preparing live coals for sandal heating system.

Figure 11.3. People of all ages sit around the table.

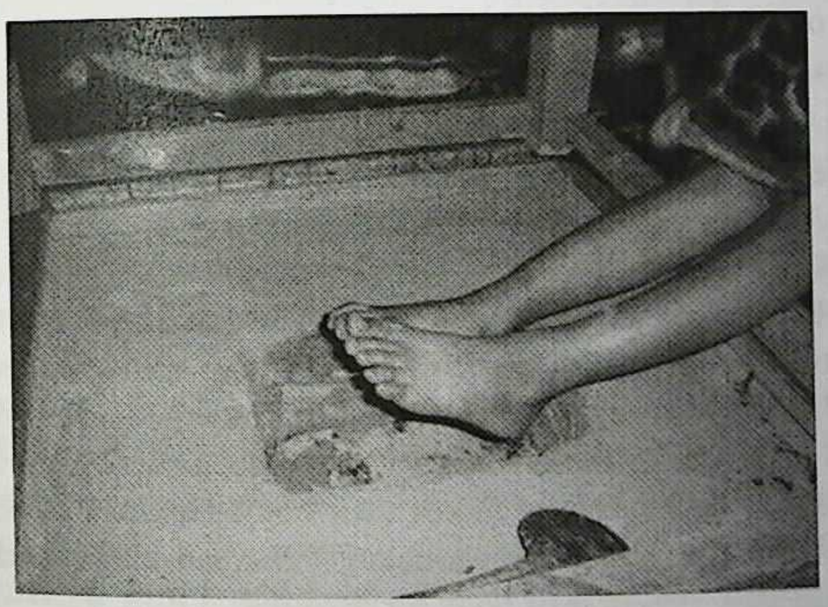


Figure 11.4. Children, can crawl under the blanket and fall on the coals.

As a result, they can suffer severe burns followed by serious complications, such as contractures and amputations.

In the case of sandal burns of the foot, it is usually not only the skin that is injured but also underlying tissues: subcutaneous fat, fasciae, muscles, and even bones [1-4].Another feature of sandal burns is their predominant localization on the distal segments of the extremities followed by serious post burn scar deformations. This localization is what makes sandal burns and their

complications one of the most complex research and practical problems in traumatology, orthopedic and pediatric surgery.

During the last 15 - 20 years, researchers have studied many aspects of the pathogenesis of the burn disease and its complications [5, 6]. As a result, incidences of disability and mortality have been reduced. Many researchers believe that burn disease development is more severe in children than in adults because of children's undeveloped physiological repair mechanisms, morphological incompleteness, and the immaturity of their organs, as well as their intensive metabolism. The epidermis of children, especially in those aged 3 years and younger, is much thinner than that of adults [7]. As a result, children's burn injuries are more severe than those suffered by adults. To improve our knowledge, this article presents the first detailed description of the sandal burns and their treatment in children.

METHODS

During a 10-year period (1992-2001), 114 patients with severe sandal burns of the foot were treated at the Samarkand Inter-Regional Burn Center, Uzbekistan. Of these, 19.3% (n = 22) of the patients were younger than 1 year of age, 57% (n = 65) of the patients were between 1 and 3 years of age, 9.6% (n = 11) of the patients were between 3 and 5 years of age, 5.3% (n = 6) of the patients were between 5 and 10years of age, 3.5% (n = 4) of the patients were between 10 and 14 years age, and 5.3% (n = 6) of the patients were from 15 to 76 years of age. Among those admitted to the hospital, 28 (24.6%) patients presented severe burns covering 5% of their body's surface area, 64 (56.1%) patients with burns covering approximately 10%, and 22 patients with burns covering more than 10% of their body surface area.

Of the 114 patients admitted to the hospital 64.9 % (n = 74) were in shock. All other patients, transferred from other regional hospitals, had toxemia. On admission of these patients, blood analyses were conducted for a proper diagnosis. Hemoglobin content, hematocrit volume, blood coagulability, and the presence of trace substances were tested. If needed, the clinicians administered a urinalysis and other tests.

The burn surface of each patient was covered with sterilized materials. The patients who were in shock received an initial treatment of burn wounds only when they had recovered from the burn shock. All patients were given high- and low-molecular blood substitutes, 0.9% sodium chloride for correction of their water-salt metabolism, 5% glucose, and other drugs.

The main methods of total and local treatment of severe burns of the foot in addition to other effective methods, included necrotomy, necrectomy, amnion - shell covering, homograft plastic surgery, autodermoplasty, and the surgical removal of postburn scar deformities. Necrotomy and necrectomy are important when preparing a wound for autodermoplastic surgery.

The characteristics of the sandal burns of the foot include coagulation necrosis because of the contact with live coals, circular vascular and nerve compression and, as a result, a secondary necrosis. To prevent this, the patients with recent burns were treated with necrotomy. Chymotherapeutic materials were placed on the wound surface to accelerate the rejection of the necrotic tissues.

Necrectomy was performed as early as 7 - 10 days after the burn incident if the burned surface area did not exceed 5% to 7% of the patient's total body surface area. In patients with extensive burns, that is, covering more than 10% of their total body surface area, a partial necrectomy was performed. We limited ourselves to exarticulation or amputation of toes and also to excision of deep foot necrosis. As a result, the duration of the necrotic tissues rejection was diminished.

Fifty-one (50%) of the patients had an amniotic membrane shell covering and homograft-replacement surgery. We used homografting when a child had a hard necrectomy and we wanted to avoid additional trauma by removing an autotransplant. We also did homografting when the necrosis was not totally removed, and we were not sure that an auto skin graft would survive.

We normally placed skin grafts on the granulation tissue, according to Tursunov B.S. et al, [8, 9] when a wound was completely ready for autograft closure. It is believed that the wound surface, when well prepared for plastic surgery, is bright pink, neat, moist, with little bleeding, and without edema. It should be covered with a thin layer of tender, fine-grained granulation tissue without any fibrose, suppurative and necrotic films. It should have a marked border of peripheral epithelization without inflammation and with minimal micro flora [10].

We removed the grafts with a dermatome [11].The width of the grafts ranged from 3 to 5 cm., their length depended on the location of donor sites, and their thickness was 0.2 to 0.3 mm. If the burn area was more than 6% to 8% of the total body surface area, an interval of 2to 3cm was left between the grafts. Later, these intervals were filled in with new epithelium that was grown on the grafts. This allowed coverage to take place on a larger body surface area. We did not leave any intervals between the grafts when the wound area did not exceed from 5% to 8% of the total body surface area. The first

autografting was performed 3 - 6 weeks after the trauma depending on the wound area. If the recovery of donor sites was smooth, the second auto grafting surgery was performed 2 weeks after the first.

RESULTS

Of all the patients, 86 % (n = 98) were healed after the first autodermoplastic surgery. The secondary autodermoplastic surgery was performed on 14 % (n = 16) of the patients because their wound surface area covered more than 10% of the total body surface area. In 14% (n = 16) of the patients, the transplanted skin dissolved in some places. These patients also had a second surgery. Of all the 29 surviving patients, 8% (n = 34) came back after treatment and burned skin restoration to the hospital for a new surgery because they had lost the ability to exercise normal movement of their affected extremities. Complications, especially in the fingers and joints, were as follows: contractures, ulcerating scars, complete and partial dislocations, and growth aberrations. Of all 26 complications,5% (n = 9) were contractures 1 year after burn, 50% (n = 17) were contractures 5 years after burn, 23. 5% (n = 8) were contractures 9 years after burn.

We performed 51 reconstructive surgeries on 37 patients. Of all the patients, 92% showed satisfactory results, and 8% were unsatisfactory. Unsatisfactory results were reported for the children who had gone more than 8 years after the burn incident and had irreversible changes in the tissues. As a result of using this method of treatment for burned children in our practice, the percentage of post burn consequences, such as the impact on mobility and growth of the extremities, was greatly reduced.

DISCUSSION

In Middle Asia, sandal burns are of special interest. Cases of sandal burns are more frequent during wintertime when people in distant mountain regions use an inappropriate heating system such as the sandal. Most of the patients with sandal burns have upper- or lower-limb injuries. Characteristics of sandal burns include not only skin injuries but also injuries to the underlying tissues. Unlike most types of burns, sandal burns are followed by coagulation necrosis because of the contact with live coals.

Patients with sandal burns require immediate hospitalization, the special treatment protocol as described in this article, and fast preparation of an injured site for skin grafting. After skin grafting these patients require a special treatment protocol as well, to avoid post burn contractures, [12-16] which can affect mobility and the growth of the extremities. At the Samarkand Regional Burn Center, we have been successful in our treatment of deep sandal burns because of our organization of specialized medical care services, modern equipment, and new medical methods of rehabilitation for burn patients.

During the last 15 to 20 years, a campaign against using sandal heaters has been underway in Uzbekistan. Many booklets on sandal burn problems are published. They inform citizens about the dangers of sandal burns, the complexity of their treatment, as well as the social and financial damages to society. According to the latest data of natural gas distribution service, using modern air conditioners for heating resulted in lowering the number of burned children. In 2005, the percentage of children with sandal burns was reduced by 88% compared with 1985.

Currently sandals are rarely used in the cities and countryside, with the exception of the far-away mountain areas, where the introduction of district-wide heating systems is very difficult and where the winters are very cold. Residents in these areas place a handmade square table in the central part of a room and put live coals inside. However, they often do not bother to set up some kind of barrier around the coals. Because of that, children, when left unsupervised, still fall onto the coals and receive deep burns. At present, educational programs for parents and their children are being launched in schools and day care centers for the purpose of sandal burn prevention.

Patient Y

Patient Y (Figure 11.5) was a 1.8-year-old boy who was admitted to Samarkand Inter - Regional Burn Center with the following diagnosis: a sandal burn (IIIA-IIIB degree) of the outward surface of the shin and both feet. In the figure, the patient is shown on the 12th day after the burn. The patient was in serious condition. His consciousness was blurred, and he answered questions inadequately. His skin and visible mucosae were pale. His nasal breathing was smooth but lung breathing was hard. He had muffled heart sounds and a rhythmic pulse. His arterial blood pressure was 80/60 mm Hg. He had a dry tongue and a soft, painless abdomen. Local examination revealed a burn wound of the external surface of a the shin and both feet, with a

disrupted epidermis and weak sensitivity. The bottom of the wound was pale with marble hues, and its edges were pink. The soles were insensitive. Toes of the left foot were black, charred, wrinkled, and numb. The results of the patient's blood analysis were as follows: hemoglobin, 116.0; hematocrit, 49.0; and blood coagulability, 5.5. The urinalysis was normal.

An initial surgical debridement of the wound was performed. An antiseptic dressing was applied. Detoxification drugs, low- and high-molecular blood substitutes, painkillers, antibiotics, and other drugs were prescribed to the patient. The next day necrotomy was performed, and chymotherapeutic remedies were placed on the wound. On the 7th day after the burn, a partial necrectomy of the shin and feet were performed because of their insensitivity and nonviability. The patient's condition improved gradually, his temperature came down. His appetite came back.

On the 12th day a total necrectomy was performed. The wound gradually began to heal. On the 18th day the wound on the shin and dorsal foot area healed. A granulation wound formed on the soles. Then autoplastic surgery was performed. A graft was taken from the external surface of the right hip and placed on the granulation wound. The extremity was immobilized with a plaster splint.

Figure 11.5.Thermic burn, IIIB-IV degree of the both shin and feet. The condition in 14 days after burn trauma.

An examination was performed on the 3rd day after the surgery. The skin was engrafted. The patient was discharged from the hospital in satisfactory

condition for ambulatory treatment. Physical therapy was recommended for the patient. The second examination was performed 1.5 months later. The patient was in a satisfactory condition. The transplanted skin had a normal color. The sole sensitivity was good.

Patient X (Figure 11.6) was a 1.5-year-old girl who was hospitalized in the Burn department of RSCUMA with the following diagnosis: sandal burn (IIIA-IIIB degree) of both feet, and burns of the left toes (IV degree). The patient is shown in Figure 1 on the 6th day after the burn. She answered questions inadequately. Her skin and visible mucosae were pale. Her nasal breathing was easy, but the breathing was not deep. Heart sounds were muffled, pulse was 120 to 140 beats per minute, and blood pressure was 70 to 50 mm Hg. The abdomen was soft. She didn't have urination or bowel movements. Local examination revealed that the epidermis of both feet was disrupted and covered with a black film, the wound bottom was pink, and its sensitivity was very low. The results of the blood test at admission were: hemoglobin, 132.0; hematocrit, 56.0; leukocytes, 10.3; blood coagulability, 3 to 4 m/g; and ESR, 14 rnm/g.

The patient was given an antishock treatment. The initial surgical debridement of the wound was performed on the 2nd day. The scraps of necrotic tissue were removed with scissors. The wound was covered with an aseptic dressing. Necrotomy was performed on the feet. On the 8th day after getting the burn we started necrectomy. General anesthesia was used.

Figure 11.6. Patient X, was a 1.5-year-old girl who was hospitalized in the Burn department of RSCUMA with the following diagnosis: sandal burn (IIIA-IIIB degree) of both feet, and IV degree of the left toes.

The patient had undergone a blood and plasma transfusion and also other blood substitute transfusions. She took antibiotics and other medications. Free autodermoplastic surgery was performed. A graft was taken from the external surface of the hip and placed on the wound. The extremity was immobilized with a plaster splint.

An examination was performed on the 4th day after the surgery: the patient's skin looked good. There was no graft rejection. The patient was in satisfactory condition when she was discharged from the hospital for outpatient treatment. Physical therapy and exercises were recommended. The secondary examination was performed a month after discharge, at which time we deemed the patient to be in satisfactory condition. The transplanted skin looked normal, had pink coloration, and its sensitivity had returned.

Patient Z

Patient Z (Figure 11.7) was a 2-year-old boy who was transferred to the Burn Center from a regional hospital with a burn wound in the area of the right and left foot. According to his mother's story, the child had received a sandal burn 4 days before. In the regional hospital the child was given all the necessary antishock drugs and treatment as patients X and Y when they were first admitted to the Burn Center. At the time of admission to the Burn Center, his general condition was satisfactory, his consciousness was clear, and his skin and visible mucosa were pale. Nasal breathing was easy, the pulse was rhythmic, and the blood pressure was 90/60. The tongue was a little bit dry, covered with a white fur. The abdomen was soft, painless. Urination and defecation were normal.

Local examination revealed a burn wound in the area of the foot. The wound was covered with black necrotic tissue; its bottom was pale and had a shining hue. The sole was insensitive; the toes were charred, wrinkled, and numb. An antiseptic dressing was placed on the wound and the next day exarticulation of the II-III-IV and V left toes and partial necrectomy were performed under general intravenous anesthesia.

Gradually, the patient's general condition improved. The patient had undergone several blood and plasma transfusions. He took antibiotics regularly. The wound in the dorsal area of the foot healed. In the sole area a granulation wound formed. It was bright pink, clean, fleshy, with little bleeding, without fibrose, suppurative and necrotic films.

Figure 11.7. Patient Z, was a 2-year-old boy who was transferred to the Burn Center from a regional hospital with a burn wound in the area of the right and left foot.

Autodermoplastic surgery was performed. a 0.2-mm thick graft, was removed from the external and internal surfaces of the hip, placed on the wound surface, and sutured. The extremity was immobilized with a plaster splint. The post surgical period proceeded normally. On the 4th day, an examination was performed. No changes in the transplanted skin were observed. The patient was discharged from the hospital in a satisfactory condition for outpatient treatment.

REFERENCES

[1] Shakirov, B. M. (2004). Sandal burns and their treatment in children. *J Burn Care Rehabil*, *25*, 501-505.

[2] Shakirov, B. M. et al. Sandal burns. The 13th Congress of international Society for Burn injuries. *Abstract book*. 107 Brazil.

[3] Tursunov, B. S. (1986). Collection of scientific work. Modern issues of local surgery. *Prophylaxis and surgical treatment of burns in children*. Moscow: Meditsina, 199-204

[4] Shakirov, B. M., Tagaev, K. R. & Tursunov, B. S. et al. (2007). Surgical Treatment of Contact Severe Foot Burns in Children // 12th Congress of EBA, Budapest, Hungary, 12–15 September, p. 6.

[5] Merz. J., Schrand, C., Mertens, D., Foote, C., Porter, K. & Regnold, L. (2003). Wound care of pediatric burn patient. *AACN Clin Issues*, *14*, 429-41.

[6] Suchanek, I., Rihova, H., Kaloudova, Y. & Mager, R. (2004). Reconstructive surgeries after extensive burns in children. *Acta Chir Plast*, *45*, 139-43.

[7] Kane, T. D. & Warden, G. D. (1996). Pediatric burn injury. In: Rudolph AM, Hoffman JIE, Rudolph CD, editors. *Rudolph's pediatrics*. Stamford, CT: Appleton & Lange, 861-7.

[8] Tursunov, B. S. (1985). [Modern issues of city population hospitalization. Issues of hospitalization and rehabilitation for children with severe burns]. Samarkand: Meditsuna, 36-9.

[9] Tursunov, B. S., Koroboyev, H. K. & Nikulin, V. I. (1987). Rehabilitation of early-aged children with burns. Moscow: Meditsina, 1-26.

[10] Atayasov, H. N. (1972). *Plastic surgery*. Moscow: Meditsina.

[11] Kolokoltsev, M. V. (1949). Unrestricted skin transplantation with dermatome [MD thesis]. Gorky, Russia.

[12] Povstyanoy, N. E. (1973). Surgical rehabilitation of burnt people. Moscow: Meditsina.

[13] Shakirov, B. M. (2007). Foot post-burn bent contracture deformities. *J. Burns*, V.*33*, N. 8, 1054-1058.

[14] Leung, P. C. et al. (1986). Burn contractures of the foot. *J. Foot Ankle Surgery*. V.*6*, N 6, 289-294.

[15] Povstyanoy, N. E., Sizov, V. M. & Tursunov, B. S. (1987). Methods of surgical treatment for post-burn contracture in children. *Clin Surg*, *3*, 31-4.

[16] Tursunov, B. S. (1986). Treatment of burn contracture deformities in children. *Clin Surg*, *3*, 26-7.

Chapter 12

BURN INJURIES OF THE BONES AND JOINTS IN THE FOOT

Extensive injury to the distal part of the lower extremities presents a difficult problem to the surgeon. Bones and joint injuries in the foot area due to burn traumas are observed in approximately 2% of all cases. The amputation rate of the lower extremities in patients with high voltage electrical injuries is reported as 40% [1].

There is little information available in literature concerning exarticulation and amputation of the toes in burn cases, in terms of their performance and this makes it difficult to determine the indications for performing amputations and exarticulations, methods and techniques of performance and also follow–up treatment [2-5].

It is necessary to differentiate primary and secondary osteonecrosis. Primary osteonecrosis develops as a result of a direct effect of a high temperature agent or electric current. It causes immediate destruction of bone structures. Secondary osteonecrosis develops in later periods and is caused by angio and neurotrophic disturbances in the bone as a result of the death of soft tissues surrounding the bone and periosteum. The leading role in the development of secondary osteonecrosis is a disturbance of the blood supply in separate areas of the bone.

Unviable burnt toes are revealed on the 2^{th}-4^{th} day after burn injuries. Due to the insignificant thickness of the subcutaneous tissue, especially on the dorsal surface, the disturbance of tendons, joint capsules, bone phalanges takes place immediately at the moment of trauma.

Such deep burns of the toes are characterized by their marked mummification. Necrotized skin becomes wrinkled and dry. Active movement of the toes disappears. Amputation and exarticulation become necessary. In amputation of the toes the functional importance of every millimeter of each of the toes must be taken into consideration.

Where typical amputation or exarticulation of the toes with employment of skin grafts cut from dorsal or plantar surfaces for stump covering is impossible it is acceptable to form grafts from preserved lateral surfaces. If this is impossible as well we must then combine amputation with single moment plastic closure of the stump by a free skin transplant. In injuries of one – two toe joints purulent arthritis usually develops and results in sepsis and electrical injuries result in erosive bleeding, that cannot be controlled by the bandaging of vessels and causes limb necrosis.

Nineteen patients with deep foot burns of the IV degree were treated in the burn department of RSCUMA and at the Samarkand Inter-Regional Burn Center. The causes of the IV degree burns were sandal burns in 17 cases and electrical injuries in 2 cases.

Exarticulation in 7 patients was performed on the 2nd day, in 5 patients on the 3rd in 5 patients on the 4th and in 2 patients on the 5th day after burn trauma.

Exarticulation was performed late because in some patients with burn trauma, the demarcation line developed late. In such patients after the appearance of the demarcation line of necrosis it is reasonable to perform a resection of the interphalangeal joint with a single moment immobilization of the proximal and distal phalanx into a functionally favorable position (easy flexion) and closure of the wound by free skin transplants. Joint fixation is achieved best of all by fastening with a pin. The pins put on the wound don't prevent engraftment and are removed after the development of a stable ankylosis (Figure 12.1 and 12.2).

Among the observed patients, exarticulation in the area of the Shapartov joint was performed in 2 patients, Lisfranc joint in 1 patient, ankle joint amputation in 1 patient and a lower extremities amputation was performed in 2 patients.

Indication for amputation was a total charring of the entire foot tissue. In order to establish the amputation level in every patient we took into consideration the tissues condition above the demarcation line, the degree of injury and we also tried to use all possible methods to form a stump, for making a prosthetic appliance in the future.

The amputation and exarticulation technique in burnt toes has its own characteristics, mainly caused by the difficulty of the stump closure by a skin graft well supplied with blood.

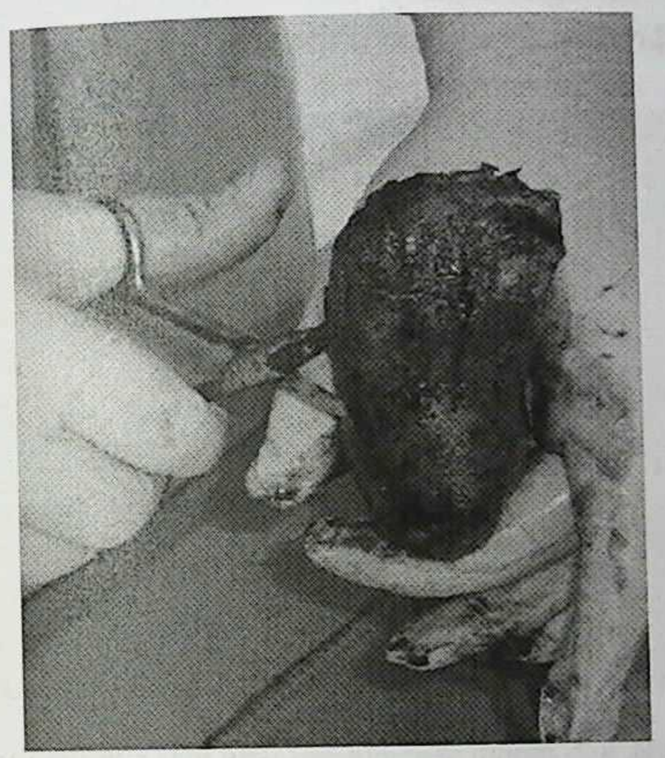


Figure 12.1. Patient A, a 1.1-year-old boy who was admitted to Samarkand Inter - Regional Burn Center with the following diagnosis: Sandal burn (IIIB-IV degree) of the right foot. Exarticulation of all toes of the right foot was performed.

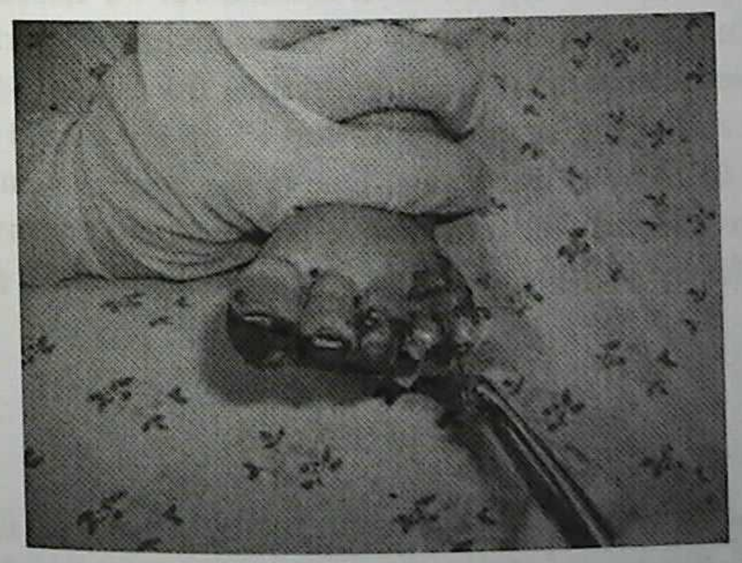


Figure 12.2. Patient B, a 1.6-year-old boy who was admitted to the burn department of RCSUMA with the following diagnosis: Sandal burn (IIIB-IV degree) of the left foot. Exarticulation of the IV-V toes of the left foot were performed.

We used amputation only when we were fully confident that the injured parts of the foot were nonviable. However, the amputation level in deep burns has not been resolved till now especially in early age children. We performed amputation not through healthy but burnt surfaces after carrying out necrectomy and preserved viability of the deeply located tissues (Figure 12.3).

Figure 12.3. Patient B, a 7- month year-old girl who was admitted to the burn department of RCSUMA with the following diagnosis: sandal burn (IIIB-IV degree) of both lower extremities. Exarticulation amputation of the right shin was performed.

We sawed the bone using the usual method but we closed the stump with soft tissues. In all cases treatment of the stump was performed without suturing and we restored the skin covering using free skin plasty 2 weeks later. With this, the end of the stump was closed by an all-around graft of 0.2-0.3 mm thickness taken by a dermatome. Due to the employment of this method we were able to eliminate the influence of infection and preserve a long stump from the limb for the creation of a prosthetic appliance for our patients.

REFERENCES

[1] McCauley, R. L. & Barret, J.P. (2000). Electrical injuries. *Plastic surgery indications, and outcomes*. 1st ed., Philadelphia: Mosby; 375.

[2] Hendon, D. N., editor. (2001). *Total Burn Care*. 2nd edition, W.B. Saunders.

[3] Crkvenjas, Z. et al. (2005). Surgical treatment of electrical burns by local flap plastic surgery. *Acta Chir Plast,47* (1), 10-2.

[4] Shakirov, B.M. (2004). Sandal burns and their treatment in children. *J Burn Care Rehabil,25*, 501-505.

[5] Azzena, B., Tiengo, C., Salvati, A. & Mazzoleni F. (2007). Combined use of free pedicled skin flaps for the reconstruction of extremities in high voltage electrical injury. *Burns*, vol. *33*, No3, 382-386.

Chapter 13

PHYSIOTHERAPEUTIC TREATMENT

Physiotherapeutic treatment of the foot with burn trauma is employed in early stages of treatment for quickening the regenerative process and shortening the period of local inflammation and consequently for creating conditions to prevent the formation of hypertrophic scars, post burn contractures and deformations.

In IIIA & B-IV degree burns the treatment begins on the 2^{nd}-3^{rd} day after receiving the burn trauma. Thus, in order to decrease edema of the soft tissues in the wound area and around it, magnet therapy is employed. The procedure is carried out once a day. The duration of the treatment course is 10-15 sessions. In the diagnostics of deep foot burns magnetotherapy is stopped a day before performing early surgical treatment in order to prevent increased bleeding during the surgical intervention.

Physiotherapeutic treatment is continued 24 hours after excision of the necrotic crust with simultaneous or postponed autodermoplasty. In the cases where early surgical necrotomy with skin plasty is performed, magnetoherapy is employed to prevent the development of rough post-burn scars. If the operative intervention is limited by excision of the necrotic tissue up to the subcutaneous fatty tissue or superficial fascia, physiotherapeutic treatment contributes to a rapid development of granulating tissue, shortening the period of time necessary for the preparation of the wound surface for the upcoming autodermoplasty.

As for the infection of burn wounds, the following types of physiotherapeutic treatment are used: electrophoresis with lincomycin and UVR. The procedures are carried out daily and the course of the treatment lasts for 7-10 days.

POSITIONING AND PHYSIOTHERAPY

Positioning and splinting is carried out on the day after the admission of the patient with deep burns to the burn department . Positioning is the act of giving the patients' body and extremities a certain position in order to escape further contractures. Indications for positioning and splinting are the burns in functional zones. It is necessary for healing to give the wound extended position from the beginning. It is also important directly in the postoperative period after performing autoplasty.

Positioning is used in burns of the ankle joints with an extension of the anterior surface. In burns of the Achilles tendon splinting is applied in a neutral physiological position of 90°. In addition not only is certain positioning used but various types of immobilization of the extremities as well, beginning with the application of a splint to the employment of a nail apparatus for external immobilization.

The last one is more favorable in injuries of ankle joint area as they are able to carry out active processing of the extremity in distal and proximal parts and make it easier to care for the injury. An adequate strategy to provide surgical tactics, physiotherapy and therapeutic exercises, enable us to create conditions preventing the development of cicatrical deformations and foot contractures. After rehabilitation of the skin covering and discharge from the burn department it is indicated to wear the splints for 3-4 months, periodically taking them off during the day for therapeutic exercises and massage. Therapeutic exercises begin after an assessment of the patient's condition by a cosmetic physician the day after hospitalization.

The main aim of therapeutic exercises is to rehabilitate the function of the foot, to prevent the development of contractures, to decrease the risk of complications developing. Therapeutic exercises are carried out very carefully, individualized for every patient. Movements must be slow and extending. Therapeutic exercises must be carried out 2-3 times a day for 30-40 minutes and after discharge from the immobilization stage until complete maturing and reverse development of a scar.

Types of exercises:

1. Passive, when therapeutic exercise instructor carries out the exercises with the patient's extremity.
2. Active exercises of the patients with the help of the instructor.

3. Active exercises to improve strength or to manage impaired functions of the ankle joint. They are employed during the period of convalescence.
4. Resistance exercises – complicated weight bearing exercises. Exercises are often combined with massage on the burn scars in the foot area.

The aim of massage is to extend and to soften tightening scars by trying to break adhesion. Massage is used for faint tightening scars no earlier than 4 months after the foot burn. Massage on burn scars in the foot area is necessary and is carried out 2 -3 times a year.

Contraindications for therapeutic exercises are:

1. Unstable patient's indexes of life, temperature higher than 38^0, pulse rate – 120, hem transfusion.
2. Burns of the IV degree before the operation.
3. Patients with electric burns, until the degree of injury to the skin and other systems can be determined.
4. In severely marked pain syndrome. But if it is necessary, anesthesia can be administered.

EXERCISES TO IMPROVE AND SUPPORT JOINT MOBILITY

1. Passive extending exercises in the foot area must be carried out with a full range of movements in order to prevent joint contracture. To increase mobility of joints that have contractures, the exercises must be carried out with the greatest permissible range of movements and to use weight for extending contracted structures. It is necessary to isolate the injured joints by positioning and stabilization of the foot and extending the muscles for the prevention of contractures; passive extensions will help to lengthen the muscular fibers. Compression of the opposite muscles produces responsive relaxation of the contracted ones providing a wider range of motions. Exercises must be controlled and used only for selected groups of muscles.

Contractures of ligaments can be prevented due to the employment of a structural and active regimen of exercises. The joints, managed with a complete range of motions will keep their mobility, while passive extension will improve the elasticity of the ligaments.

2. Active exercises – exercises with a complete range of movements are carried out to prevent the development of adhesion and contractures of the ankle joint and toes. Active exercises which are employed to improve mobility must be gradual and increase according to the degree of resistance and rate of performance.
3. Specific exercises – only essential work is carried out, with this, all foot joints are controlled: blocking exercises for determining muscular work; exercises on the table – to isolate deep foot muscles, metacarphalangeal flexor and interphalangeal extensor joints; exercises for resistance of the muscles effecting the injured foot are not only weakened but they act against resistance of injured joints and tissues. The exercises against resistance also improve the patient's ability to mobilize almost immobile joints of the foot. Static (isometric) exercises are carried out during the early stage of rehabilitation. These exercises decrease tension in joints and soft tissues.

Exercises for Preserving and Improvement of Tendons Slipping

Both passive and active exercises are employed.

The tendons of flexors and exercises for slipping rehabilitation of the tendons of flexors, depend on an estimation of the area of adhesion development in the foot area. Blocking exercises – holding of specific joints for isolation of extended tendon. Exercises with isolation of the superficial tendon – flexion of one toe by a straightening of the others.

Tendons of the extensor and extension of the interphalangeal joints and keeping of the metacarpophalangeal joints in the bent position is the main exercise for a deep extensor which gradually results in the extension of the interphalangeal joints.

Compressive Dressing and Physiotherapy

After the removal of the stationary department compressive dressing, therapeutic exercises are most important for the prevention of rough scar development. After complete wound healing measurements from the injured foot are taken for a special boot. The terms of wearing it are specific to each individual. Hypoxic effect on the scar, decrease of collagen and its derivatives production, constant physical pressure make it possible to prevent the development of rough cicatrizing. The boot is worn from 1 week to 1 month until there is a complete formation of scars.

It is important to employ physiotherapeutic procedures and alternating them with treatment at a health resort that employs a method of underwater massage of the cicatrical areas .

1. Magnetotherapy is continued with 10 to 20 sessions daily for no less than a month.
2. Electrophoresis (lidaza, hydrocortisone) 10 – 20 sessions daily with an interval of 4 weeks between the courses.
3. Phonophoresis (hydrocortisone, irixol), 8-15 sessions daily with 3-4 month interval.

In 1-2 months after discharge the patient receives the next course of physiotherapeutic procedures.

A control examination for treatment tactics are carried out a month after discharge or treatment in a health resort, then every 3 months during the next 1-2 years.

PART II: FOOT BURN CONSEQUENCES

Chapter 14

CLINICAL PICTURE OF POST-BURN FOOT DEFORMATIONS

The clinical picture of post-burn foot deformations may be varied both by localization of the injury and by the severity of its manifestation. Scars create obstacles for the continued growth of extremities.

Cicatrical change of the tissue around the joints, the various degrees of their tightening and their limited movements, the absence of separate foot segments and other severe consequences of burns can be presented and taken into consideration in a deep and comprehensive study of this problem.

It is important to study not only the cicatrical changes from the side of skin coverings but also the osteoarticular changes, reflecting on the main pathology of the skeletal muscular apparatus as a consequence of foot and ankle joint burns, as well. The character of osteartucular changes can be marked in different ways due to the severity of the foot deformations.

In developing a system and in a description of post burn foot deformations we used the classification of B.V. Parin (1946), taking into consideration the peculiarities of anatomo-morhological and functional displacements and described the clinical picture of burn foot deformations according to their degree.

Our investigations make it possible to establish a general regularity, revealing that a distinctive picture of changes in all tissues of the injured foot and impairments of functional abilities, regardless of localization, depend on the degree of deformation. On the basis of these findings the following classifications are made:

1) In the first degree of deformations insignificant functional impairment from the side of the injured foot is marked, and separate cicatrical tightening in the area of the ankle joint or around it cause not only cosmetic insufficiency but may aggravate the process of the patients growth.
2) In the second degree the impairments of the foot segment functions or joints with restriction of movements that are half of normal are revealed, more extensive and movable cicatrical tightening and membranes sharply straining during active movement are observed; the signs of osteolysis, atrophy and underdevelopment of the foot in long existing deformation are revealed.
3) In the third degree sharp functional restriction of the injured foot due to the scars that are more often located in the joints area; more significant trophic disturbances osteolysis, atrophy and underdevelopment of bones are observed.
4) In the fourth, the most severe form of deformation, complete insolvency of the foot joints is observed with consequent extensive cicatrical injuries and as a result a significant or complete adhesion. Absence or preservation of only the separate contact moments in the joints, results in the most severe functional and anatomomorphological displacements up to a complete joint ankylosis or a significant foot osteolysis.

Taking into consideration the specific peculiarities of the clinical definitions of the degrees of the injuries and their effect on anatomomorphological displacements we propose a more detailed description of every deformation stage separately.

The first deformation stage occurs in 19% of cases as a result of superficial burns with the presence of a mobile cicatrical tightening that do not prevent the complete use of this limb. However, it is necessary to notice that they seldom request surgical aid in deformations like these but rely more on a conservative treatment. The first degree foot of deformation is more often revealed and a scars location is marked on the dorsal surface of the ankle joint area when receiving the burn from boiling water and on the sole surface from a sandal burn and has unfavorable effect on the foot function. The clinical picture in the first degree of deformation is in the main connection of the cicatrical changes of the skin coverings and the indistinctly marked structural changes. On walking the patients are moderately limping on the injured area,

but finally the deformation effects functional abilities. In prolonged deformation, muscular atrophy and a misalignment of the foot take place producing difficulties in wearing of footwear. The following observations can be given as an example.

Patient A, a 1.8 year old boy was admitted to the Samarkand Inter-Regional Burn Center with complaints about a right foot deformation. It was determined, that he had received a sandal burn. He was treated at the hospital, and the wound was cured in 22 days. Free autodermoplasty in the area of the left leg and foot was performed. After discharge scars and extensor contractures of the left foot gradually developed. On admission the patient's parents complained of a deformation of the II-III-IV-V toes of the right foot, pains during extended walks and difficulties in wearing footwear. On examination: scars on the dorsal surface of the left foot at the base of the II-III-IV V toes at the extensor position at an angle of 155-160^0, movements limited to 10-12^0, were revealed. Diagnosis: Postburn extensor contracture of the II-III-IV-V toes of the right foot of the II degree (Figure 14.1).

As it is seen from the given example the patient has all the symptoms to warrant a long observation in spite of insignificant foot dysfunction and he must undergo conservative or surgical treatment.

Figure 14.1. Post burn extensor contracture of II-III-IV-V toes of right of the foot.

The second deformation degree makes up 18% of all foot injuries. Cicatrical contractures of the second degree are characterized by scars around the joint that at maximal possible movements are straining and tightening and look like membranes, with almost 50% limitation of movements in the joints of the foot toes and ankle.

The second deformation degree includes various injuries: flexor deformation of the toes, extensor deformation with a partial syndactyly of the separate toe phalanges and a deformation of the ankle joint of a dorsal flexor character. In the second degree of foot and ankle joint deformations the patients walk with moderate lameness and experience difficulties in wearing footwear. We show our observation as an example.

Patient B., a 4 year old boy was admitted to Samarkand Inter-Regional Burn Center with complaints of right foot deformation. It was determined, from the patient's complaints (self-report), that he had received a hot water burn. He was treated at the hospital, and the wound was cured in 25 days. With the child's continued growth a cicatrical contracture developed. On admission he complained of deformation of the IV-V right foot toes, pain during extended walks and difficulties in wearing footwear. On examination there were: scars on the dorsal surface of the foot at the base of the IV-V toes, in the extensor position at a 155-160° angle, movements were limited to 10-12°. Diagnosis: Post-burn extensor contracture of the IV-V right foot toes of the II degree (Figure 14. 2).

Figure 14.2. Post burn extensor contracture the IV-V right foot toes of the II degree.

The third deformation degree occurs in 42% of cases. Frequent injury factors are the sandal and burning hot objects. Most of the various deformations are revealed in these foot injuries.

Deformations of the toes are most often observed as of a flexor or less often of an extensor character. In addition the toes have a partial cicatrical adhesion from the plantar or dorsal surface of the foot; the toes movements are limited with frequent dislocations and subluxations. The patients have marked lameness and cannot wear usual forms of footwear. Ankle joint deformation as a rule is evident as a dorsal flexor contracture of the mobility of the foot.

The patients with a foot deformation, combined with an ankle joint injury, have both lameness and difficulties in walking rapidly and cannot run due to a disturbance of the supportive ability in the affected foot. As a result plantar callosity develops in the internal and external surface of the foot with frequent ulcerations of the scar.

The following observation is given as the example. Patient C., a 3 year old girl was admitted to the Samarkand Inter-Regional Burn Center with the complaint of a right foot deformation. It was determined, from the patient' statement, that she had received a sandal burn and was treated at the Inter-Regional Burn Center, where free autodermoplasty on the dorsal and plantar surface of the right foot was performed. Upon examination, extension of the first toe of the IV degree and of the III degree is noted on the background of extensive rough and dense scars in the area of the dorsal surface. Diagnosis: Post-burn extensor contracture of the I-II-III-IV-V toes of the right foot of the III-IV degree (Figure 14.3).

Figure 14.3.Post-burn extensor contracture of the I-II-III-IV-V toes of the right foot of the III-IV degree.

The fourth deformation degree occurs in 21% of cases. According to statistics the main cause of severe deformations is a sandal burn; less deformations are caused by fire and burning hot metal.

In the IV degree of deformation the most frequent injury is associated with the foot and ankle joint. With this type of dorsal flexor deformation, the dorsal surface of the foot has adhesion with the anterior surface of the leg and movement in the ankle joint is limited to $10\text{-}15^0$, the patients tread on the heels when walking.

Ankle joint deformation is often combined with an injury of the whole foot that often causes flexormobility deformations. Combined deformation of the toes is also observed: of either a flexor or extensor character. Definite regularity is observed here, as in the location of this type, dislocations and subluxations often develop. A comparative study of the localization of sandal burn subjected tissue injuries has been carried out and in a number of cases complete charring of the foot and toes takes place.

Patient D., a 4 year old boy was admitted to the Samarkand Inter-Regional Burn Center with complaints of a deformation of both feet. It was determined, that he had received a sandal burn at the age of 10 months, was treated in the Burn Center where necrotomy and skin plastic operations were performed many times. On examination of the right foot it is observed that there are no IV and V toes; the foot is tightened with strong cicatrical deformation and an extensor lateral contracture to the leg, movement in the joint is absent; there are cicatrical changes to the dorsal surface of the left foot with the absence of the III-IV-V toes (Figure14.4).

Figure 14.4. Post burn extensor contracture of the left ankle joint of the foot and a flexor contracture of the right foot and toes of the III-IV degree.

In this case the patient treads on the injured limb and walks on crutches. Thus, clinical observations show that post burn foot deformations cause various types and severity of injuries. Under the effect of deep burns not only the skin but all subjected soft tissues are affected and definite displacements in the osteoarthritic apparatus take place.

Chapter 15

X-RAY PICTURE OF OSTEARTICULAR CHANGES IN THE ANKLE JOINT AND FOOT

Only a few papers on the problem of foot burns can easily be found in the accessible scientific literature. The X-ray method is the main method in the recognition and study of the pathology of the bones and cartilage of the foot and ankle joint. 79 patients underwent X-ray examination at the burn department of RSCUMA and the Samarkand Inter-Regional Burn Center. All observed changes in the bones and joints of the foot area in patients with burns were put together to form a clinical X-ray working strategy. Timely detection of marked changes in the area of the foot gives an opportunity to undertake a number of preventive measures and administer a more efficient treatment.

INTRODUCTION

The anatomic-functional peculiarities of the foot-ankle joint marked by the complexity of its structure, absence of protective adipose and muscular tissue, result in a contracture with an injury of the deep-foot structure after deep burns. The disturbances in the function of the foot and ankle joint influences the function of the whole lower joint, its mechanics, gait, bearing and can even lead to a distorted pelvis, curvature of the spine and other physical disruptions [1].Thus, the development of a rehabilitation system for patients with post-burn extremity deformities, ambulatory follow-up treatment, and home injuries of these patients are problems of a particular significance.

In Central Asia, and particularly in Uzbekistan, many episodes of burns take place at home due to the use of sandal heaters. Despite improvements in living conditions and public education efforts, the traditional device, a sandal, containing live coals, is still used for heating the lower part of the human body [2,3].

The X-ray method is the main method for the recognition and study of the pathology of bones and cartilages in the foot and ankle joint. Though there are many medical literature works describing the character of the clinical roentgenological changes in bones and joints as the result of burns, the problem of a deep structural and destructive breach in the bone-joint apparatus in long term periods after thermal foot trauma has still not been completely investigated. The injury of the bone and foot can initially appear as the direct result of the burn trauma or as a secondary result of a trophic breach. Insufficient coverage of this problem in scientific literature and frequent post-burn complications that result in disabilities impelled us, the staff members of the burn department of RSCUMA and the Samarkand Inter-Regional Burn Center, to carry out this study.

PATIENTS AND METHODS

79 X-Ray examinations of patients with post burn foot contractures and deformations have been carried out. All observed changes in the bones and joints in the foot area of the patients with burns were put together to form a working clinical X-ray strategy. We attributed the changes due to the direct action of high temperature to the group of primary disturbances of 18 (22. 79%) patients and burn complications of the foot and their consequences to the group of secondary disturbances of 61 (77. 21%) patients. The causes of patients burns were: sandal burn in 60 patients (75. 95%), flame burns in 12 patients(15. 19%) and electrical burns in 7 patients (8. 86%) Table 15.1.

We have examined by means of X-ray 79 patients with heavy burns. 153 burns the feet (Table 15. 2). Of all the cases, 52 were contractures persisting for 1 - 5 years, while 27 were contractures for a period of 6 - 10 years. The marked deformities of the bone ankle joint changes were observed in 23 patients, with changes in the form and slow growth of bones in the foot and ankle with its deformities. Contractures of the $1^{st} - 2^{nd}$ degrees were observed in 9 cases, of the 3^{rd} degree in 42 cases, and of the 4^{th} degree in 18 cases.

Table 15.1. Number of cases

Causes of burns	Males		Females	
	Quantity	%	Quantity	%
Sandal burns	38	48.1%	22	27.85%
Flame burns	8	10.1%	4	5.1%
Electrical burns	5	6.32%	2	2.53%

Table 15.2. X-Ray of bone changes

The numbers of patients treated	Character of changes						
	Osteoporosis	Osteolysis	Under-development	Osteoarthropathia	Strain and sprains	Arthrosis	Ankylosis
79	43	28	17	14	39	7	5
153 (100%)	28.10%	18.30%	11.11%	9.15%	25.49%	4.58%	3.27%

RESULTS

As we can see from the Table 15.2. the most characteristic structural changes of the bone tissue were osteoporosis (28.10%). The early appearance of the dystrophic process in an after burn foot bone is osteoporosis, which was observed by means of X-ray 5-6 weeks after the thermal trauma. Osteoporosis is first seen in the optimal blood supply zones: epiphysis, and small spongy foot bones. Necrosis of the periartucular soft tissues in deep burns of the foot is established by the inspection of the affected area. X-ray examination reveals a disturbance of the usual operation of soft tissues. Secondary lesions of the bones and joints of the foot in burns are most frequent and varied. They developed in different periods after the burn trauma, they are dystrophic or purulent inflammatory in nature and lead to various consequences. Particularly common trophic disturbances manifest as osteoporosis. It is clearly marked in patients with chronic pain syndrome or with a slow closing burn wound in the foot area. Osteoporosis was mainly observed in III-IV degree deformations and in old burns: a year ago (8), two years ago (19), 3 years ago (16).

In cases of osteoporosis we observed the dystrophic changes of hypertrophic character in 26 patients (60. 47%) and diffusion character type in

17 (39. 53%) cases. The compensatory reconstruction of the foot bone was seen as a hypertrophical form of osteoporosis. As the foot was always kept in the position of maximal loading a marked refraction of the bone is observed. The foremetatarsus (trabecula) is massive, thickened and situated in a longitudinal direction. The picture of the bone substance was large-looped with some light cavity areas, but the most vividly seen changes were in the heel bone. Rough and compact bone beams in the heel bone were situated in a fan-shape and very rarely were they split at the background and were connected with the compact cortical plate, and that causes the increase of weight loading on the heel bone (Figure 15.1).

As the diffusion form of osteoporosis of the bone structure had a large-cell character and the bone beam was thinned that led to marked transparency of the bone substance and outlined the cortical bone layer. That resulted in full dysfunction of the foot (the foot toes were maximally bent) and stopped the ability to be leaned on (Figure 15.2).

Figure 15.1. The patient B, 14 years old suffered from hot ash burns at the age of 3 years (he fell into the pit full of hot ashes) was treated at the burn center. The diffusive osteoporosis of the foot bone was seen on the roentgenogram photo. On the projection of ram heel, boat-shaped and wedge-shaped bones the destructive area with irregular and illegible contour is seen.

Figure 15.2. The patient C, 8 years old, at the age of 10 months suffered from a sandal burn, was treated at burn center, where he repeatedly had undergone the necrectomy and skin-plastic surgery treatment. The roentgenogram photo showed the diffusive osteoporosis, deformation of the phalanxes from both sides (mostly seen on the left), the outline of the final phalanxes is irregular and thickened, sclerosed.

- Foot osteolisis was observed in 28 (18. 30%) cases. The structural changes and resolution of some bones (or parts) of the foot have been the result of the neurodystrophic process in bone tissue. Osteogenesis disturbances are revealed by X–ray examination in patients a year after the trauma on the burnt foot. Osteolysis in the toe phalanges is revealed by X–ray examination 4 weeks after the burn. At the first disappearance of the closing plates of the nail phalanges, tuberosity is revealed. The X-ray radiography has shown the absence of the nail and the middle phalanxes of the II-III-IV toes in 14(50.0%) cases, in 8 (28.57%) patients the process took 1 toe and in 6 (21,43%) patients – it took the head of the IV-V metatarsus bones and the area of the heel bone. All the rest of the phalanxes were cone-shaped, sharpened, sclerosised and closed by the final plate. There were often seen breaches between the heel phalanxes or the metatarsus phalanx's joints (Figure 15.3).
- The under-development of the foot and toes was seen in 17 (11. 11%) cases. This was observed with heavy foot deformations, when the ends of the metatarsus bones were displaced to the back, perforating the skin and provoking ulcerations. The X-ray radiography showed the remains of the bones, which lost their form and were connected

into one conglomeration, which were locked in as a deformed and derogated stump.

Figure 15.3. The patient A, 13 years of age was taken to the burn center. When he was 2 years old he suffered from a hot ash burn and was treated by conservative method. The roentgenogram photo showed the hypertrophic osteoporosis at the left part, osteolisis in the marked part of the V metatarsus bone and partial osteolisis of the II-III-IV metatarsus bones and a hypertrophy of wedge-shaped bone. At the right side there is an irregular osteoporosis of bones, a stop of hypertrophy of the metatarsus bone and toes phalanges.

- Osteoarthropathia in the foot was seen in 14 (9. 15%) cases. The X-ray radiography showed the swell and deformation of the joint outline surface, clearing of the bone structure on the basis of thinness and reduction of bone in size. In 8 cases there was the sharpened end of metatarsus bones. These changes were followed by osteolysis of the foot toes phalanxes. In 6 cases the foot had a crescent-shaped form.
- Strains and sprains of foot toes were observed in 39 (25. 49%) cases, mainly, in the deformations of the foot of the III-IV degree. X–ray study clarifies the relationship of bones in the joint and reveals changes in the soft tissues and articular margins of the bones. The powerful, cicatrical heaviness or solid areas tightening the joints of joined bones was clearly seen. The radiography had shown the sharp changes (breach) and swell of joint ends at the metatarsus bones and the main toes phalanges. The phalanges were underdeveloped and sharply deformed. At the sole dislocation of the toes the metatarsus bones were raised to the back and its longitudinal slit was somehow

extended. In the case of a back toe sprain, on the contrary, owing to the prolapsus of the metatarsus bones we observed the thickening of the base and in this case the nail phalanges were subject to osteolysis.

- The degenerative-dystrophic injuries in foot joints is the basis of Arthrosis. In 7(4. 58%) patients we examined this arthrosis. We have observed the osteoporotic reconstruction in the epiphysis, which reduces the bone's firmness, and as a result of weight overload leads to deformation and a breach of the congruence of the foot joint area, clinically characterized by statistical foot deformations.
- Foot anchylosis is a heavy injury of the tissue with a pulling on the elements of the joint ligamentous or bone-joint apparatus (in 5 cases) into an inflammatory or necrobiotic process. In the area of the anchylosed joint we can see the heavy foot deformation with a predominance of wide and united cicatrious processes. The foot anchylosis is often seen at the point of the sole flexion (bend).

DISCUSSION

In burn disease deep changes in various systems, organs and tissues of the patient, including the skeletal articular apparatus occur. The challenge of X–ray examination is to recognize these changes in time to control their dynamics and contribute to a successful treatment of burn victims. The roentgenologic changes of burns were shown in detail in the works of some authors [4-8]. Though there are many medical literary works describing the characteristics of the clinical roentgenologic changes in bones and joints as the result of burns, the problem of deep structural and destructive breaches in the bone-joint apparatus for long-term periods after thermal foot traumas, still was not completely investigated. In deep burns of the III-IV degree in children, covering 5% and more of the body surface, that cause the development of burn disease, most patients develop osteoporosis of a uniform, spotted and reparative type. During prolonged treatment of burn disease, premature degenerative changes of the joint, sublaxations, ankilosis and calcification in specific soft tissues were observed. In childhood and adolescence the disturbance of osteogenesis is noted. The degree of the manifestation of the observed changes in the area of the foot and ankle joint depended on the depth of the burn as well as the methods of treatment and the duration of the existence of the wound surfaces and scar contractures. Timely detection of marked changes in the area of the foot gives an opportunity to undertake a

number of preventive measures and administration of a more efficient treatment.

The patient with a burn in the foot and ankle joint must be under constant examination control if there are cicatrices and the danger of slow growth of the burnt foot joint and development of secondary bone-joint changes are present. The earlier operation is advised depending on the severity of the contracture. That assessment is achieved by a strict clinical examination.

The analysis of burn after-effects and their mechanics in patients as the result of the growth of their systems allowed us to determine the assemblage of the persons who must be rehabilitated:

- those, having limited deep burns of the foot-ankle joint;
- those, having deep burns or burns of the III degree in the foot-ankle joint;
- those, having deep burns even if they have no disjunction of the skeletal muscular apparatus, on discharge from the hospital but having a loss of skin surface in the foot-ankle joint.

The surgical treatment of burnt foot deformation leads to distinct positive changes in the bones. However this is a long process and it proceeds differently depending on the quality of a given treatment protocol, and in cases of irreversible changes, compensatory and adjustable mechanisms are developed to improve their mechanical features as the bone support.

REFERENCES

[1] Mirazimov, B.M., Tursunov, B.S.& Grishkevitch, V.M. (1991). *Post-burn Deformities of Extremities in Children*. Tashkent: Ibn Sino Publishing House, 342.

[2] Shakirov, B.M. (2004). Sandal burns and Their Treatment in Children. *J. Burn Care Rehabilitation* (USA) November-December, Vol.*25*-N6, 501-505.

[3] Shakirov, B.M.& Tursunov, B.S. (2005). Treatment of Severe Foot Burns in Children. *J. Burns*. (ISBI). November, Vol.*31*, Issue 7, 901-905.

[4] Colson, P. (1956). Osteoporosis after severe burns. Acta chir., Belg. Supplement, *1*, 509-513.

[5] Dokuchaeva, N.F. (1957).*The X-ray radiography of bone system at thermal burns*. Diss., Samarkand.

[6] Moncrief, I. (1958).*Complications of Burns, Ann. of Surg., 147*, 4, 443-475.

[7] Evans, E.B.& Smith, I. (1959). Bone and Joint Changes Following Burns; a roentgenographic study. Preliminary report. *The journal of the Bone and Joint Surgery*, V.41A, *5*,785-799.

[8] Evans, E.B. (1966). Orthopedic Measures in the Treatment of Severe Burns. *J. Bone and Joint Surg*., 48A, *4*, pp.643-669.

Chapter 16

GENERAL PRINCIPLES AND METHODS OF BURN DEFORMATION ELIMINATION IN THE FOOT AREA

Rehabilitation of the injured joints function is the basis of reconstructive surgery of foot burns. The basic method of burn deformation elimination is considered to be an operative treatment under the following indications:

a) disruption of the movements in the joints, caused by a decrease of displacement and straining of skin coverings and also a retraction or injury of deeply located tissues (tendons, muscles, etc.);
b) staticodynamic impairment of the lower extremities.
c) marked uncomfortable subjective sensations due to cicatricial masses;
d) periodic ulcerations of cicatrical fields in the foot area.

The difficulty involved in the treatment of ankle joint and foot deformations is closely connected with the general tasks concerning rehabilitation of the form and function of the injured lower extremities.

It is reasonable to use local tissues regardless of whether there is little change to the skin or an earlier transplant, particularly if there are in depth folds and storage of tissues.

However the basis of plastic surgery restoration of the lost skin covering the foot is free transplantation of the skin and stem plasty. The first one is used in foot deformations in any location (dorsal, plantar surface etc.). The second one in naked bones and joints, because of a necessity to eliminate tissue defects and also in osteotomy.

In all these various cases surgical intervention must be early, before the development of secondary bone deformations.

Local skin plasty. In operative treatment of burn results local skin plasty has advantages because after excision of scars the defect is replaced by local tissues having the same features. The simplest method to eliminate a small defect is to mobilize the refreshed margins of skin and to suture them (Figure16.1).

In plastic surgery both local and displaced triangular flaps near the injury are used (A.A. Limberg 1946, 1963). The developed system of dermaplasty, with the employment of the approach of using a triangular flap of skin (Z-plasty), made it possible to increase the skins resources due to its mobilization on all sides of the defect and to use triangle width in order to increase the distance between two points. (Figure 16.2,). It is particularly valuable in cases when the elimination of tightening of scars looking like folds is necessary.

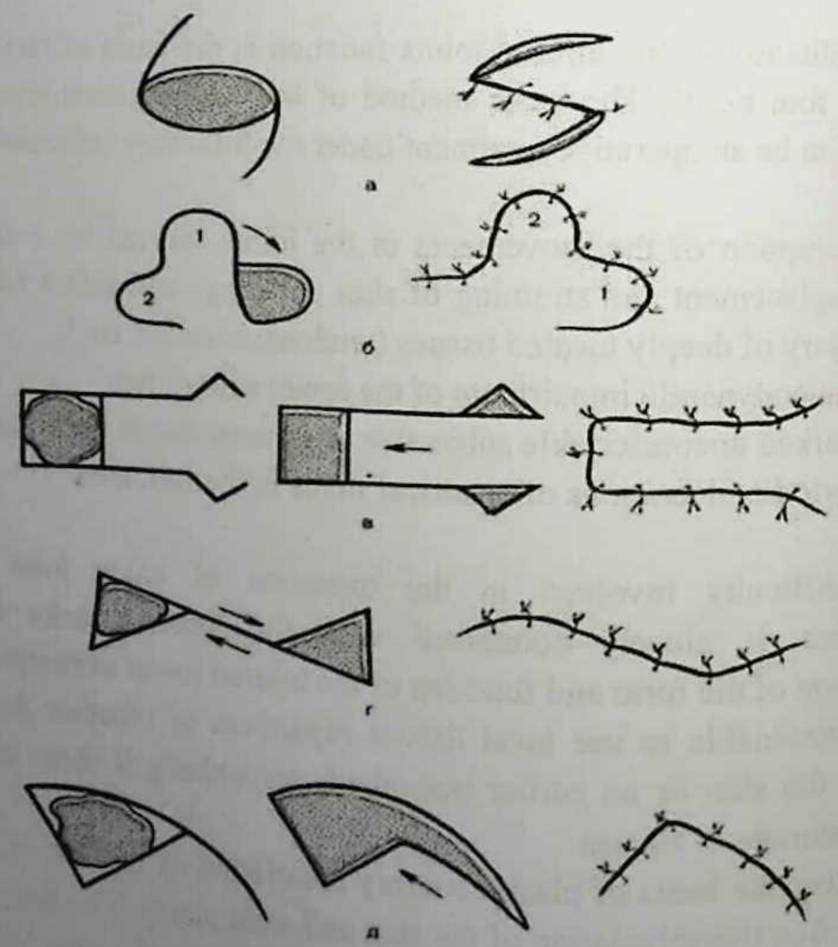


Figure 16.1. Various methods of the closure of skin defects by displacement of grafts of near-by tissues: a. d. e. – triangle, b- bilobed, c- rectangular.

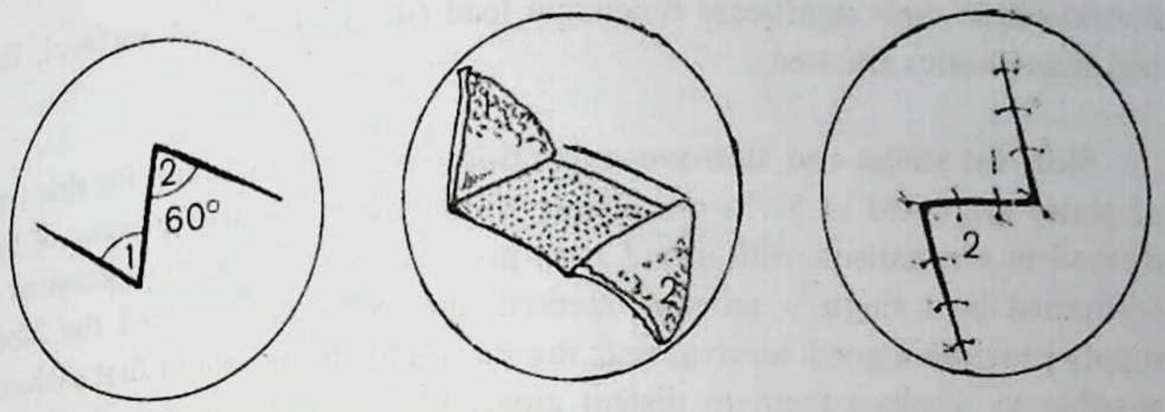


Figure 16.2. Extension of the skin due to dislocation of symmetric triangle flaps (1,2) according to A.A. Limberg.

In extensive post burn injuries cicatricial tissues, suitable for plastics, can be used. However displacement of cicatricial triangle flaps(up to 30%) is often accompanied by their necrosis which leads to negative results.

Free skin plasty – is performed in the areas where the tissue structure is able to provide plasmic nutrition of the graft during the first 2-3 days after the operation. In spite of preference to local skin transplantation, we widely use this type of dermaplasty in the mobilization of the joints in the foot and ankle joint area in mild and severe contractures. Up to now there are contradictions concerning the employment of transplants: layer by layer or split. The indications for layer by layer transplant are the injury of the plantar foot surface and extensive foot and ankle joint defects. In these cases we use 0.3-0.4 mm thick transplants in adults and 0.2-0.3 mm in children. They are easily survived and the patient seldom experiences subsequent scarring.

Combined skin plasty - can be performed during an elimination of all deformation forms in the foot area and it consists of the combination of local plasty and free skin transplantation. Combined skin plasty has strict indications and advantages in free skin plasty. In those cases when it is impossible to cover the injury by local tissues, free skin transplantation can be added. From the other side in the employment of free skin plasty it is necessary to consider the following: to close functionally active areas with local tissues if possible and the rest of the wounds on the inactive areas with free skin transplants, in uncovering of deep structures – tendons, joints, bones and the impossibility of covering them with local tissues and also taking into

consideration their significant functional load (the plantar foot surface), flap and stem plastics are used.

Skin–fat strips and skin-muscular flap plasty. Indications for this type of plasty are noted in 5-7% of patients with foot burns. Advantages of this method in comparison with round stem plasty are obvious: the operation is performed in a single – moment method, the axial character of the blood supply provides a good survival rate; the flaps have a long stem that makes it possible to displace them to distant areas; they can be used both for the reconstruction of covering tissues and for elimination of deeper foot defects.

The gastrochemius muscle consisting of two stems, starting from condyles of the femur, forming the Achilles tendon and adjoining to the heel bone has good plasty features. The flap includes half of the muscle and a considerable area of the skin above it. The skin-muscular flap closes the defects in tissues on the same leg or cross flaps grafting on the other foot (Figure 16.3).

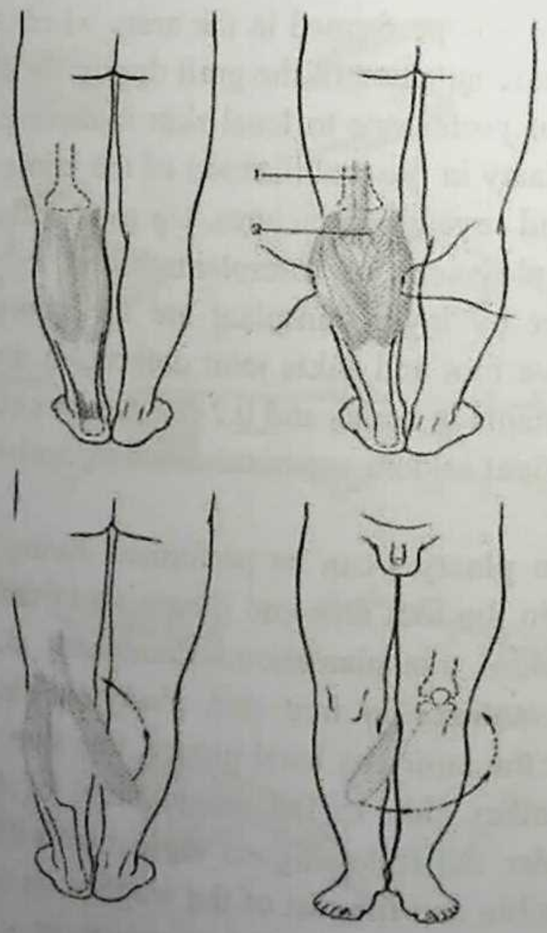


Figure 16.3. Gastrochemius skin – muscular flap.

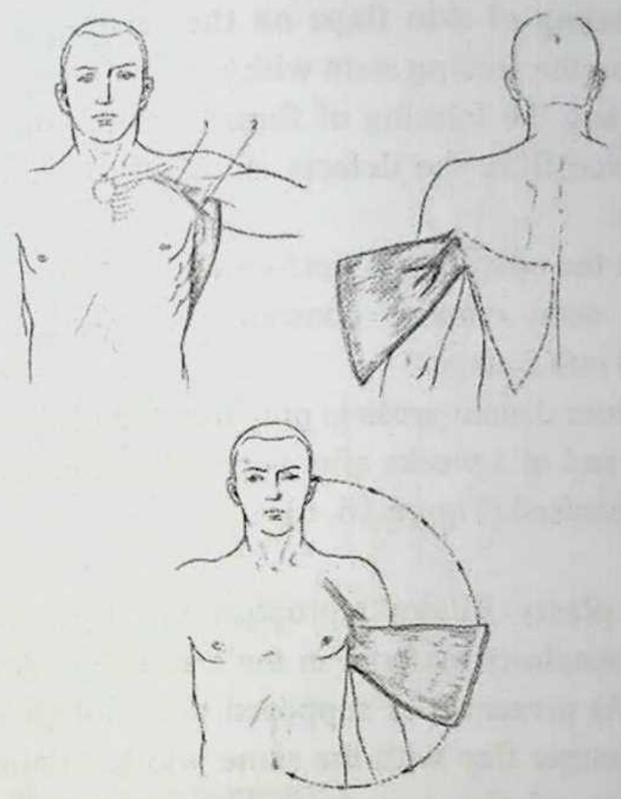


Figure 16.4. Skin – muscular flap from the widest muscle of the back.

For dermaplasty of the heel–plantar surface defects it is necessary to reconstitute the covering of soft tissues which can bear a great physical exertion and in this case a thoracodorsal flap is often used. The thoracodorsal flap has ample innervations due to the retrosternal nerve and its layer-by-layer structure which provides a good resistance to the physical load quality in revealing feeding vessels and their relatively large diameter, stability of this donor zone topography, ease of its closure and also this flaps resistance to infection (Figure 16.4).

There is a group of muscles on the plantar foot surface which can be used for dermaplasty. They are the muscular abductor hallucis et digiti minimi pedis and the musculus flexor digitorum pedis. All of them start from the heel bone and adjoin to the phalanges of the corresponding toes. Feeding arteries enter the muscles at the heel bone, so they can be mobilized on a significant length distally crossed by tendons and turned for the closure of defects in the area of the ankle and plantar bone. It should be noted that in spite of the employment of new technologies for the movement of skin flaps together with subcutaneous tissue (flap plasty on MVA- microvascular anastomoses and flaps with an axial blood supply), traditional methods preserve their shapes. They are mainly used in cases of deep ulcers in the heel and the talocrural joint area.

Methods of cutting of skin flaps on the feeding stem. The method of cutting a skin flap on the feeding stem with a neighboring area defect is called the Indian method and the forming of flaps on the temporal feeding stem in areas that are isolated from the defects is called the Italian method of skin plasty (Figure 16.5).

In the first case the operation is performed by a single – moment method, because a feeding stem remains constant and in the Italian method the operation is divided into 2 stages:

At first a flap from distant areas is prepared then it is brought closer to the defect and closes it and in 3 weeks after survival and revasculation of the flap, the feeding stem is excised (Figure 16. 6).

Filatov's stem plasty. Filatov's proposal (1916) to use a round stem for displacement of dermaplasty material in the area of the defect has a great role in plastic surgery. At present it is supposed that biological training makes it possible to form a longer flap with the same width. Filatov's stem method of dermaplasty consists of the transfer of tissues to the plantar area. In dermaplasty with a flat fluteal femoral flap in the 1st stage the skin-fat strip with preservation of both stems is cut. The donor wound is sutured and the injured stem is closed by split skin.

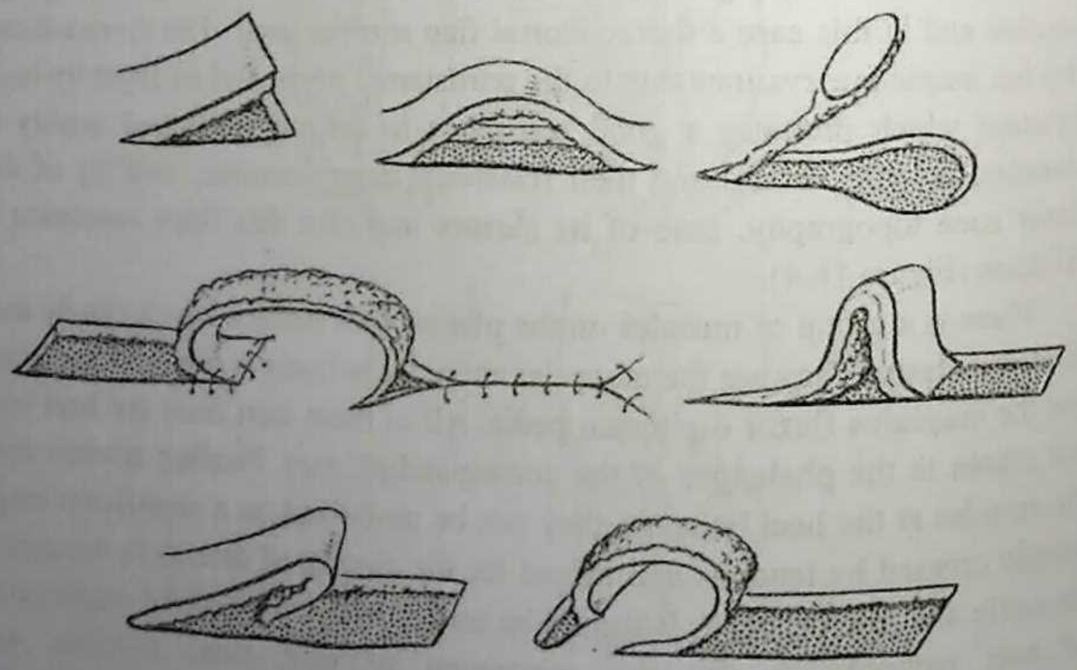


Figure 16.5.Various types of skin flaps on the feeding stem.

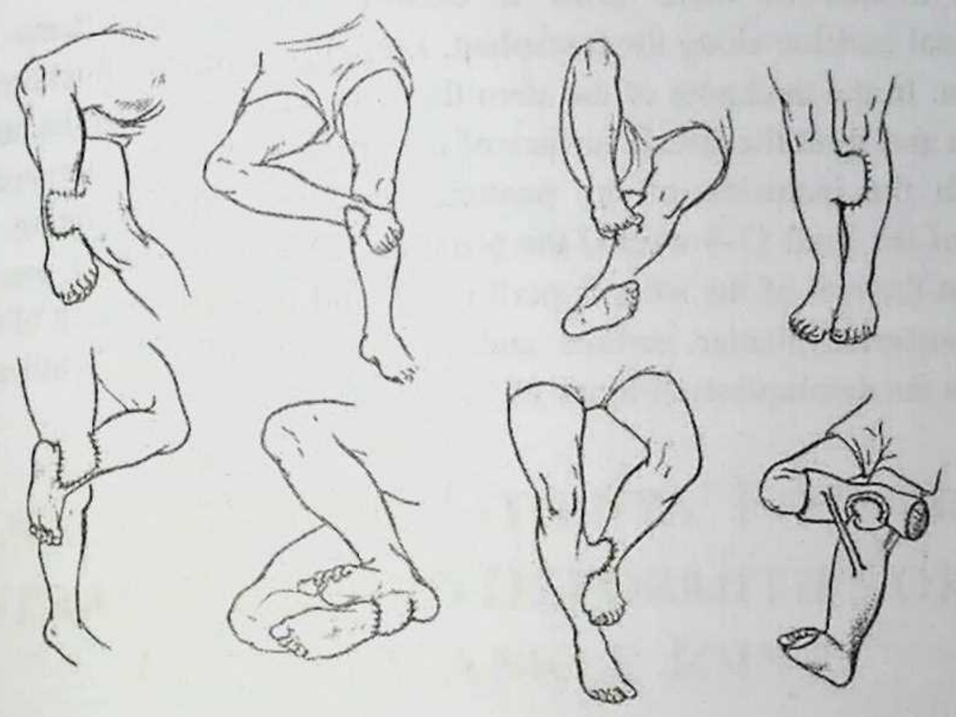


Figure 16.6. Variants of Italian dermaplasty.

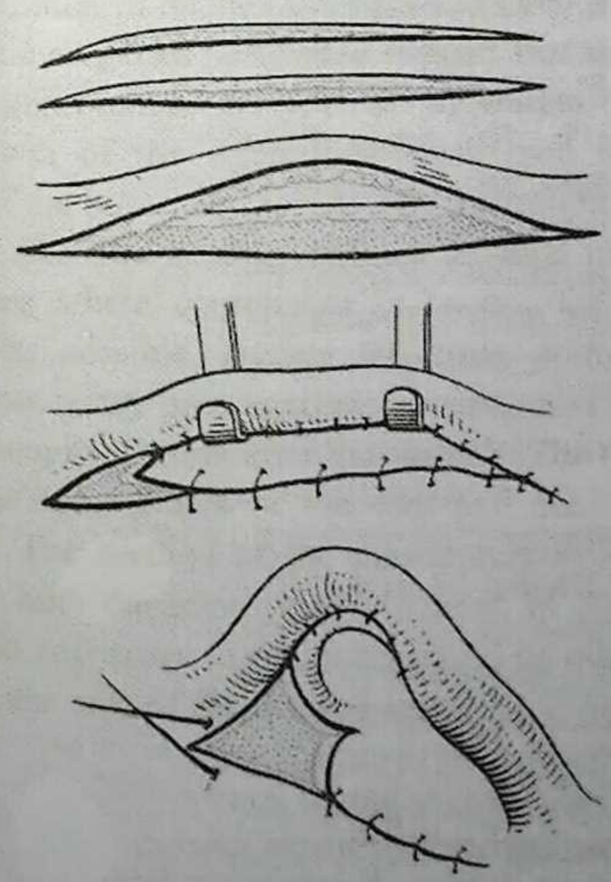


Figure 16.7. Formation of Filatovs stem.

In a month the distal crust is excised, the stem is made flatby a longitudinal incision along the transplant, keeping the regular thickness no less than 1 cm. In the thickness of the stem the scars are excised in the area of the heel bone and from the lateral surface of the heel which is then wrapped by the stem with the inclusion of the posterior surface. After attaining a stable survival of the graft (3-4 weeks) the proximal crust is excised, a procedure to flatten out the rest of the stem is performed, and then the cutting of the scars on the posterior plantar surface and in the area of the Achilles tendon completes the dermaplasty (Figure 16.7).

Chapter 17

MANAGEMENT OF PATIENTS' POST-BURN CONTRACTURES AND DEFORMITIES OF THE FOOT AND ANKLE JOINT

Post-burn contractures and deformities of the foot and ankle joint represent a relatively rare type of trauma. 101 patients were treated at the Inter-Regional Burn Center in Samarkand between 1990 and 1999. Long-term outcomes of the plastic surgeries performed suggest that the burn patient must be under constant observation in case of tightening scars or immature individual slow growth of the injured extremity and the development of secondary changes of the bones and joints. The operations must be performed within 6-12 months after the healing of burn wounds to prevent secondary changes. In the cases where contracture is severe, the operation must be performed as soon as possible. During this time, continuous conservative treatment serves as necessary preoperative preparation. This treatment should be continued in the hospital setting after the surgery. The results supported our classification of scar contractures of the foot and ankle joint according to anatomical location. The method of the plastic surgery operation should be chosen according to both the severity and location of the injury, using local uninjured tissues and soft scars to make trapezoid or other shaped flaps and free grafts placed on the area of the excised scars.

INTRODUCTION

Scar deformities of the foot and the ankle joint represent 5 to 7% of all post-burn deformities [1]. The dorsum of the foot and the ankle areas are injured more often [2-5]. Contact with burning sandal woods typically causes these burns [6-8]. The complexity of the anatomical and functional characteristics of the foot and the ankle joint as well as the absence of protective fat and muscular mass result in the frequent development of contractures with disturbance of the deeply located structures [9-11]. Trauma to an ankle joint affects the functions of the entire lower extremity (static posture maintenance, walking, etc.) and may cause spinal column and pelvis distortion and other structural abnormalities [12].

The experience of the Inter-Regional Burn Center in the rehabilitation and reconstructive surgery of burns suggests that post-burn deformities of the extremities represent a separate group of severe orthopedic diseases [13]. However, in contrast to inherited or acquired diseases of the locomotor apparatus, post-burn deformities are develop on the basis of skin deficiency and scar transformations. In this kind of pathology, problems involving the rehabilitation of lost skin coverage should be solved first and then interventions into deep tissue structures for rehabilitation and reconstruction of the locomotor system should be performed. At this time, insufficient attention is paid to the stage of rehabilitation of burn extremity pathology in patients when severe deformities of extremities developed as a result of deep tissue disturbances. It has been found that 75% of the Burn Center patients who had undergone deep burns needed rehabilitation and about 35% of patients needed surgical treatment. Investigators routinely consider these deformities to separate localizations as completed processes isolated from the general burn disease process. The significant number of patients undergoing surgical rehabilitation treatment after burns suggests that the conservative methods of therapy currently used are not effective. There are some studies on different aspects of the rehabilitation and reconstruction of post-burn extremity deformations in patients [14, 15]. Particularly, the problems of plastic surgery are widely discussed in the literature on burn treatment. However, there is no consensus about the selection of the method to treat burns on the basis of different localization and severity of deformity. These methods vary significantly for children and aged patients.

Considering that, the development of a rehabilitation system for patients with post-burn extremity deformities, ambulatory follow-up treatment, and home damages of these patients are problems of a particular significance, the

aim of the present study was to evaluate the different reconstructive surgery techniques in patients with post-burn contractures and deformities of the feet and ankle joints.

PATIENTS AND METHODS

Over a 10 year period, we have treated 101 cases and total number of 134 foot and ankle joint deformities were enrolled in the study. The cases of the burns included Sandal burns, 69 contractures (68.31%), flame burns, 8 contractures (7.92%), scalding, 8 contractures (7.92%), ash, 7 contractures (6.93%) and other burns, 9 contractures (8.92%). Of these cases, 79% were old contractures that had been tolerated for 1 to 5 years, while 21% were contractures that had been ongoing for 6 to 10 years. Of the patients, 57 (56.43%) were children between 2 and 14 years of age. The distribution of the different kinds of foot and ankle joint burns is presented in the table (17.1).

The secondary bone and joint changes associated with burn scar contractures were found in 29 patients; 18 had changes in bones, 7 had changes in the area of the ankle joint, and 4 had changes in the area of the metatarsal phalangeal joints. These patients basically were all children, who came back very late to the hospital for a new surgery because of the loss of ability for normal movement of their extremities.

There were contractures of a 1^{st}-2^{nd} degree in 48 cases, of a 3^{rd} degree in 74 cases, and of a 4^{th} degree in 12 cases.

Table 17.1. The main types of foot and ankle joint trauma

Positional deformity		Number of follow-ups		%
		Patients	Feet and ankles joint cases	
Isolated contracture of foot and ankle joint	Plantar flexion	8	12	9.0
	Lateral surface	5	7	5.2
	Dorsal flexion	4	5	3.7
	Whole ankle joint	5	8	6.0
Expanded extension contractures of the dorsum of the foot (digits, ankle joint)		42	51	38.0
Plantar surface of the foot		17	22	16.4
Distal part of the foot		20	29	21.7
Total		101	134	100

In 16 patients, isolated contractures along either the medial or lateral side of the foot resulted in supination or pronation deformities, respectively. If the scars expanded to a distal third of the dorsum of the foot and the contracture was not eliminated in time, not only did this limit digit flexion but dorsal subluxations and dislocations occurred (13 cases). The same kind of deformities developed after free skin transfer as well, when growth of the skin transplants or sutures/scars occurred later in an immature individual and as a result extension contractures of the toes developed.

RESULTS

Isolated contractures of the ankle joint. According to anatomical localizations, 12 contractures were categorized as dorsal flexion, 7 as lateral-margin, 5 as plantar flexion and 8 of the whole ankle joint (Table 17. 1). The scars limited motion in the joint which in turn decreases the patients' activity. In addition, the irregular position of the foot caused its secondary deformity. It was this factor that made performing early operations necessary. The first task was to bring the foot to the regular position. Location, degree of the scar contracture, the availability of adjacent uninjured skin will determine the type of plastic surgery operation needed for reconstruction. Insufficient amount of soft tissues in the area of the ankle joint and decreased elasticity of the skin make it difficult to perform local plastic surgery. This surgery was possible only in cases where folded and soft tightening tissues were available as a reserve of cover across the scar.

Dorsal contractures of the foot limited plantar flexion. Dorsal scars from 3rd to 4th degree burns can cause dorsiflexion contractures of the foot and ankle as great as 30-40° giving a clinical appearance of the foot being parallel to the leg.

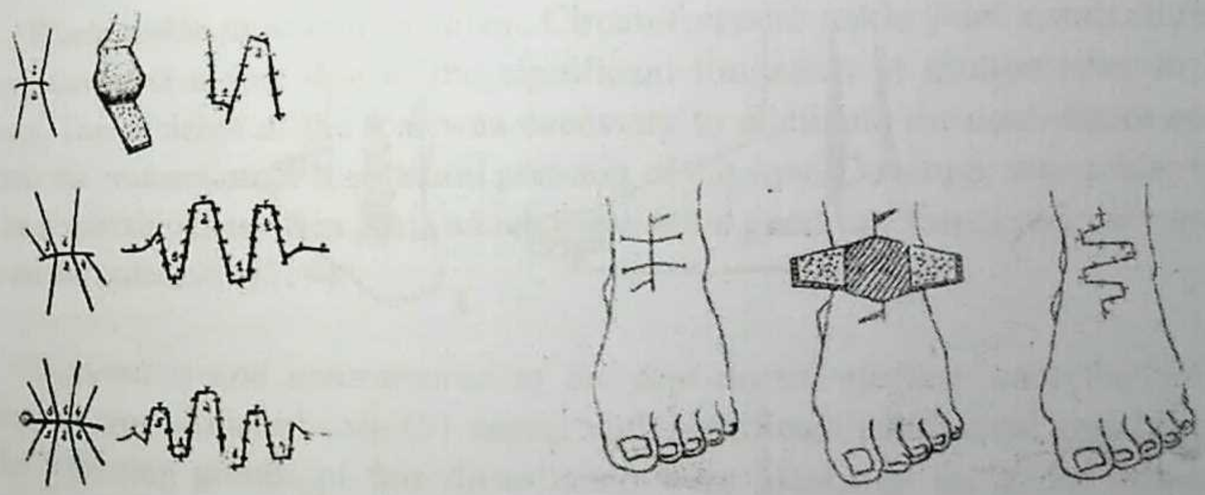
The extremity had little means of support. In all 12 cases, along the median of the extension surface of the joint, there was a marked fold which was formed in a flexion zone during the plastic surgery. Therefore, in 7 cases, sharp-angled flaps were cut from the layers of the surrounding skin according to the type of simple or multiple Z-plasty performed (Figure 17.1).

All subcutaneous connective tissues were included in the flaps. In the case of a significant adduction of the foot to the ankle, plastic surgery with only one or several trapezoid flaps or in combination with free skin grafts had the best probability to form the active zone by using local tissues. In 8 cases, avoiding

sharp angled cuts and using full-thickness adipofascial flaps helped to reduce flap necrosis in a majority of patients.

As the trapezoid flaps heal, the incisional scars eventually reduce becoming more elastic thereby decreasing tension. Good functional recovery and satisfactory cosmetic results were achieved for the group (of 7 patients). There were 4 cases of new scar formation of post trapezoid skin dermaplasty which were treated with trapezoid shaped (full thickness) skin grafts from the uninjured skin of the arch (of the ipsilateral foot). In cases of scar contractures with ulceration and without folding of the scars, the scars were excised in a diamond pattern then covered with a split thickness skin graft.

Lateral surface scars were observed in 7 cases. Scar tightening protruded on the anterior part of the ankle causing a lateral contracture. In these conditions, routine flap plastic surgery was the best method (Figure 17.2).



Panel A. The forms of two or multiple contrary oriented trapezoid flaps.
Panel B. Plastic surgery with contrary oriented trapezoid flaps on tightening scar tissues located on the anterior in step surface of the ankle joint.

Figure 17.1. Strategy of treatment for dorsal foot contractures.

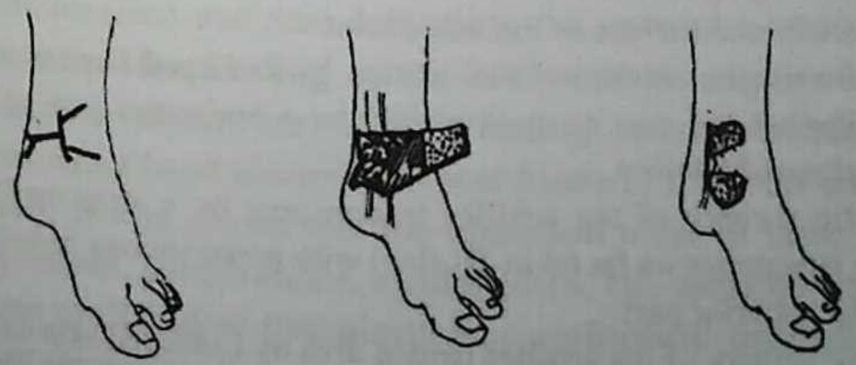
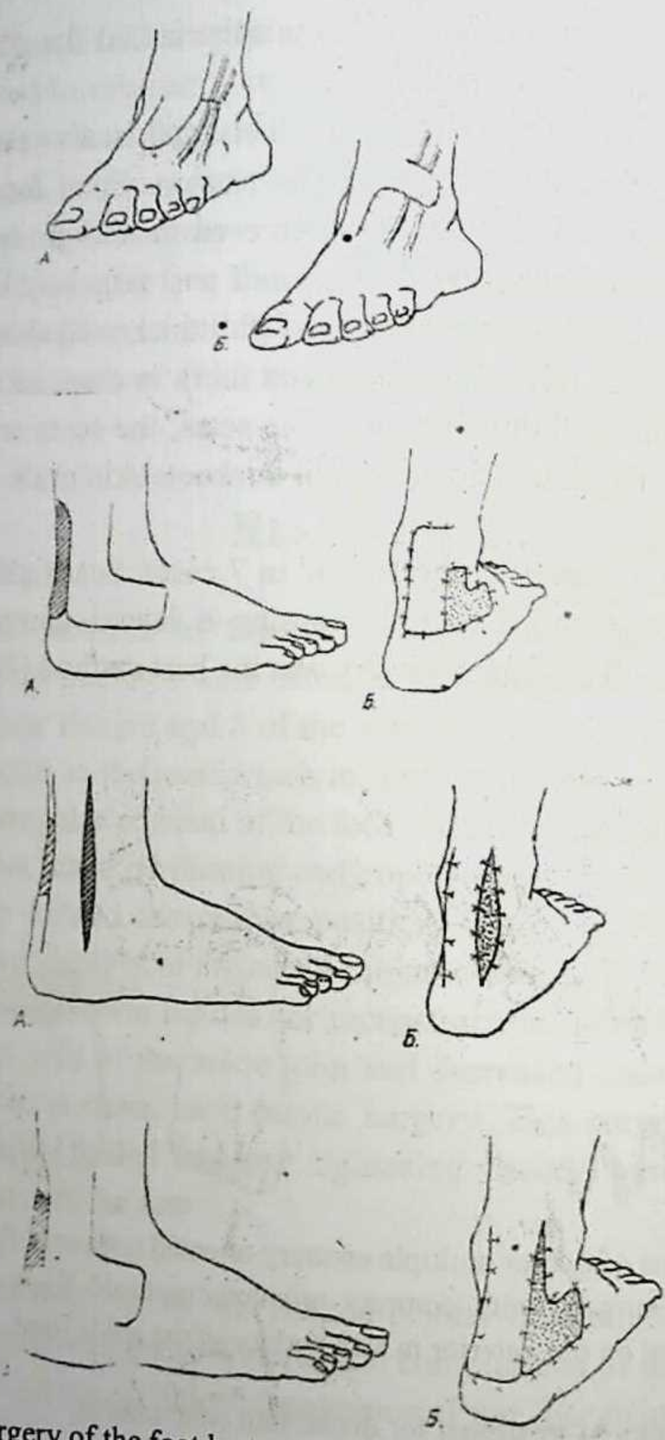


Figure 17.2. Strategy of treatment for lateral surface scars.



Panel A. Plastic surgery of the foot by tongue-shaped flaps in the location of tightening scars on the lateral surface of the ankle joint.

Panel B. Plastic surgery of the achilles tendon by L-shaped flaps in extensive ulcers. The achilles tendon was covered mainly by a horizontal part of the flap on the lateral surface of the foot.

Panel C. Plastic surgery of the achilles tendon area by a strip made from the skin including subcutaneous fat (skin-fat flap) with preservations of both pedicles in an ulcer of the superior part.

Panel D. Plastic surgery of the achilles tendon area by L-shaped skin-fat flaps.

Figure 17.3. Strategy of treatment for plantar flexion contractures.

Posterior heel burns causing plantar flexory foot contractures occurred more seldom (5 cases). Keloid scars damaged an area of calcaneal tendon in 4 patients. In 1 patient, deep burns caused a defect of the tissues in the mentioned area with an ulceration of scars. In the case of keloid scars with low risk of contractures, the operations were performed after conservative treatment and after the emerging of scar connective tissues. The scars were then excised and the wound was closed by free skin grafting. Regular skin coverage grew over it and after a long period of time there were no cases of contracture recurrence. In 4 patients with damaged tissues, partially involving the calcaneal tendon, L-shaped flap plasty on the lateral surface of the ankle and foot was used. The study of the features of the skins structure, blood supply and innervation of the talus area showed that soft tissues, located in the area of the external talus and lateral surface, are good plastic surgery materials for tendon covering (Figure 17.3).

Whole ankle joint contractures. Circumferential ankle joint contractures were the most severe due to the significant limitation of motion seen in 8 cases. The excision of the scar was necessary to eliminate the contracture and allow the restoration of the natural position of the foot. Coverage was achieved with a split thickness skin graft which provided a good functional recovery and cosmetic outcome (17. 4).

Deformities and contractures of the foot dorsal surface were the most frequent type of disturbance (51 cases) with significant anatomical variability. The following groups of this disturbance were identified as: a) an isolated injury to the dorsum of the foot; b) a disturbance with an extension of scars on the digits causing a contractual extension of the metatarsal-phalangeal joints with or without involvement of the ankle joint, and with or without syndactylous digits. In terms of surgical rehabilitation, it was important to prevent the development of a deformity of the foot bones. Therefore, at the beginning of subluxation and foot deformity, the operation was performed no later than 6 months after healing of the burn wounds occurred. First of all, functional disorders, distortions, and tightening tissues deforming the foot were eliminated using local tissues (soft scar tissue in the folds and tissue from the transfer site). It was shown that the operation must be done in one stage. All tightening tissues, subluxations, syndactyliae, etc. must be corrected at the same time. Free graft and/or flap plasty was performed, depending upon scar extension, scar thickness, tissue reserve in the folds, and the degree of the contracture.

Limited moderate deformation of the foot dorsum with a re-extension of the metatarsal-phalangeal joint was treated by elimination of the contracture. Soft scars and transplants were not removed but partially mobilized. Rough scars were partially or completely removed. Dermatome skin transfer was applied to the wound. It was important to relax the digits slowly. In extensive soft scars with protrusions going from the ankle joint of the digits, contracture was not clear. The reserve of tissues in the folds was a suitable material for the dermaplasty. In these cases the dermaplasty was based on the dispersal of protrusions and application of a tissue reserve across the scar in order to reduce the tissue tightening along the scar. Z-plasty performed in the area of tightening on different levels was the most appropriate technique for this purpose.

In cases of large rough scars causing contractual extensions of the III-IV degree with subluxation of digits and syndactylia, there appeared problems with footwear though static and dynamic functions of the foot were not disturbed. In these cases, pathological tissues were incised to the level of the metatarsophalangeal joints, thus imparting a line of distal incision of a dentate form. As has been done on the back side of the hand, plastic surgery of the commissures between the toes was performed using trapezoid and triangular grafts, which were cut out of the surface of the inter-digit space or of the lateral surfaces of the digits. These grafts were fixed with the free ends on the level of the heads of the metatarsal bones. Simultaneously, there was performed redressation, elimination of subluxations and dislocations of the digits which were gradually transferred into the position of plantar flexion under the angle from 60 to 90^0 in the metatarsophalangeal joints. The positions of the digits were maintained with retrograde Kirshner wires, particularly in III-IV degree burn contractures. If fixation with wires was not effective, toes were sewed through the nail phalanges by means of a thick ligature to the plantar surface of the foot. The technique was effective in eliminating dislocations and subluxations of digits in all patients. Developing wound defects occurred in some patients where more than 2/3 of the foot dorsum was closed by split skin transplants as thick as 0.3-0.4mm. In spite of the satisfactory functional recovery and cosmetic results achieved with this method we noticed that in the contracture of the toes of the IV degree with complete dislocation there was stretching on the side of the plantar surface on the level of the metatarsophalangeal joints and a redundancy of soft tissues occurred including skin with subcutaneous tissue swelling like a roller. Developing a reserve of tissues 2.5-4.0 cm wide is like an extension of a tissue strip going from the inner surface of the I and to the external surface of

the V metatarsal bone. Taking into consideration the presence of a tissue reserve on the plantar surface of the foot, the method combining skin plastic surgery and elimination of severe contractures of the foot was developed and used. After incisions of the massive scars on the dorsum of the foot, a strip of skin including subcutaneous tissues was cut on the plantar surface across the foot (in a transverse direction to the foot) with two nutrient pedicles on the level of the metatarsophalangeal joints. This strip was transferred above the lumen to the dorsal surface of the foot and was applied in a transverse direction closing the area of the metatarsophalangeal joints. The wound on the plantar surface was sutured without tightening. Nutrition from a bridge-like stem of this kind was carried out due to the corresponding arteries of the I and V digits.

Despite that the ratio of width to length of this stem was 1:4 there was no interruption of nutrition to the transferred skin-subcutaneous strip in any of the 10 performed surgeries.

The rest of the wound was closed by means of free skin transplantation. The described methods allowed the logical use of the reserve of plantar surface tissues to close the opened metatarsophalangeal joints with subcutaneous tissue. This provided faster rehabilitation of the motion in the digits and more favorable outcomes without a recurrence of contracture.

In 9 cases with a dislocation of 2-3 digits (I-III or III-V) plastic surgery was performed by cutting out the skin-flat plantar graft. The attached base of this graft was on the external surface of bone V or the internal surface of the metatarsal bone I and the free end above the metatarsal bone III. In all these cases, disturbance of blood circulation was not observed in grafts transferred to the dorsum of the foot. Untreatable dislocations of toe V were seen in 4 patients and the toes were amputated. Removal of II-V toes did not disturb functioning of the foot. However, removal of digits I disturbed rolling of the foot, therefore it was saved when possible. The following deformations of the dorsal surface were particularly difficult to treat: 1) tightening scars which went from the ankle joint to one of lateral surfaces, 2) development of deformities of the bones and joints, and 3) disturbance of the foot bones formation and growth. Deformations of this type formed during the 6 to 18 months after a serious burn of the foot sole surface (17. 5).

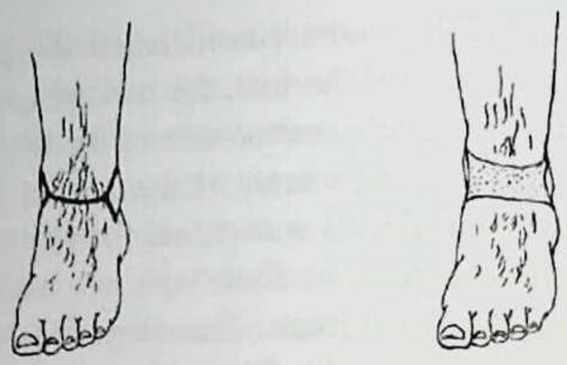
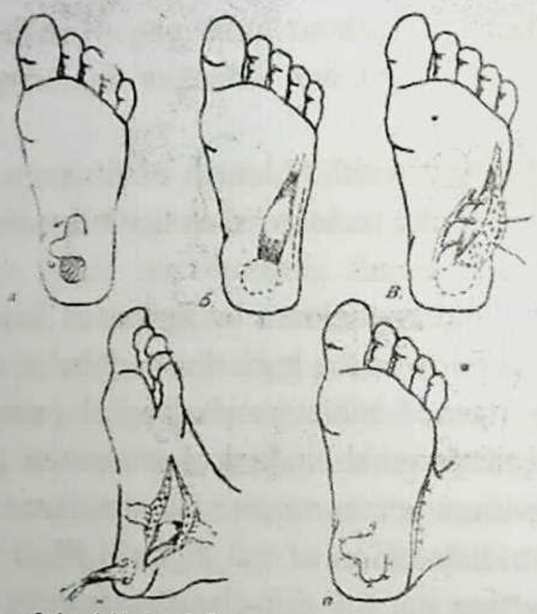


Figure 17.4. Strategy of treatment for a whole ankle joint contracture.



Panel A. Ulcer and lines of the bilobed flap.
Panel B. The muscle abducting digit V and its blood supply.
Panel C. Mobilized muscle is carried on through the tunnel into the wound on the heel.
Panel D. Plasty covering the muscle by bilobed flap.

Figure 17.5. Double plasty in a deep ulcer of the heel.

The first step to treat these deformities was to reinstate the weight-bearing ability of the foot and extremity. This required the use of an entire battery of orthopedic procedures. After incisions of the scars, a rebandage of the foot was performed. If a 90° angle between the plantar surface and the ankle plane was not achieved, then closed or opened osteotomy of the foot bones was performed on the basis of the most developed deformity. The foot was then set in regular position and finally a cast was applied in the position of hypercorrection. Developed wounds were closed by means of postponed skin plastic surgery. After the skin transplants took root (3 to 4 weeks after the operation), a new cast was applied until the complete fixation of the osteotomy bones in the corrected position (2 to 3 months).

Trauma to the plantar surface of the foot with the development of scars and deformities (22 cases) resulted from sandal burns or contact burns (asphalt and ash burns). This resulted in various degrees of digit flexion, sometimes to a complete symphysis of one or several digits to the plantar surface (7 cases). If these deformities lasted longer than 18 months, then not only the disturbance of static posture and walking occurred but also different kinds of deformities of the bones and joints developed such as beak-like or sickle-like deformations of the foot. In 7 patients, isolated scar disturbances of the plantar surface of the foot caused significant problems because there was always a deficit of soft tissues suitable for plastic surgery in this area and also because the scars expanded around the area. In addition, skin which is capable of bearing high pressure is needed on the plantar surface.

In the absence of bone deformities of the foot, free skin transplantation was performed. Rough, plane, and ulcerous scars were incised on a whole expansion. Wound margins were given a broken shape. The wound defect developing in 24-48 hours was covered by a skin transfer 0.5-0.6 mm thick. At the same time, flexion contractures of digits were treated by means of overextension by 30-40°.

If scars on the area of the heel or in the zone of the distal part of the forefoot area were located directly under the bone, a long stem-like skin plate (Filatov graft) was used. In 8 such cases, both affected joints were covered with one Filatov graft (Figure 17.6).

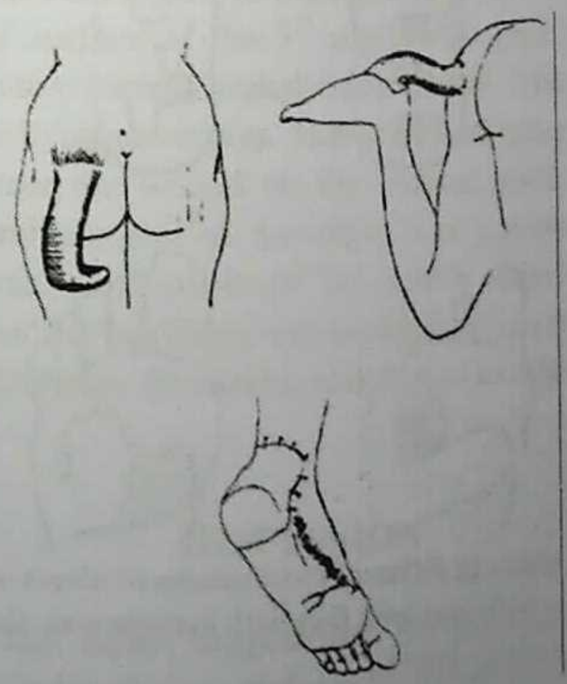
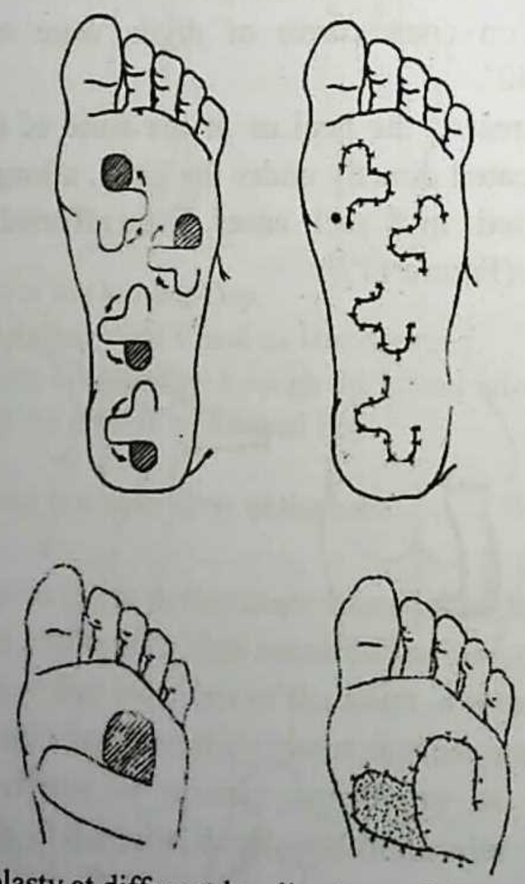


Figure 17.6. Filatov graft.

After taking root on one foot, the transfer was undercut from the leg and then its free end was implanted on the plantar surface of the other foot. The present method allowed the shortening of the stages of operative interventions and facilitated the healing of the wounds of the other foot. This also decreased the amount of time in the immobilized position and facilitated graft migration. Using skin-fat tissue transplants also secured the further correct development of the foot bones.

In 2 patients, plastic surgery was performed with bilobed skin-flat flap to eliminate shallow defects of the surface, when located in the areas of the main exertion of the foot (heel, heads of metatarsal bones). The larger lobe was applied to the wound formed after the incision of ulcerated scars, the smaller lobe of the donor wound covering the wound from which the larger lobe was taken. This method of plastic surgery made it possible to extend tissues onto a large area. This results in complete recovery of the skin, is resistant to exertion, and without atrophy or newly formed scars (Figure 17.7).



Panel. A. Bilobed flap plasty at different localizations of ulcers on the plantar surface.
Panel B. Plastic surgery with one-lobe flap with average size ulcers located in the area of heads of the metatarsal bones.

Figure 17.7. Strategy of treatment for plantar surface burns.

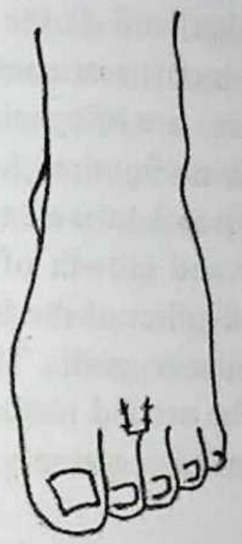


Figure17.8. Strategy of treatment of inter-digital symphysis Pi - form (like gate).

The distal part of the foot was injured in 29 cases. Inter-digital symphysis was eliminated by means of local tissues (II-form, like a gate (Figure6), trapezoid, triangular grafts) transplantation (16 cases). These therapies made it possible to eliminate flexion contractures of the digits and to make a cover on the plantar surface which did not interfere with foot development and reinnervation of the skin and gradual increase of exertion.

The skin becomes stable with time when there was symphysis of digits I and V of the foot plantar surface, when combined skin plastic surgery was performed (13 cases). Full thickness skin grafts of the medial surface of the hallux or the lateral surface of the 5th digit was used for coverage of the deficits in the respective metatarsophalangeal joints. The digit was set in the position of moderate hypercorrection. The graft was transferred to the formed wound defect to cover the wound on the plantar surface of the digit. The wound on the lateral surface of the digit was covered with a free skin transplant. There was no necrosis of the grafts after this procedure. The successful outcome of the operation was secured by covering the main area of the wound with healthy skin-fat tissues, resistant to exertion.

DISCUSSION

The results of this report suggest that the outcomes of plastic surgery treatments of burn induced foot and ankle deformities depend on: 1) the localization of scar contractures; 2) the depth of injury; 3) the presence of local

uninjured skin for reconstruction, and 4) the presence of osseous injury or osseous changes secondary to chronic scar contractures.

In Middle Asia, sandal burns are of special interest. Most of the patients with sandal burns have lower-limb injuries. After skin grafting these patients require a special treatment protocol as well to avoid post burn contractures which can affect the mobility and growth of the extremities. However, the basis for plastic surgery rehabilitation of the lost skin coverage of the foot is free skin transfer and the Filatov graft. The first is used to treat foot deformities in any location. The second method is used in cases of exposed bones and joints, in cases when it is necessary to eliminate tissue defects, and also in cases of osteotomy.

In summary, from the outcomes of the operations we came to the conclusion that the burn patient must be under constant observation in case of tightening scars or slow growth of an injured extremity and development of secondary bone and joint contractures. The operations must be performed within 6-12 months after the healing of burn wounds has occurred in order to prevent secondary changes. In the case where the contracture is severe the operation must be performed as soon as possible.

During this time, continuous conservative treatment serves as a necessary preoperative preparation. This treatment should be continued in the hospital setting after surgery.

According to the severity of the contractures, four categories were identified by [16]: mild, moderate, severe and mutilated type. Most of those burns were to the dorsal side of the foot and selection of the treatment method was based chiefly on the severity of the trauma. Patients admitted to The Inter-Regional Burn Center of Samarkand had a much larger variety of burn localizations. The results confirmed the usefulness of our classifications of the scar contractures of the foot and ankle joint according to anatomical localization. Therefore, the method of treatment should be chosen according to both severity and localization, using local uninjured tissues and soft scars to make trapezoid or other shaped flaps and free grafts placed on the area of the excised scars.

REFERENCES

[1] Povstyanoi, N.E. (1973).*Surgical Rehabilitation of Burn patients.* Moscow: Meditsina.

[2] Tursunov, B.S. (1988). Medical Rehabilitation of Children. Burn Reconvalescents with Trauma of Locomotor Apparatus. *Thesis of Doctor of Medicine*. Moscow, 386.

[3] Khodzhakulov, ChR., Fazlitdinov, N.& Sakhabutdinov, G. (1991). The surgical postburn deformities of the foot and ankle join. *Klinicheskaya Khirurgiya*, No 12, 34-35.

[4] Liang, M.D. et al. (1998). Presuturing – a new technique for closing large skin defects: clinical and experimental studies // *Plast. Reconstr. Surg.* Vol. *81*, No 5, 694–702.

[5] Guild, S. (2001). A new splinting approach for dorsal foot burns. *J Burn Care Rehabil,22*, 454-456.

[6] Shakirov, B.M. (2004). Sandal burns and their treatment in children, *J.Burn Care Rehabil,25*, 501-505.

[7] Shakirov, B.M.& Tursunov, B.S. (2005). Treatment of severe foot burns in children. *Burns*, Vol.*31*, No7, 901-905.

[8] Shakirov, B.M., Tursunov, B.S.& Tagaev, K.R. (2006). Treatment of sandal burns in children. British trauma society annual clinical meeting. *Abstract book*, October 12-13, 0145.

[9] Yudenitch, V.V.& Grishkevitch, V.M. (1986).*Guide to the Rehabilitation of Burn Patients*. Moscow: Medicine, 364.

[10] Mikhailov, I.A.& Popov, S.V. (1992).*Surgical treatment of the results of foot burns*. Paper presented at the International Conference "Intensive Treatment of Severe burn Patients". Moscow, 284-286.

[11] Suchanek, I., Rihova, H.& Kaloudova, Y. et al. (2004).Reconstructive surgeries after extensive burns in children. // *Acta. Chir. Plast,45*, 139–43.

[12] Mirazimov, B.M., Tursunov, B.S.& Grishkevitch, V.M. (1991). Postburn Deformations of Extremities in Children. Tashkent: Ibn Sino Publishing House, 342.

[13] Shakirov, B.M., Tursunov, B.S.& Tagaev, K.R. (2005). Surgical treatment after-burn contracture of the dorsal foot surface. *J. Annals of reconstructive plastic and cosmetic surgery*,No 4, 160-161.

[14] Erdogan, B., Gorgu, M., Girgin, O., Akoz, T. & Deren, O. (1996). Application of external fixators in major foot contractures. *J Foot Ankle Surg,35*, 218-221.

[15] Steinwender, G., Saraph, V., Zwick, E. B., Uitz, C. & linhart, W. (2001). Complex foot deformities associated with soft-tissue scaring in children. *J Foot Ankle Surg,40*, 42-49.

[16] Shakirov, B.M. (2010). Evaluation of different surgical techniques used for correction of post-burn contracture of foot and ankle,No3, 137-143.
[17] Leung, P. C. & Cheng, J. C. (1986). Burn contractures of the foot. Foot & Ankle, *6*, 289-294.

Chapter 18

SURGICAL TECHNIQUES USED FOR THE CORRECTION OF POST-BURN CONTRACTURES OF THE FOOT AND ANKLE

Post burn contractures and deformities of the foot and ankle joint are distressingly common and severe in developing nations and are of a significant problem in developed countries as well. Functional disturbances of the foot and ankle joint affect the functioning of the entire lower joint, its mechanics, and the patients gait and bearing, and can even lead to a distorted pelvis, curvature of the spine and other disturbances.

Between 1990 and 2002 we treated 69 cases and a total number of 76 foot and ankle joint deformities were enrolled in the study. The choice of plastic surgery operation was made on the basis of the severity and localization of the injury in the area of the excised scars.

We observed the follow–up during a period of 1 to 8 years in 57 patients with burn deformities of the ankle (82. 6% of all of the observed patients in the clinic). In 41 (71.9%) patients the deformities were completely eliminated in 13 cases (22.8%) the results were satisfactory and three patients (5.3%) had poor results.

The victims of a burn in the ankle joint must be kept under constant examination if scaring is present, because of the danger of retarded growth of the burned foot joint and the development of secondary bone-joint changes. Earlier surgery is advised depending on the severity of the contracture.

INTRODUCTION

The anatomic-functional specifics of the foot-ankle joint marked by the complexity of its structure, an absence of protective adipose and muscular tissue, resulted in contracture with an injury of the deep-foot structure after deep burn traumas [1-4].

Functional disturbances of the ankle joint may severely affect posture and gait, and can even lead to distortion of the pelvis, curvature of the spine, and other disturbances [5]. Until recently little attention has been paid to rehabilitation surgery of post-burn deformities of the foot and ankle joint.

Serious deformities of the foot and ankle joint may occur especially in children after sandal burns [6]. Sandal burns are characterized by such severe deep injuries because of close contact of the body with live coals or wood and include not only skin injuries of various depths but also injuries to the underlying tissue: subcutaneous fat, fasciae, muscles, and even the bones.

Most surgeons assess scar related joint contracture using a scale proposed in 1946 [7] which reflects the severity of the joint dysfunction [8].

Ankle joint contractures are classified into four different degrees in reference to the neutral position of the foot. The amplitude of ankle movements is taken into consideration as a basis, normally equal to 65-80° i.e. 40 - 50° of plantiflexion and 20 - 30° of dorsiflexion. The extent of the contracture is determined in relation to the limitation of movement expressed in degrees.

The creation of a rehabilitation system for patients with post-burn extremity deformities, for outpatient follow–up treatment, and for home therapy is thus a problem of particular significance. The aim of the present study was to evaluate different surgical reconstructive techniques in patients with post-burn contractures and deformities of the ankle joints. Although the literature has much to say on the various issues of rehabilitation and reconstructive surgery in the treatment of post burn foot deformities [9,10] and although surgical techniques are widely described in the literature, different opinions exist with regard to the choice of methods, depending on the defect, its severity, and the patient's age.

In the light of these considerations, it is clear that the development of a rehabilitation system for such patients is of critical importance.

PATIENTS AND METHODS

Between 1990 and 2002 we have treated 69 such cases for a total number of 76 foot and ankle joint deformities that were enrolled in the study. The cases of the burns were as follows: sandal burns 38 - (55%); flame, -11 (15.9%); scalds, - 6 (8.7%); chemical, - 4 (5.8%); ash, - 6 (8.7%) and electricity, - 4 (5.8%). Among all the cases, 46 were old contractures persisting for 1 - 5 years, while 23 were contractures existing for 6 – 10 years.

First and second degree contractures were observed in nine cases, third – degree in 42 cases, and fourth - degree in 18 cases. Marked deformities of the bone-ankle joint were observed in 23 patients, with changes in the form and slow growth of bones in the foot ankle joint with a deformity. Eighteen out of the 76 cases of burns (23.7%) occurred in patients up to 5 years of age, 28 cases (36.8%) in patients 6-14 years old, and 30 cases (39.5%) in patients over 15 years old.

The main types of burn aftereffects of the foot-ankle joint are presented in Table 1.

RESULTS

Isolated Contracture of the Foot–Ankle Joint

Scar contracture varies, depending on its location. Using anatomical principles we distinguished the following contractures of the foot-ankle joint: dorsiflexion (9 cases), lateral surface (7), plantiflexion (5), and whole ankle joint (7). The main aim is to correct the position of the foot. The type of plastic surgery operation was determined in relation to the location and spreading of the scars, the degree of contracture, and in the skin located nearby.

Dorsiflexion

Dorsal scars due to third and fourth degree burns can cause dorsiflexion contractures of the foot and ankle as great as 30-40° limit plantar flexion and give a clinical appearance of the foot being parallel to the leg. Our patients walked on their heels as the joint gave less support. In five cases we cut the pointed flaps according to simple or plural Z-form plasty. The flaps included the subcutaneous tissue. However, we found that this operation was more indicated in mild contractures.

Table 1. Type of after effect

Position of deformity of patients	Patients	Feet and ankles joint cases	Percent %
I Isolated contracture of foot-ankle joint	25	28	36.84
1. Dorsal flexion	8	9	11.84
2. Lateral surface	7	7	9,.21
3. Plantar flexion	5	5	6.58
4. Whole ankle joint	5	7	9.21
II Extended contractures of the dorsum of the foot (digits, ankle joint)	44	48	63.16
Total	69	76	100%

Trapezoid flap plasty, either of the pure type or in combination with free skin transplantation (4 cases), was found to be the best method for creating an active zone (in the ankles) from local tissue. Our operation technique was to divide the sheets of flaps, to fold by a longitudinal cut along its crest, and then to cut out trapezoid flaps, starting from the middle of the line or from the line of the joint flexion. The ends of the cuts were given a fork-like form for more complete elimination of tightening and better function of the wound margins with the ends of the grafts. The grafts were moved towards each other and sutured by touching sides. If tightening was not eliminated completely, another pair of grafts was cut out (Figure 18.1).

Flaps and sheets of scars that were not included were either removed or used as approaching triangular flaps for dermaplasty. In the follow–up periods the scars became thinner, softer and more elastic due to the elimination of tightening. The borders of the replaced flaps became smooth and only slightly marked.

LATERAL CONTRACTURE

In seven cases the scars were located on the lateral surface of the ankle joint, occupying the entire area of the ankle and can achieve an anterior-median line of the joint. The greatest scarring defect was at the margin at the point of transition to healthy skin. It was at the anterior margin that the largest extent of tissues in the flexion of the joint occurred. Owing to constant traumatization during the growth of connective tissue, scar contracture

continued and as a consequence the margin of the scar protruded, involving healthy skin and forming a fold.

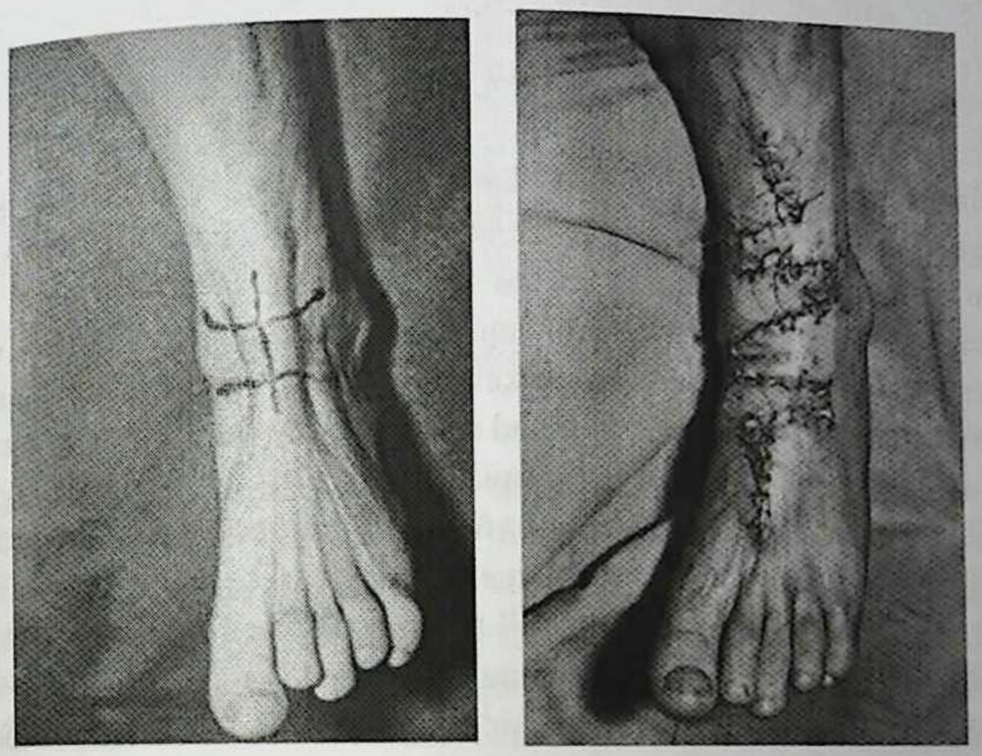


Figure 18.1. Patient A, Pre-operative scar contracture and result after surgery.

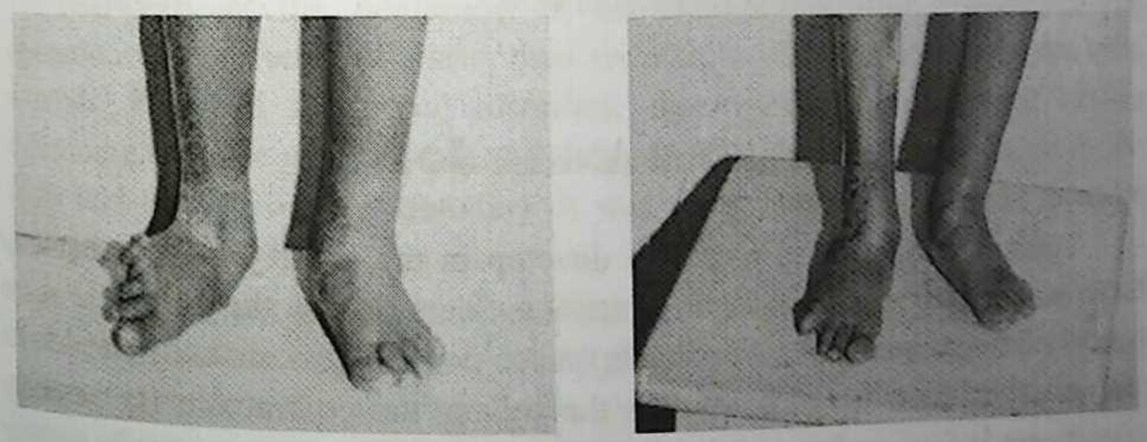


Figure 18.2. Patient B, Pre–operative deformity and post-operative result.

The tissue was stored in the thickness of the folds and the scar sheets were deficient in length. This is what caused the contracture.

The best method was routine flap plasty. By practicing a horizontal cut, the scar sheet was separated from the healthy skin and the scars were cut in a direction toward the ankle and passed around it like a fork. We cut a full-thickness graft from the healthy skin and used this to close the injury in the

scar zone. In this way the graft was full bodied and it grew together along with the youngster, thus preventing a relapse of the contracture (Figure 18.2.).

PLANTIFLEXION CONTRACTURES

Plantar flexible deformations of the ankle joint were the result of burn damage to the posterior surface of the shin with involvement of the Achilles tendon in the process, leading to the development of equine foot. When standing or walking, patients with equine foot exert their weight on the anterior section. Out of five cases of keloid scars, one patient had injuries in the zone of the heel tendon and four had suffered deep burns with tissue defect in the affected zone in addition to ulcerous scars.

The operation was performed after the conservative treatment and maturation of the scars connective tissue. In such cases, with tissue defects in the area of the tissue of an injured heel tendon, we used L-shaped flap plasty from the lateral surface of the ankle and foot. We then cut the scars with the ulcer over the tendon. On the lateral side of the distal third of the ankle and foot, near the injury, we cut the skin-fatty graft and closed the injury and heel tendon from three sides with it. On the wound where we have taken the graft from we placed a free transplantation of skin.

WHOLE ANKLE JOINT

Thick keloid scars do not often develop in the ankle joint area but they may cause dysfunctions and malformations. Scars tighten the joints and cause sharply limited movements (7 patients). Such contractures are considered to be the most difficult. It is known that the tighter the contracture is, the more significant is the crooking of the foot to that side. There is practically no free scar on the whole width, for which reason the chosen method of operation was to cut the scars until full elimination of the contracture, followed by reconstruction of the natural foot position with free split-skin transplants. As a result, the skin lining grew, providing a good functional and cosmetic outcome (Figure 18.3).

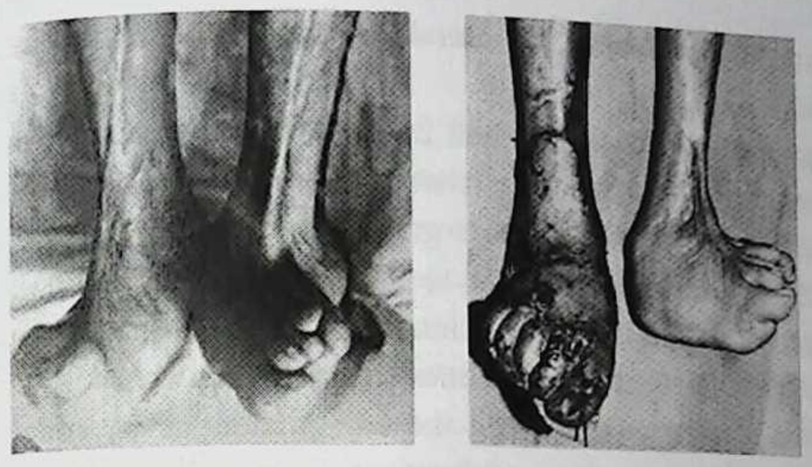


Figure. 18.3. Patient C, Pre –operative deformity and post-operative result.

Extended contractures of the dorsum of the foot (digits and ankle joint) is the most frequent type of disturbance (48 cases) with significant anatomical variability. The following groups of this disturbance were identified as: a) an isolated injury to the dorsum of the foot; b) a disturbance with extension of the scars on the digits causing a contractual extension of the metatarsal-phalangeal joints with or without involvement of the ankle joint and with or without the syndactylous digits. In terms of surgical rehabilitation, it was important to prevent the development of a deformity of the foot bones.

Therefore, at the beginning of subluxation and foot deformity, the operation was performed no later than six months after the healing of the burn wounds. First, all functional disorders, distortions, and tightening tissues deforming the foot were eliminated using local tissues (soft scar tissue in the folds and tissue from the transfer). It was shown that the operation must be done in one stage.

All contracting tissues, subluxations, syndactyliae, etc. must be corrected at the same time. Free graft and/or flap plasty was performed, depending upon the scar extension, the scar thickness, the tissue reserve in the folds, and the degree of the contracture (Figure 18.4).

Patients with large rough scars causing third / fourth degree contractual extension with subluxation of the digits and syndactylia had a problem with footwear, although the foot mechanism and dynamic functions were not disturbed. In these cases, pathological tissues were incised to the level of the metatarsophalangeal joints, thus creating a line with a rough distal incision. As this was usually done on the back of the hand, plastic surgery of commissures between the toes was performed using trapezoid or triangular grafts, which

were cut out of the surface of the inter-digit space or out of the lateral surfaces of the digits.

These grafts were fixed with their free ends on the level of the heads of the metatarsal bones. Simultaneously, redressation, elimination of subluxations and dislocations of digits which were gradually transferred into the position of the plantar flexion at an angle of 60 to 90° in the metatarsophalangeal joints. The position of the digits were maintained with retrograde Kirshner wires, particularly in III-IV degree burn contractures. If fixation with wires was not effective, toes were sewed through the nail phalanges by means of a thick ligature to the plantar surface of the foot. The technique was effective in eliminating dislocations and subluxations of the digits in all patients. Developing wound defects in some patients taking up more than 2/3 of the foot dorsum were closed by split-skin transplants 0.3 0.4 mm thick (Figure 18.5).

Figure 18.4. Patient E, Pre–operative deformity and post-operative result.

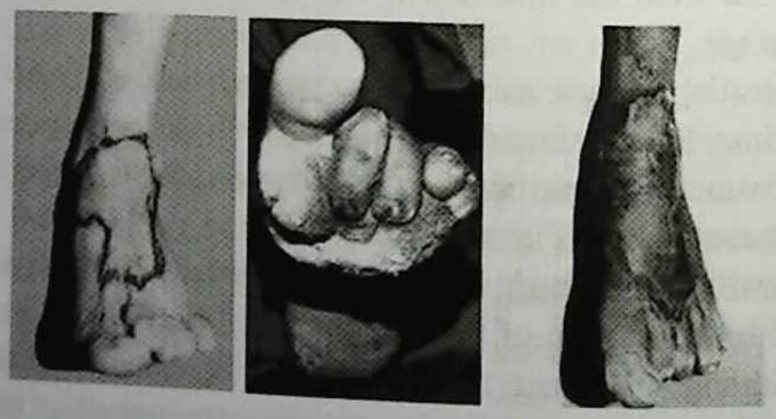


Figure 18.5. Patient D, Pre–operative deformity and post-operative result.

The most recent results of rehabilitative and reconstructive treatment in the foot area were taken from the outcomes of the operations performed and immediately before the patients were discharged from hospital. The

anatomical aspects of the elimination of the deformities was taken into consideration.

As a shown in the Table 2 in 71.05% of all cases the contracture of the foot-ankle joint was completely eliminated and the conditions necessary for the rehabilitation of the injured ankle were ensured. There was improvement after burn treatment or secondary changes due to inflammatory processes and foot inactivity due to its wrong position; in 3.95% there was not improvement. Negative results were due to deep tissue defect, irreversible changes in the bone-joints, late assistance of medical aid, and post-operative effect. We did not observe any ulceration of the skin grafts.

The follow–up results over one to eight years in the 57 patients with burn deformities of the ankle joint (82.6% of the total number of follow–up patients in the clinic) were estimated. In the evaluation of the follow–up results of the operative treatment of the ankle joint burn deformities we considered it to be a good result if the patient had no disturbances, the extremity was correct in form, the joint presented an adequate amplitude of movements, and the transplanted graft was similar to normal healthy skin.

Table 2. Results

Types of injury	Patient's quantity change	Good		Better		Without Changes	
		Quantity	%	Quantity	%	Quantity	%
I. Isolated contracture of foot-ankle joint	28	19	67.86	8	28.57	1	3.57
1.Dorsal flexion	9	8	42.11	1	12.5	-	-
2.Lateral contracture	7	4	21.05	3	37.5	-	-
3.Plantar flexion	5	4	21.05	1	12.5	-	-
4. Whole ankle joint	7	3	15.79	3	37.5	1	100
II. Extended contractures of the dorsum of the foot (digits, ankle joint)	48	35	72.92	11	22.91	2	4.,17
Total	76	54	71.05	19	25.,00	3	3.95

The result was considered to be satisfactory if the form and functions of the extremities were considerably improved but physiotherapeutic measures or

some small additional operations were necessary. If there were recurrences of the contractures and the patients needed serious operative interferences due to the impairment of functions after the operations that were performed earlier, follow–up results were considered to be bad. In 41 (71% of cases) patients the deformities were eliminated completely, in 13 (22.8% of cases) the results were satisfactory and in 3 (5.26%) patients the results were bad.

DISCUSSION

The high percentage of patients who underwent post burn reconstructive surgical treatment indicates poor effectiveness of conservative methods of therapy used today [11-13]. A permanent maintenance system of burn rehabilitation reduces the disablement among patients who recovered. Controlling the dynamics of a scar change development, makes it possible for patients to escape severe post-burn effects, which can be prevented only by reconstruction or rehabilitation surgery [14, 15]. Yuldashev suggested that operative treatment of the ankle joint contracture ought to be early and must be performed by six months after the healing of the burn injury. Azolov et al. [16] recommend performing the operation in 2 stages: at first the scars on the anterior surface of the joint area are removed then on the posterior one or vice versa, with a 5-6 month interval.

There are various studies in the literature on different aspects of the rehabilitation and reconstruction of burn extremity deformations in patients [17-19].

Owing to the spreading of scars and the functional disorders they cause [20], post burn contractures of the foot and ankle joint and the back of the foot were divided into four degrees, on the basis of the results in 85 patients.

These results suggest that for treatment of the deformities of the ankle-joint, induced by burns, a method of differential plastic surgery should be used depending on 1) the localization and expansion of scars, 2) the presence of skin, and 3) the presence of bones that are not injured or changed.

The patients with ankle joint deformities must be monitored carefully if there are scars and there is the possible danger of slow growth of the burned foot joint and the development of secondary bone-joint changes. Early surgery is advised depending on the severity of the contracture.

The analysis of burn after-effects and their dynamics in patients allowed us to determine the group of patients who must be rehabilitated:

- patients with a limited deep burn of the foot-ankle joint;
- patients with a deep burn or burns of the III degree in the foot-ankle joint;
- patients with a deep burn even if they have no disjunction of the skeletal muscular apparatus, on discharge from the hospital but having a loss of skin surface in the foot-ankle joint.

The experience obtained proves the fact that children of the above mentioned categories should be taken in for clinical observation for a long period of time until the end of growth (18-19 years) even if there is no initial burn deformities in the foot-ankle joint [21-22].

The reason for this lies in the regularity of the fact that during the child's growth, scar growth falls behind. The loose scars and scar fields invisible when the patients are discharged from the hospital and having no effect on the foot ankle joints in the first 2 --3 years may change due to tightening of the scars and the restriction of movement in 5-6 years and more after the original burn trauma and as a result can become the cause of the formation of serious secondary deformities and the development of sprains and bone dislocations. When the joint is slow in growth; the bones become crooked causing damage of and dysfunction of the extremities.

The main role has to be played by rehabilitation centers, where all methods of treatment are available (medical and physical training, ultrasound, kinesiology, radone and other medical (pirogenal, lidazi, triamthinolana) and physical treatments (ultrasound, magnetic waves, compressionbalneotherapy, radon and hydrogen sulphide baths).

REFERENCES

[1] Mikhailov, I.A.& Popov, S.V. (1992). Surgical Treatment of the Results of Foot Burns. Paper presented at the International Conference «Intensive Treatment of Severe Burn Patients», Moscow, 284-286.

[2] Yudenich, A.A., Mikhailov, I.A.& Sarigin, P.V. (2002).*The Surgical Treatment of Post-Burn Scar Deformities of Foot-ankle Joint and Foot.* Materials of International Conference "The Actual Problems of Thermic Injury, dedicated to 70th anniversary of S.R.I.", Saint-Petersburg, 461-462.

[3] Moroz, V.Y., Adamskaya, N.A.& Knaz, V.A. et al. (2006).*Computer Modeling in Reconstructive Surgery, The First Medical Aid.* Materials of

International Conference. "The Actual Problems of Thermic trauma named" after. I.I Djenalidze. Saint-Petersburg, June 20-22, No3. 244-245.

[4] Sakirov, B.M. (2008).*Plastic surgery operation with post burn contractures and deformities of the foot and ankle joint*. Abstract book. The 14th congress of the International Society for burn Injuries, Canada,97.

[5] Mirazimov, B.M., Tursunov, B.S.& Grishkevitch, V.M. (1991).*Post-burn Deformities of Extremities in Children*. Tashkent: Ibn Sino Publishing House, 342.

[6] Shakirov, B.M. (2004). Sandal Burns and their Treatment in Children. *J. Burn Care Rehabilitation. 25*, 501-505.

[7] Parin, B.V. (1946). Operative treatment of scar contractures – Molotov: regional Public House, 71.

[8] Dmitriev, G.N. (2000).*Reconstruction-Rehabilitation Surgery of Burn Effect*. (Consequences). Materials of International Congress "Combustiology on the Century Boundaries" Moscow, October 9-12,192-193.

[9] Shuchanek, I., Rihova, H., Kaloudova, Y.& Mager, R. (2004). Reconstructive Surgeries after Extensive Burns in Children. *Acta. Chir. Plast,45*, 139-143.

[10] Schneider, J.C. et al. (2006). Contractures in burn injury: defining the problems // *Burn Care Res,27*, 508–514.

[11] Amarante, J., Costa, H.& Keis, J. et al. (1986).New distally based fascioculaneous flap of the Ieg // *Bril.J. Plast. Surg.*, Vol. *39*, No3, 338–340.

[12] Lee, Y., Minn, K.W.& Baek, R.M. (2001). A new surgical treatment of keloid: keloid core excision // *Ann. Plast. Surg.*, Vol.*46*, No2, 135–140.

[13] Yudenich, A.A., Mikhailov, I.A.& Sarigin, P.V. (2002). The Surgical Treatment of Post-Burn Scar Deformities of Ankle-Foot-Joint and Foot. Materials of International conference «The actual problems of Thermic trauma» dedicated to 70th anniversary of SIR. *Saint-Petersburg*, 461-462.

[14] Mustal, T.A. (2004). Scars and Keloids. *BMJ*, *328*, 1329-1330.

[15] Yuldashev, K.Y. (1985). Analysis of the results of treatment in children with post-burn ankle joint and foot deformities. // *Injuries and diseases of lower extremities*. Collection of scientific works. Tashkent Medical institute. – Tashkent, 144-149.

[16] Azolov, V.V., Dmitriev, G.I.& Ghegalov, V.A. et al. (2002). Rehabilitation stages of patients with severe burns. // Materials of International Conference "Actual problems of thermic trauma" devoted to 70 years of SRI of urgent medical care named after I.I. Djanelidze a 55 years of Burn center. Saint Petersburg, June 27-29, 405-406.

[17] Guild, S. (2001). A new splinting approach for dorsal foot burns. *J Burn Care Rehabil,22*, 454-456.

[18] Steinwender, G., Saraph, V., Zwick, E.B., Uitz, C& Linhart, W. (2001). Complex Foot Deformities Associated with Soft-tissue Scarring in Children. *J. Foot- Ankle Surg,40*, 42-49.

[19] Shakirov, B.M., Tursunov, B.S.& Tagaev, K.R. (2004). Problems of Rehabilitation of Post-Burn Reconvalecence. *J. Allergology and Immunology*, Moscow, March, No1, 176.

[20] Leung, R.S.& Cheng, J.S. (1986). Burn Contractures of the Foot. *J. Foot Ankle,6*, 289-294.

[21] Erdogan, B., Gorgu, M., Girgin, O., Akoz, T.& Deren, O. (1996). Application of external fixators in major foot contractures. *J Foot Ankle Surg,35*, 218-221.

[22] Shakirov, B.M. (2010). Evaluation of different surgical techniques used for correction of post-burn contracture of foot and ankle. *J. Annals of Burns and Fire Disasters,3*, 137-143.

Chapter 19

DIFFERENT SURGICAL TREATMENTS OF POST-BURN TROPHIC ULCERS OF THE PLANTAR SURFACE OF THE FOOT

Burns of the plantar surface of the foot with the subsequent formation of scars is often complicated by non-healing trophic ulcers. Trophic ulcers increase due to constant local irritation, reaching various depth and area, penetrating to the bone and the tendons and covering the area by several centimeters in diameter up to the whole heel area.

A total of 21 patients (12 men and 9 women) have been under our observation at the Samarkand Burn Center, Uzbekistan, for prolonged trophic ulcers of the soft tissues of the plantar surface of the foot.

Ulcers sizes were from 1.0-2.5 to 3-4 cm in diameter. All patients had undergone earlier unsuccessful operations (3-5 times).

The method of closure should be chosen according to both the severity and localization of the injury, using local uninjured tissues and soft scars to make bilobed skin-flap plasty, one-lobed skin-flat flap, tube graft and other shaped flaps and free grafts placed on the area of the excised scars.

In 18 observations a satisfactory result was achieved and no complications were noted. The grafts were viable, sensitivity was preserved and no marginal necrosis was noticed. Patients were able to return to work in 1.5 -2 months after surgery.

INTRODUCTION

The burn trauma of the plantar surface of the foot with the following formation of a cicatrix is often complicated by non-healing trophic ulcers. The resulting scars as well as a split graft of skin are unstable for load pressure. In addition to contraction, the scars are ulcerated over the protruding bone formations (calcaneus, the heads of metatarsal bones) due to the pressure. Trophic ulcers increase due to constant traumatization, reaching various depth and area, penetrating to the bone and tendons, covering the area from several centimeters in diameter up to the whole heel area. The patient's ability to walk and to work are impaired because of the pain.

In a number of articles [1-6], the remaining areas of intact skin were used in a variety of grafts for frostbite, bruised and cut wounds to the plantar surface. However, there was no information concerning post-burn trophic ulcers.

The features of the clinical course of treatment for sandal burns that occurred in the past in some mountain areas of Middle Asia, where primitive heating devices called sandals, were used, is noteworthy [7]. Sandal burns are characterized by such severe deep injuries because of close contact of the plantar area of the foot with the ash of coals or woods and include not only skin injuries of various depths but also injuries to the underlying tissues: subcutaneous fat, fascia, muscles, and even bones [8].

Unlike the other parts of the body it is necessary to recreate a cover of soft tissue on the sole of the foot that can bear a lot of pressure. Split-skin grafting does not satisfy this requirement. In planning the operation it should be taken into account that its main purpose is to create a cutaneous fat or muscular–cutaneous–fat layer on the sole of the foot, stable enough to handle pressure and not be injured while walking. It is important to take into account the structure of fatty tissue and skin thickness, their blood supply and innervations after transferring to the plantar surface of the foot.

MATERIAL AND METHODS

A total of 21 patients (12 men and 9 women) have been under our observation at the Samarkand Inter-Regional Burn Center, Uzbekistan, for prolonged trophic ulcers of the soft tissues of the plantar surface of the foot.

The causes of the trophic ulcers development were: sandal burns (17 patients), hot ash burns (three patients) and electrotrauma burns. Most patients had deep foot burns caused by sandal heaters. In these cases, the sandal burns caused especially deep and severe injuries of the tissue because of the immediate contact with the burning agent. They occurred because, in the summer, many children walk barefoot and often step onto or fall into hot ashes through carelessness and a lack of awareness (Table 19. 1.).

Of 21 patients, seven patients were under 14 years old and 14 patients were between 14 and 48 years old. Ulcer sizes were from 1.0–2.5 to 3–5 cm in diameter. One should distinguish small ulcers (up to 2 cm in diameter), medium ulcers (3–4 cm) and large ones (>4 cm), as well as superficial ulcers when the heel bone or flexor tendon is covered with subcutaneous fat tissue and deep ulcers in which the above mentioned structures are exposed after the removal of scars. The wound gets a grey staining and the margins become dense without granulation and with signs of epithelization.

All patients had undergone earlier unsuccessful operations (3–5 times), processing of ulcers by laser and conservative treatment with different solutions and ointments; but it was ineffective. With these, there was healing of the ulcer, but before long it opened again. All patients admitted to the department underwent preoperative examination including roentgenography of the foot bones, examination of the foot vessels by means of an ultrasound and a study of the ulcer flora and their sensitivity to antibiotics. Further, aerotherapeutic sets were used for all patients with trophic ulcers. For 10 days, we decreased the number of microorganisms and suppressed infection by cleaning the wound to make granulation healthier. B-group vitamins and protein preparations (infezoli and others) were given intravenously.

RESULTS

Depending on the location, extent and depth of the tissue defects on the plantar surface of the foot, a method of reconstructive surgery is planned.

It is important to take into consideration the structure of the fatty tissue and skin thickness and their blood supply and innervation after transfer onto the plantar surface of the foot. In superficial ulcers when an interlayer of fatty tissue is preserved between them and the bone, a bilobed cellular cutaneous flap or aponeurotic cutaneous flap plasty is the best method. Therefore, after elimination of the limited surface defects of the plantar surface located in the area of central loading area of the foot (heel), we performed bilobed skin flat

flap plasties in seven patients. The significance of a bilobed skin-flap plasty is to use the most appropriate local tissues to fill the defects in the supporting foot area; these are the tissues of the supporting foot area. This method allows dissipation of the tension on the tissues when closing the donor wound in a large area that is remotely located from the center of the defect.

Table 19.1.

Causes of burns	males		females	
	Quantity	%	Quantity	%
Sandal burns	10	47.6%	7	33.3%
Hot ash burns	1	4.8%	2	9.5%
Electrical burns	1	4.8%	-	-

Preoperative preparation includes sterilization of the ulcerous surface and removal of the cornified epidermis. Together with bathing, ointment is applied to the foot. Thick layers of the epidermis are mechanically removed. The more effectively the cornified tissues around the ulcers and in the zone of expected cutting of bilobed skin flat are removed, the easier is to rotate it and to suture the tissues with less tension, because elasticity increases.

The operation begins with excision of the scars by circular incision in the total depth of the area, removing it in one piece along with the ulcer. Capillary bleeding must be over the entire surface and if not, then tissues are excised additionally. In accordance with the newly formed wound, a bilobed skin flap is planned. Surgery was performed with a bilobed skin-flat flap to eliminate shallow defects of the surface, when located in the areas of the main load point of the foot (heel). The larger lobe was applied to the wound formed after the excision of the ulcerated scars. The smaller lobe of the donor wound covers the wound from which the larger lobe was taken. This method of plastic surgery made it possible to extend tissues onto a large area. This results in complete recovery of the skin, resistance to exertion, and without atrophy or newly formed scars (Figure 19.1).

In six observations, a satisfactory result was achieved and no complications were noted. The grafts were viable, sensitivity was preserved and no marginal necrosis was noticed. In one patient, a partial necrosis was observed due to changes in the tissues. In this case, the displaced muscle remains viable under the scar; above the muscle, the open wound is formed and granulation tissue is its base. In this case, we excised the ulcer with the cicatrical granulation tissue and re-performed plastic surgery with a bilobed

cutaneous-flat flap, which had a satisfactory engraftment and restored the bearing surface of the foot.

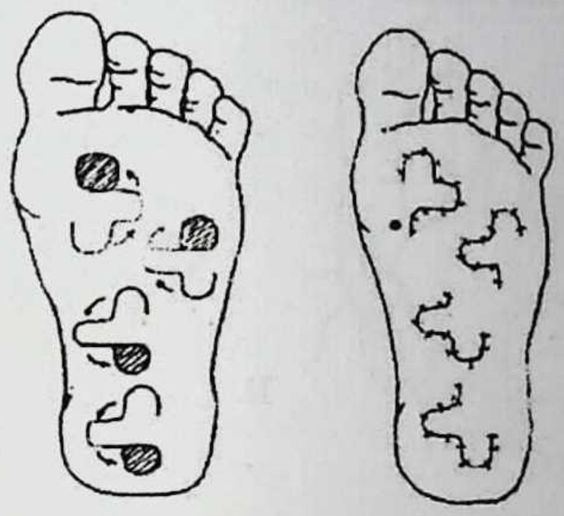
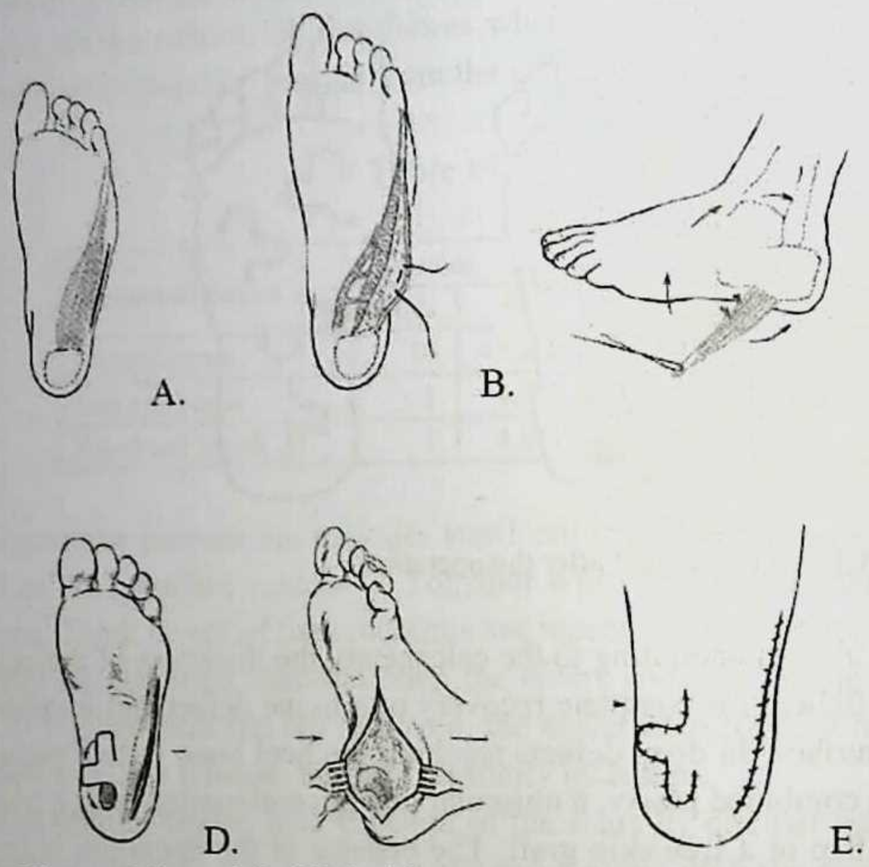


Figure 19.1. Scheme before and after the operation.

In deep ulcers penetrating to the calcaneum, the thickness of the cutaneous flaps is insufficient for complete recovery of a tissue defect and formation of a supportive surface. In deep defects reaching the heel bone in two patients, we performed a combined plasty, a muscular one in combination with a transfer of the skin fat flap or a free skin graft. The essence of the operation is in radical removal of scars by circular cutting up to the calcaneus as a single block including the ulcer, within the limits of the healthy tissues. Then, incision of skin and subcutaneous tissue on the outer edge of the foot is performed. The soft-tissue defect is made up by the muscular flap. Therefore, by separate incision on the outer edge of the foot the muscle-abducting digit V is isolated and its tendon is crossed and mobilized to the heel bone, maintaining communication with the surrounding tissues on its inner surface where the muscle receives its blood supply from the lateral plantar artery.

The artery is a branch of the external calcaneal artery and its safety is a guarantee of a successful operation. The tendons are stitched and the thread acts as a holder. From the side of the wound, a tunnel is made in the direction of the selected muscle, which is taken out to the wound by the holder. The muscle is fixed to the edges of the wound by separate sutures so that it will not enter the tunnel. The bed is sutured by a double row suture; the muscles and wound are drained by a rubber releaser. At the end of the operation, the skin covering is restored. Then, the bilobed cellular cutaneous flap is cut, the lobe is laid on the muscle in the area of the wound defect and the wound is covered by the second lobe where the first lobe was taken from and all wounds are

sutured by bringing the margins closer to each other. There were no complications in all cases (Figure 19.2).



Panel A. Ulcer and lines of the bilobed flap.
Panel B. The muscle abducting digit V and its blood supply.
Panel C. Mobilized muscle is carried on through the tunnel into the wound on the heel.
Panel D. Plasty covering the muscle by a bilobed flap.
Panel E. After operation.

Figure 19.2. Double plasty in a deep ulcer of the heel.

Treatment of ulcers located in the area of the head of the metatarsal bones is difficult as it is impossible to use muscular plasty. In localization of ulcers in the heads of the metatarsal bones of the foot plantar surface, we have performed plastic surgery by one-lobed skin-flat flap in two patients. For this, we first excised the ulcer with scars down to healthy tissues. The flap is cut out near the wound across the foot. Its apex is located on its inner lateral surface and the base near the flap. It is important to keep the adipose tissue intact, separating it in an angled manner with the fixation of the muscles on the inner edge of the foot and from the plantar aponeurosis. The flap, rotated about 80°, is put on the wound and fixed to the edges of the wound without tension. The under-flap space is drained by rubber releasers. The donor wound is closed by

split perforated skin. With this, a skin-flat flap preserves the sensitivity, is resistant to pressure load and became almost undistinguishable from the surrounding skin. In all cases, there were no complications (Figure 19.3).

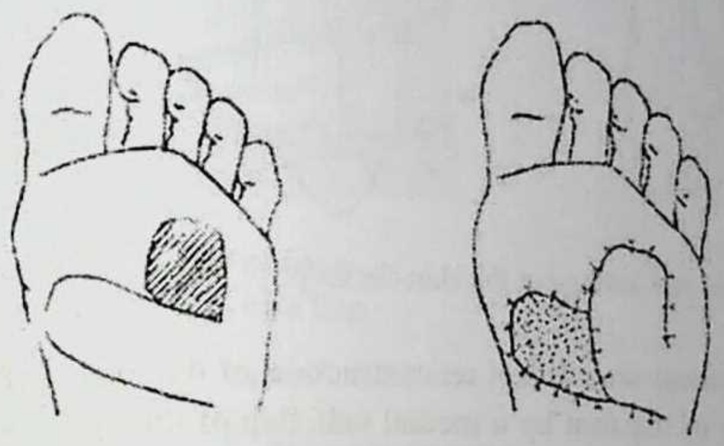


Figure 19.3. Foot before and after the surgery.

When placing the skin in the heel area and in distal part of the plantar surface directly on the bone, we used tube grafts in six cases. The Filatov graft method of plastic surgery by tube grafts is to transfer tissues on the sole. In plastic surgery by a flat gluteal–femoral graft at the first stage, the skin-fat bond is cut out with preservation of both legs. The donor wound is sutured and the tube wound is closed by a split skin graft. A month later the distal leg is cut off, the tubed graft is flattened by a longitudinal incision on the transplant, maintaining a uniform thickness not less than 1 cm. With this thickness of the tubed graft, the scars are excised in the area of the calcaneus and the lateral surface of the heel and the last is wrapped by the tubed graft after connecting the posterior surface. After a stable survival (3–4 weeks), the proximal leg is cut off, the remainder of the tubed graft is flattened, the scars are segmented on the posterior surface of the heel and Achilles tendon and plastic surgery is completed. In five observations, a satisfactory result was achieved and no complications were noted. The grafts were viable, sensitivity was preserved and no marginal necrosis was noticed. In one case, we excised the ulcer with cicatrical granulation tissue and reperformed plastic surgery with bilobed cutaneous flat flap, which had a satisfactory engraftment and restored the load bearing surface of the foot (Figure 19.4).

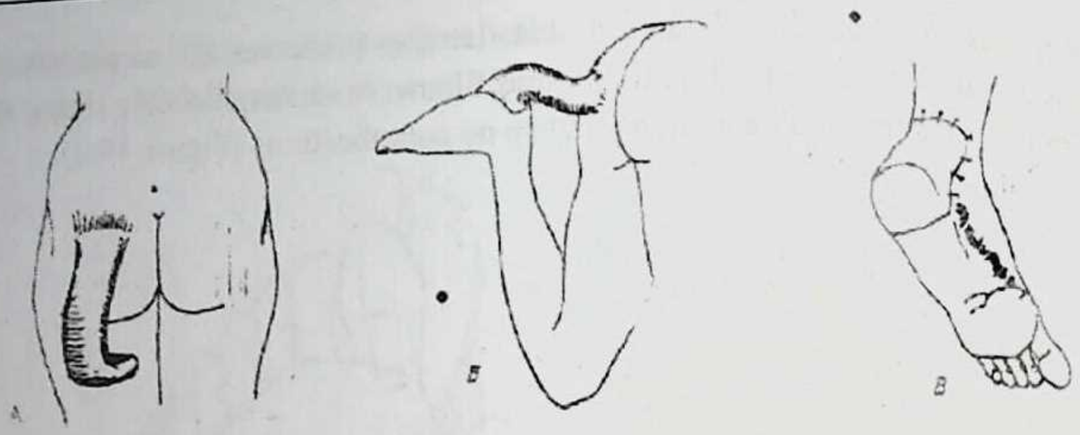


Figure 19.4. Panel A. Cutting out the skin-fat strip.

In the calcaneal area defect reconstruction of the heels soft tissues on the supportive side of the foot by a medial calf flap of the opposite leg is used to bear the load, in four cases we have performed a two-stage reconstruction of the heel soft tissues by a medial calf flap of the opposite leg. Before the operation, the borders of the graft are planned on the leg so that the base of the flap corresponds to the inner surface of the medial tibial condyle bone and the opposite border or the end of the flap is 4–6 cm above the medial ankle. The first incision was performed on the anterior edge of the tibial bone to the dissection of the deep fascia of the shin, which is fixed by individual sutures to the subdermal layer of the graft and these threads act as holders. The flap is mobilized towards the gastrocnemius muscle separating it from the salens muscle. As for the calcaneal tendon, the strip is split away and a continuation of the medial head is stitched to the fascia. Next a skin–fascial layer is dissected. The flap is lifted and the fascia is further separated from the periosteum in the area of the tibial condyle bone. After that, the distal half of the flap is stitched in the area of the calcaneal tendon, and the back of the heel where the flap is thinner and a thicker proximal portion are used for plasties of the bearing surface of the heel.

After fixing the flap on the back of the heel, an angle is formed by stitching the skin edges of the flap, which corresponds to the corner of the calcaneus. By individual sutures, the fascial muscle is fixed to the heel bone, which prevents its displacement. Then, the flap is cut off from the tibia, forming a bed for the heel. Following the surface of the skin flap, the scars are excised and plastic surgery is completed. A satisfactory result was achieved in three out of four patients, although one patient had necrosis of the distal part and the end of the flap due to a mistake in formation of the flap pedicle. In connection with this, the operation was repeated (Figure 19.5).

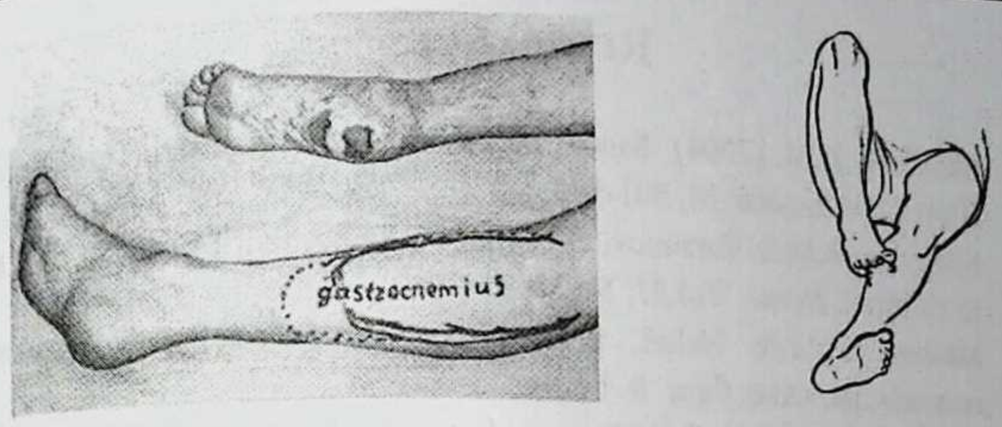


Figure 19.5. Panel A.The line of incision.
Panel B. Plastics of the heel area by a flap.

DISCUSSION

Post burn scars of the plantar surface of the foot are sometimes complicated by the formation of trophic ulcers. Conservative treatment of such ulcers is ineffective and gives only a short-term effect. Treatment of the defects of the plantar surface of the foot due to contact burns (sandal burns) is a difficult problem since there is always a lack of soft tissue suitable for plastic surgery in this area. Ulcers are located mainly on the supportive surfaces above the heel bone and the heads of the metatarsal bones. They can be widespread, occupying also the lateral and posterior surfaces. The skin around the ulcer and non-load bearing surface of the foot can be healthy.

Regarding surgery, one must take into account the need to achieve the following objectives: to create a pressure-resistant layer of soft tissues of 1.5–3 cm thickness and to remove protuberances on the heel bone, if they exist. Choosing the place and the method for taking or transferring the tissues, sex and age of the patient are taken into account. Therapeutic exercises begins after assessment of the patient's condition by the physician and the physical therapist the day after surgery. The main goal of physical therapy exercises is rehabilitation of the foots function. In development of superficial abrasions on the flap, the patients were recommended to rest for 5–7 days and as a rule, the wounds epithelized themselves after that period. Patients can return to work in 1.5 months after the operation, but full adaptation of the flap and its satisfactory engraftment occurs at 2– 3 months. During this period, the patient should not use normal pressure on the flap boots. Patients are beginning to walk normally and restore their working capacity. Patients can resume work in 1.5–2 months after surgery.

REFERENCES

[1] Shakirov, B.M. (2004). Sandal burns and their treatment in children, *J. Burn Care Rehabil*,*25*, 501-505.

[2] Shakirov, B.M.& Tursunov, B.S. (2005). Treatment of severe foot burns in children. *Burns*, Vol.*31*, No7, 901-905.

[3] Mathes, S. J.& Nahai, F. (1979).*Clinical atlas of muscle and musculocutaneous flaps*. S. Louis.

[4] Scheflan, M., Nahai, F.& Hartramph, C.R. (1981). Surgical management of heel ulcers – a comprehensive approach. – *Ann. Plast. Surg.*, v.7, N 5, 385-406.

[5] Yudenitch, V.V.& Grishkevitch, V.M. (1986). Guide to the Rehabilitation of Burn Patients. Moscow: Medicine, 364.

[6] Mirazimov, B.M., Tursunov, B.S.& Grishkevitch, V.M. (1991). Post-burn Deformities of Extremities in Children. Tashkent: Ibn Sino Publishing House, 342.

[7] Grishkevich, V.M.& Moroz, V.Y. (1997). Replacement Surgical Treatment of the Burns effect on lower extremities. Medicine, 297

[8] Moroz, V.V. (1996). Rehabilitation of the burned patients. *Russia. Med. Journal*,No4, 19-24.

Chapter 20

SURGICAL TREATMENT OF POST-BURN TROPHIC ULCERS AND CICATRICES OF THE FOOT CALCANEAL AREA

The burn trauma of the posterior surface of the talus area and ankle joint with the following formation of cicatrix is often complicated by a non-healing trophic ulcer. Ulcerous cicatrices located in the Achilles tendon zone are constantly traumatized by walking with shoes on, because the area of the tendon adjoining the talus is on the surface of the support. As a result, ulcers gradually increase and cicatrices become rough and deep. The wound fundus gets a grey staining and the margins become dense without granulation and with signs of epithelization.

Twelve patients have been under our observation at the Samarkand Burn Center, Uzbekistan, for prolonged non-healing ulcers and cicatrices located in the Achilles tendon zone. Most of the patients with sandal burns have been under our observation. Sandal burns are caused by the contact of feet with burning coals. Ulcer sizes were from 1.0-3.5 to 4-5 cm in diameter. After cicatrices dissection, a deep wound measuring 5-11 cm in length was formed. For orientation, we divided the posterior surface of the calcaneal tendon area into three parts: calcaneal, ankle and supramalleolaris areas. Large wound surfaces can be closed by a long L-form graft.

Satisfactory results were achieved in 11 cases, and no complications were noted. However, in only one patient a marginal necrosis of the external talus part adjoining the ulcer due to tissue changes has been noted, but that had no influence on the satisfactory results of the operation.

The patients may resume work in 1.5 months after the operation. However, complete graft adaptation and acclimatization to the place of the graft occurs in 2-3 months. During this period, patient must not wear common shoes that press onto the graft.

INTRODUCTION

The term 'plantar' ulcer was introduced by Price in 1959 [1] and was defined as a chronic ulceration of the sole of the foot, situated in well-defined areas overlying bony prominences, resistant to local or systemic therapy and characterized by a marked tendency of recurrence.

For the first time Grabb & Argenta [2] introduced the grafting method, with a blood supply from the artery malleolaris anterior that makes it possible to close the affected zone with limited lesions. Some authors prefer Blair-Brown grafts [3].

Initially, Elshahy [4] had used the local skin and fatty graft, prepared on the lateral or medial surface of ankle joint. According to Amarante et al. [5], satisfactory results were achieved with dermaplasty of defects in the area of the Achilles tendon and with a skin-fascial graft on the distal base from the medial surface in the malleolus.

Shakirov et al., [6] offered the L-form skin and fatty graft in the case of trophic ulcers in the post-burn wounds of this calcaneal area.

The feature of the clinical course of sandal burns that occurred in the past in some of the mountain areas of Middle Asia, where primitive heating devices called sandals, were used, is noteworthy [7]. Sandal burns are characterized by such severe deep injuries because of a close contact of the plantar area of the foot with the ash of coals or woods and include not only skin injuries of various depths but also injuries to underlying tissues: subcutaneous fat, fascia, muscles, and even bones [8].

The burn trauma of the posterior surface of the talus area and ankle joint with the following formation of cicatrix is often complicated by non-healing trophic ulcers.

Ulcerous cicatrices located in the Achilles tendon zone are constantly traumatized by walking with shoes on, because the area of the tendon adjoining the talus is on the surface of the support. As a result, ulcers gradually increase and cicatrices become rough and deep. The wound fundus gets a grey staining and the margins become dense without granulation and with signs of epithelization. In spite of a large number of methods used, the problem of the

elimination of extensive defects in a zone of the Achilles tendon has not been completely resolved. The study of the features of the skin structure, blood supply and innervations of the talus area showed that soft tissues, located in the area of the external talus and lateral surface, are good plastic surgery materials for tendon covering.

The donor area from where the skin and fatty graft had been taken had the following features: first, the skin in the talus area was rather thick and rough, stable against traumatization with shoes and easily shifted with a marked subcutaneous fat layer so it can be taken in a fold; second, it has a good arterial blood supply as there is an artery fubularis behind the donor site and the peripheral ramus of the same artery in front of the donor site that forms the vascular network [9,10] and third, the area of the external talus has axial innervations provided by the sural nerve. The sural nerve passes in the anterior area of the talus. Enumerated anatomical features of the blood-supply structure and innervations make the area of the lateral talus and foot rather valuable as the donor area for the preparation of a skin-fat graft and re-animation of normal-covering tissues above the Achilles tendon and posterior surface of calcaneus.

MATERIAL AND METHODS

A total of 12 patients (7 men and 5 women, aged 9 to 54 years) have been under the author's observation at the Samarkand Burn Center, Uzbekistan, for prolonged non-healing ulcers and cicatrices located in the Achilles tendon zone (Table 20. 1). The causes of the trophic ulcers included sandal burns (10 patients), sulphuric acid burns (1 patient), and electro-trauma burns (1 patient). Ulcers sizes were from 1.0-3.5 to 4-5 cm. in diameter. All patients had undergone an operation before (2 - 4 times). The donor area, from where the skin and fatty graft had been taken from, had the following features.

Table 20.1.

Causes of burns	males		females	
	Quantity	%	Quantity	%
Sandal burns	5	41.7	5	41.7
Sulfuric acid burns	1	8.3	-	-
electro burn	1	8.3	-	-

THE OPERATION TECHNIQUE

After cicatrices dissection, a deep wound measuring 5-11 cm in length was formed. For orientation, we divided the posterior surface of the calcaneal tendon area into three parts: calcaneal, ankle and supramalleolaris areas (Figure 20.1).

Large wound surfaces can be closed by L-form graft. The posterior crural surface above the Achilles tendon is its base between the distal and middle-third of the leg. The graft is directed laterally and forwards, its posterior border is the margin of the cicatrices and its anterior side is about 2 cm farther from the talus apex. Then the graft passes through the lateral surface of the foot at an angle of about 90^0 along the foot margin. The width of the graft is 5- 6 cm and the length is 18-20cm. Of these, the vertical part is 13-14 cm and the horizontal part is 5- 6 cm.

The correlation of parts is 3.1, 2.1 and 1.1. Based on the spread of the tissue defect, the graft is planned with a surplus length of 4-5 cm as the graft contracts after mobilization and when it covers the calcaneal tendon, and the calcaneis are fixed under the condition of some extension of width on account of length.

The graft mobilization starts from its apex, penetrating at once to the fascia and covering the muscles by means of the incision and strictly along the fascia from which the graft was raised up to the superior distal third of the ankle joint. With this, the terminal branches of the artery fibular is intersected and the other branches that penetrated into the graft on the foot from the side of the plantar in the zone of the ankle joint, which is higher from the side of the tendon of the long fibular muscle, where their number is less than on the foot, the graft was mobilized to be placed above the Achilles tendon. Graft sensitivity is provided by the calf nerve, rete venosum plantare, and the arterial blood supply is collateral due to a thick network making up the base of the graft through the long post-fibular muscle, moving away from artery tibialis anterior and also along the anterior border of the pointed muscle, a little more distal to the artery tibialis branch. Depending on the area and localization of the defects, cicatrices and ulcers, the L-form graft was placed on the wound surface either longitudinally or at an angle with its vertical part, lying across, closing the wounds distal zone. The medial margin and the end of the graft were connected with the proper wound margin by one or two rows of sutures, and by means of the lateral margin of the graft, the lateral surface of the Achilles tendon was closed and was fixed by catgut sutures to the fascia through the sub dermal layer. The donor wound was closed with a split

thickness skin graft and a compression bandage was applied and fixed using stretched sutures.

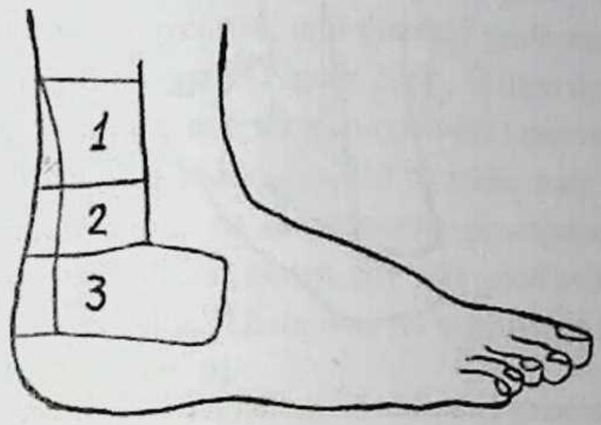


Figure 20.1. Division of Achilles tendon into calcaneal, ankle, and supramalleolaris areas.

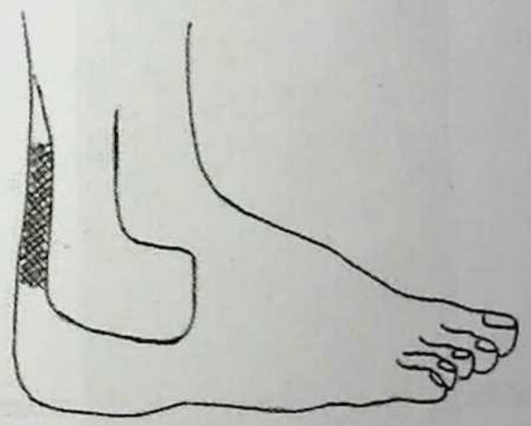


Figure 20.2. Ulcerating cicatrix in the area of the Achilles tendon zone. The borders of the L-form skin fascial graft have been pointed out.

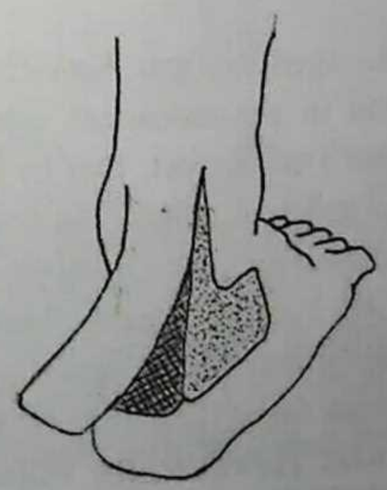


Figure 20.3. L-form skin-fascial graft from the inferior third of the crus and foot has been mobilized.

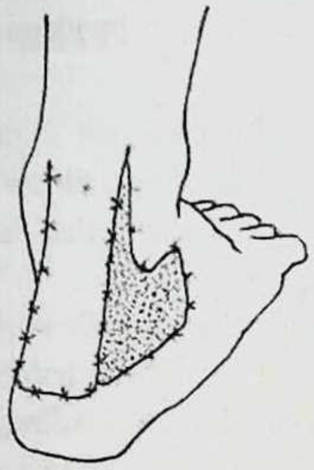


Figure 20.4. After ulcerating cicatrices dissection the wound was covered by mobilized skin-fascial graft.

Figure 20.5. The result of the Achilles tendon plastics by means of L-form skin-fascial graft.

CASE REPORT

Patient A., Patient A., aged 24, was hospitalized with complaints of a chronic non-healing wound in the calcaneal area of the left foot. It was determined, from the patient's self-report, that he had received a sandal burn 3.5 years before during an epileptic attack. He was treated at home, and the wound was cured in 5 weeks but with the development of cicatrices in the area of the Achilles tendon. At 3 months after healing, a trophic ulcer had developed. The size of the ulcer increased gradually. So the patient was operated on in the Burn Center for non-healing trophic ulcers, where free-skin transplantation was performed. However, the trophic ulcer recurred, and the patient was re-admitted to the Burn Center. During medical examination of the calcaneal area of the left foot, a post-burn non-healing trophic ulcer (1.5 - 2.5

cm in diameter) was revealed. The fundus was of a grey color, and the margins were dense, without granulations (Figure 6). Surgery was recommended to the patient. L-form graft plastic surgery was performed (Figure 20.7). The postoperative period was uneventful, and the skin graft was fixed well to the proper tissues and wound margins (Figure 20.8). Within the second week, the dorsal plaster bar was applied, and the sutures were removed on postoperative day 11. Later the patient was recommended to make easy passive and active movements in the ankle joint. At the 2-month postoperative follow–up the graft was in satisfactory condition, sensitivity was good and the elastic mixture of skin did not create a surplus. There was no significant foot deformation in the area of the graft (Figure 20. 9).

Figure 20.6. Ulcerating cicatrix in the area of the Achilles tendon zone.

Figure 20.7. L-form skin-fascial graft from the inferior third of the crus and foot has been mobilized.

Figure 20.8. After ulcerating cicatrices dissection the wound was covered by mobilized skin-fascial graft.

Figure 20.9. The result of the achilles tendon plastics by means of L-form skin-fascial graft.

RESULTS

We observed a satisfactory result with no complications. The grafts were viable, sensitivity was preserved and no marginal necrosis was noticed. Gradually the operation efficacy improved as the cicatrices became softer, and

the fossa behind the external talus (donor site) healed. A marginal necrosis was noted on the part of the external talus adjoining the ulcer because of tissue changes in only one patient. The necrotized area was removed and the wound was closed by a split skin graft without impacting the satisfactory result of the operation.

CONCLUSION

Trophic ulcers are a common complication seen in 12 patients (7 men and 5 women, aged 9 to 54 years) and all treatment interventions have significant recurrence rates. In spite of a large number of treatment methods used, the problem of elimination of defects in the area of Achilles tendon has not been completely solved. As a rule, it is impossible to eliminate them by means of local tissues plasty. Some authors prefer Blair-Brown graft plasty that does not ensure satisfactory functional and cosmetic results, because the transplanted graft is thin, without tactile or pain sensitivity.

It often undergoes cicatrix formation with trophic ulcer recurrence. When employing plastic surgery in the area of the Achilles tendon, the use of distant-area tissues achieves a satisfactory effect by means of the Italian method of plastic surgery (crus of the other leg or buttocks) as well as Filatov's stem plasty; however, these methods are more inconvenient due to the forced position, they have many stages and displaced, denervated tissues and they may not have sufficient blood supply for the trauma zone.

The L-form skin-fatty graft, produced grafts that were viable and preserved sensitivity and save displacement from mechanical trauma in a natural way. The patients may resume their work in 1.5 months after the operation. However, complete graft adaptation and acclimatization to the place of the graft occurs in 2-3 months. During this period, the patient must not wear common shoes that press onto the graft.

REFERENCES

[1] Price, E.W. (1964). The problem of plantar ulcer. *Lepr Rev. 35*, 1964; 267–72.

[2] Grabb, W.C. &Argenta, L. C.(1981). Ibid. *68*, 723-730.

[3] Vihriev, B.C.& Belonogov, L. I. (1984). Plastic's skin-grafts of wound defects. *Herald of surgery*, 89-91.

[4] Elshahy, N.J. (1978). The usage of graft on 2 cuttings for the ulcers closing not bearing the load in the area of heel. Acta Chir Plast,*20*, 30-6.

[5] Amarante, J., Costa, H. & Reis, J., et al. (1986).New distally based fasciocutaneous flap of the leg. *Br J Plast Surg*,*39*, 338-40.

[6] Shakirov, B.M., Tagaev, K. R., Tursunov, B. S. & Achtamov, D. A. (2009). L- formplasty in the treatment of post-burn trophic ulcers and cicatrices of the foot calcaneal area. *J. Plastic, Reconstructive Aesthetic Surgery*,*62*, e 59-63.

[7] Shakirov, B.M. (2004). Sandal Burns and their Treatment in Children // *J. Burn Care Rehabilitation*,*25*, 501-505.

[8] Shakirov, B.M.& Tursunov, B.S. (2005). Treatment of severe foot burns in children // *J. Burns*, Vol.*31*, No 7, 901-905.

[9] Holmes, J. & Rauner, C. R. (1984). Lateral calcaneal Artery Island flaps. *BrJ. Plast Surg*,*37*, 402-5.

[10] Barsley, T. L., Sharp, D. T. & Chischolm, E. M. (1983). Cross-leg fasciocutaneousm flaps. *Plast Reconstruct Surg*,*72*, 843-52.

Chapter 21

BILOBED FLAP – FORM PLASTICS IN THE SURGICAL TREATMENT OF POST-BURN TROPHIC ULCERS OF THE PLANTAR SURFACE OF THE FOOT

The burn trauma of the plantar surface of the foot with the following formation of cicatrix is often complicated by non-healing trophic ulcers. Conservative treatment of this kind of ulcers is ineffective and gives only a short – term effect.

Nine patients have been operated on under our observation for prolonged non-healing ulcers located in the plantar surface of the foot.

After the cicatrices dissection, bilobed plastic surgery was performed. The postoperative period was smooth.

Satisfactory results were achieved in 8 cases, and no complications were noted. However, in only one patient, a marginal necrosis was noted in the area of the plasty of the ulcer because of tissue changes. The necrotized area was removed with scar granulation tissues and the wound was closed by a bilobed skin - flat flap influencing the satisfactory result of the operation.

INTRODUCTION

The burn trauma of the plantar surface of the foot with the following formation of cicatrix is often complicated by non-healing trophic ulcers.

Ulcerous cicatrices located in the plantar zone are constantly traumatized by walking with shoes on. As a result, ulcers gradually increase and cicatrices become rough and deep in areas, penetrating to the bones and tendons, covering an area of several centimeters to the whole heel area.

Conservative treatment of this kind of ulcer is ineffective and gives only short term relief. For the first time in deep defects of the foot plantar surface Mathes S. [1], offered the use of a combined dermal–fat flap plasty for deep defects located in the heel area.

Ger R., Reiffel R. et. al, Scheflan M. et al. [2-4]offered to apply one bilobed, irregular flap, cut out from the wound at the closing tissues defect on the sole.

Initially, Yudenich V.V. et al., Mirazimov B.S. et al., Grishkevich V.M. et al.[5-7] in superficial ulcers in the heel areas and heads of metatarsal bones with tissue defects offered skin-aponeurotic flap plasty that are among the best methods of plastic surgery.

In all cases the causes of the formation of tissue defects and trophic ulcer scars were: frostbite, chemical burns, bruises and cut wounds.

The patients with sandal burns have been under our observation [8, 9]. Sandal burns are caused by contact of the plantar surface of the foot with burning coals. The burn can affect the subcutaneous fat, fascia, muscles and even bones that sometimes lead to the development of non-healing trophic ulcers.

MATERIAL AND METHODS

Nine patients (5 men and 4 women, aged 12-43 years) have been under our observation at the Samarkand Burn Center, Uzbekistan, for prolonged non-healing ulcers located in the plantar surface of the foot.

The causes of the trophic-ulcers development were sandal burns. Ulcer sizes were from 1.0 – 4.0 to 2-4 cm in diameter. The ulcers were mainly located on the supporting areas above the heel bone in 5 cases and the heads of the metatarsal bones in 4 cases.

All patients had undergone earlier unsuccessful operations (1-3 times). Choosing the place of taking and the method of the transfer of tissue in all cases, sex and age of the patient are taken into account.

Method of treatment includes three stages of operative interventions, such as: a pre-operation examination of patient; the operation itself and an after operation healing of the wound.

The surgical method of treatment depends on the depth of the wound in the soft tissue, its area and localization.

The pre-operation examination of a patient is made to determine the defect of the soft tissue (its depth and area); to investigate the localization (heel, head of I and V metatarsus bones); to make a sterile medical inspection of the ulcers area and excision of the dead thick epidermis mechanically. This treatment is recommended individually and depends on the character of wound. We differentiate 2 types of trophic ulcers: superficial and deep. The level of foot dysfunction is also different; it is more serious in cases when trophic ulcers injures the bones and tendon. The excision of the dead, thick epidermis is done after taking a hot bath and healing with ointment on the fatty base which is put on the sole. The more effective result is obtained after excision of thick epidermis in the zone of the wound by using skin-fat tissue transplants and by cutting a bilobed skin–flat flap. After excision of the thick epidermis the skin elasticity and tensility is increased and we are able to rotate it and sew the flaps with less surface tension. In cases when a the thick epidermis remains unexcised before the operation, it is more difficult to keep the operative zone sterile; besides when cutting flat flaps and cleaning the scar the epidermis may tear off and expose the infectious skin area.

The second stage is presented by the operation itself. The significance of bilobed flap plasty is to use the most appropriate local tissues to fill the defects in the supporting foot area. These are the tissues of the supporting foot area. This method allows you to dissipate the tension of the tissues when closing the donor wound in a large area remote from the center of the defect.

The operation begins with cutting the scar by a circular cut as long as its depth and excision in one piece together with the ulcer. Along the whole surface there should be capillary bleeding (extravasation), in cases where it is absent, the tissue is cut more. The bilobed flap plasty is cut according to the wound size.

The bilobed flap plasty has a base foot and 2 parts - the first (the ground, main) and the second. The first part, nearer to defect wound is used to close the wound with the cut scars; the second part, smaller in size is used to cover the donor wound, from where the first part was taken. Planning of the parts location on the sole is based on the following criteria.

The base of the flap plasty for the heel is made relative to the medial longitudinal sole section line and is placed more distal and lateral of wound;

for plastic surgery of the head of the metatarsus bones it is placed more proximate; for the first toe more medial and for the fifth toe more lateral (Figure 21.1).

In accordance with the newly formed wound a two-lobulose flap is planned. Plastic surgery was performed with a bilobed skin-flat flap to eliminate shallow defects of the surface, when located in the areas of the main exertion of the foot (heel, heads of metatarsal bones). The larger lobe was applied to the wound formed after the excision of the ulcerated scars. The smaller lobe of the donor wound covering the wound from which the larger lobe was taken. This method of plastic surgery made it possible to extend the tissues onto a large area. This results in complete recovery of the skin, it is resistant to exertion, and without atrophy or newly formed scars (Figure 21.2).

The space under the flap must be drained for 1-2 days with rubber releasers. Sutures should be removed no earlier than 2 weeks after surgery.

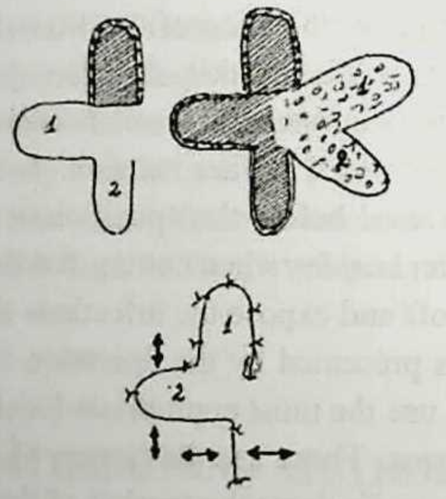


Figure 21.1. Method of defect closing with bilobed flat. The skin tensility (is marked by the arrow) is far from the flap and is spread on a large area.

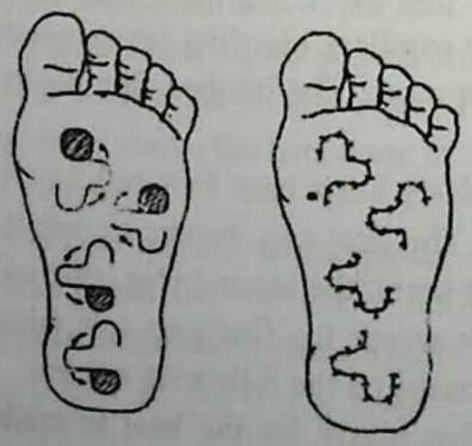


Figure 21.2. Scheme before and after the operation.

CASE REPORT

Patient B., aged 19, was hospitalized with a superficial post-burn trophic ulcer of the left plantar surface of the foot. It was determined, from the patients self-report, that she had received a sandal burn 17 years prior to admission. She was treated at the hospital, and the wound was cured in 22 days. 5 months after healing, a trophic ulcer had developed. The size of the ulcer had increased gradually.

So the patient was operated on in the Burn Center for non-healing trophic ulcers, where free-skin transplantation was performed. However, the trophic ulcer recurred, and the patient was re-admitted to the Burn Center. During medical examination of the sole area of the left foot, a post burn non-healing trophic ulcer was revealed (Figure 21.3).

Surgery was recommended to the patient. After the formation of the cicatrices a bilobed flap–form graft plastic surgery was performed (Figure 21.4). The postoperative period was uneventful, and the skin graft was fixed well to the proper tissues and wound margins (Figure 21.5).

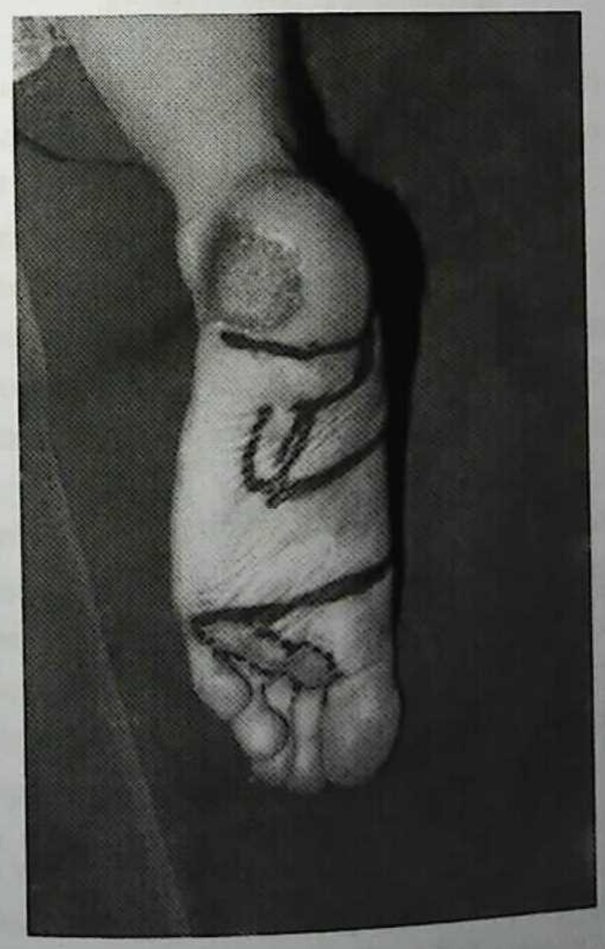


Figure 21.3. The condition before the operation. The margins of bilobed flap are marked.

Figure 21.4. The immediate result of bilobed flap plastic of the sole.

Figure 21.5. The result shown 5 months after operation.

RESULTS

In 8 cases we observed a satisfactory result with no complications. The grafts were viable, sensitivity was preserved and no marginal necrosis was noticed. This plasty gives a full-bodied skin covering, resistant to exertion and does not atrophy and is not exposed to scar degeneration.

In only one patient, a marginal necrosis was noted on the part of the plasty on the ulcer because of tissue changes. The necrotized area was removed with scar granulation tissues and the wound was closed by a split skin–fat graft influencing the satisfactory result of the operation.

DISCUSSION

Treatment of trophic ulcers is a difficult problem since this area always has a lack of soft tissues, suitable for plastic surgery. Unlike the other parts of the body it is necessary to recreate the covering of soft tissues that can bear a lot of pressure on the supporting side. Grafting of split skin or tissue of the abdominal wall does not satisfy this requirement, because the structure of the skin and fatty tissue of these areas differs significantly from the skin of the plantar surface. The best plastic surgery material is the remaining areas of intact plantar skin which is used in a variety of flap surgery methods. Contact burns, frostbites and scald traumatic injuries with loss of skin and subcutaneous tissue, result in an unstable thin covering in the outcome of both the transplanted skin and scars.

Load bearing on the transplanted skin and scars when walking results in the formation of ulcerations, making the patients unable to walk normally, so they lose their ability to work and become disabled.

After the operation the patient must during the next 3-4 months periodically take the weight off of it during the day time to perform medical exercises and massage. Treatment exercises begin after the evaluation of the patient's state of body by the physical therapist the next day after admittance to hospital. The main purpose of physical therapy exercises is to rehabilitate the foot function, prevent contracture formation and lower the risk of complications developing. Physical therapy training must be done carefully and individually based on each patient's case. The movements must be slow and stretched. Physical training must be done 2 or 3 times per day for 30 to 40 minutes, it is continued after discharge from the hospital up to a period of full growth and formation of the return scar. The patients can return to work in 1.5 months after the operation but full adaptation of the flap and its satisfactory engraftment occurs in 2-3 months.

REFERENCES

[1] Mathes, S. J.& Nahai, F. (1979). *Clinical atlas of muscle and musculocutaneous flaps*. S. Louis.

[2] Ger, R. (1976). The management of chronic ulcers of the dorsum of the foot by muscle transposition and free skin grafting. *Brit. J. Plast. Surg.*, vol. *29*, No 2, 199-204.

[3] Reifel, K.S.& McCarthy, Y. C. (1980). Coverage of heel and sole defects. A new subfascial arterialized flap// *Plast. Reconstr. Surg.*, Vol. *66*, No 2, 250-253.

[4] Scheflan, M., Nahai, F.& Hartramph, C.R. (1981). Surgical management of heel ulcers – a comprehensive approach. – *Ann. Plast. Surg.*, v.*7*, N 5, 385-406.

[5] Yudenich, V.V.& Grishkevich, V.M. (1989). Indulines for rehabilitation of burns. *M. Medicine*, 369.

[6] Mirazimov, B.M., Tursunov, B.S.& Grishkevitch, V.M. (1991). Post-burn Deformities of Extremities in Children. Tashkent: Ibn Sino Publishing House, 342.

[7] Grishkevich, V.M.& Moroz, V.Y. (1996). Replacement of surgical treatment consequences of the lower extremities burns. *Medicine*, 297.

[8] Shakirov, B.M. (2004). Sandal Burns and their Treatment in Children // *J. Burn Care Rehabilitation*, *25*, 501-505.

[9] Shakirov, B.M.& Tursunov, B. S. (2005). Treatment of severe foot burns in children. // *BURNS. J. of the International Society for Burns Injuries (ISBI)*. November, Vol.*31*, Issue 7, 901-905.

Chapter 22

POST-BURN BENT CONTRACTURES AND DEFORMITIES OF THE FOOT

The post-burn bent contracture deformities of the foot represent the complex specific pathology of a load bearing–motor apparatus developed as complications after serious burns of the foot sole surface.

Four different types of post-burn bent contractures of the foot, mild, moderate, severe and mutilated, are described. The varying degrees of involvement require different methods of treatment, which are described in detail.

INTRODUCTION

The post-burn bent contracture deformities of the foot represent the complex specific pathology of a load bearing–motor apparatus developed as complications after serious burn of the foot sole surface.

The investigation done shows that post-burn bent contractures of the toes after burns more often occurs in children. The frequency of such complications in children is mostly connected with the specifics of their growth mechanism.

First, it can be explained by the fact that children being irresponsible more often are exposed to the danger of a burn wound.

Second, the skin integument of a child is more delicate and thinner. Very often the tissue structure is involved and the tendon (sinew) muscular apparatus is effected first which results in the loss of joint function articulation.

Special attention should be paid to clinical investigation of the so called Sandal Burns that often occur in some Central Asian regions, where the people use an ancient, primitive heating device called a Sandal [1].

Sandal burn injuries which involve the distal parts of the lower extremities, namely the feet and toes, can often be observed in children around 3 years of age.

To recover the bent contractures of the feet and toes it is important to give modern treatment to deep burns of foot sole surface, and recover the skin integument [2-4].

We have observed that the location of burns in the foot sole surface, when being healed and the skin integument recovered even at an early stage by using the modern methods of dermoplastic surgery, in 38% of burned children it is impossible to stop the development of the initial contracture and they need to undergo reconstructive surgeries. The late recovery of skin integument (two months after a burn) in 100% of children, with a burn in such a location need the reconstructive surgery method of treatment.

MATERIALS AND METHODS

During the 11-year period (1990-2000), 102 cases with flexion contractures of the digits were treated in the Samarkand Inter-Regional Burn Center, Uzbekistan. 86 patients with a total of 102 contractures were enrolled in the study.

Of the 102 contractures, 67% (n=66) suffered from Sandal burns, 14.7% (n=15) from hot ash and asphalt burns, 5.9% (n=6) from flame burns, 3.9% (n=4) from chemical burns, 2.9% (n=3) from electrical burns and 7.8% (n=8) of contractures caused by other reasons.

The age distributions of the contractures were as follows 50% (n=51) contractures were in patients under 5 years old, 42.2% (n=43) of contractures were in patients between 5 and 14 years old, 7.8% (n=8) of contractures were in patients more than 14 years old.

Classification of Contractures

According to the severity of the contractures, four categories were identified.

1. the mild type, where the main problem was hypertrophic scar formation involved in very mild plantar-flexion contractures of some toes;
2. the moderate type, where less than three toes were significantly involved in plantar-flexion contractures;
3. the severe type, where three to five toes were involved with significant plantar-flexion contractures;
4. the mutilated type, where all toes were involved in plantar-flexion contractures.

The relative occurrence of the different types of burn contractures of the foot was as follows: mild, 18; moderate, 41; severe, 27; mutilated, 16.

Functionally, patients with these types of contractures had disturbances; most of the complaints were of discomfort related to footwear. When more contractures were involved, apart from footwear problems, difficulties in prolonged walking and joint pain of the toes were common.

If these deformities lasted longer than 18 months, then not only the disturbance of static posture and walking occurred but also different kinds of deformities of the bones and joints developed such as beak-like, sickle-like and malformation of the foot.

METHOD OF TREATMENT

In the absence of bone deformities of the foot, free skin transplantations were performed in 25.5% (cases 26) Rough, plane and ulcerous scars were incised on a whole expansion. Wound margins were given a broken shape. The wound defect developing in 24-48 hours was covered by skin transplants of 0.5 – 0.6 mm thickness. At the same time, flexion contractures of the digits were treated by means of overextension by 30-40°.

When there was symphysis of digits I and V of the foot to the plantar surface, combined skin plastic surgery was performed in 17.7 % (17 cases). Stretched soft tissues of the medial surface of digits I or lateral surface of digits V were used to make skin for grafts at the base of the phalangeal joint.

The digit was set in the position of moderate hypercorrection.

The graft was transferred to the formed wound defect to cover the wound on the plantar surface of the digit.

The wound on the lateral surface of the digit was covered with a free skin transplantation.

In serious cases due to scars, resulting in bent contractures of the III-IV degree 57.8% (59 cases) were with dislocated digits, the pathological tissue was cut up to the metatarsus phalange joints with an additional line of distal cut of an indented jagged form.

At the same time the redressing was done, removal of the dislocated parts of the digits, little by little they were transferred to a normal position on the foot bent at an angle of 60° till 90° in the metatarsus phalange joints.

To fix the toes at the achieved correction position, a Kirshner spoke was put through a bone or joint, through the first digit and the rest, depending on the age of the child – either spoke or injection needles of middle size were used.

In case fixation by the spoke failed, the digits were fixed sewn through the nail phalange by a thick ligature to the back of the foot surface.

The formed injured defects located at the sole area in some children were equal to 2/3^{rds} of the foot surface, in 24-48 hours were covered by a split skin transplant of 0.3-0.4 mm thick.

We have observed how Inter-digital symphysis (31 cases) was eliminated by means of local tissues (-form, trapezoid, or triangular grafts), that made it possible to eliminate the flexion contractures of the digits and to make a cover on the plantar surface which did not interfere with foot development and was stable on exertion during the time of observation.

RESULTS

By using these methods of treatment for different categories of burn contractures, patients were treated effectively. 86 patients with a total number of 102 contractures were enrolled in the study.

Results were studied in patients within the age period of one year to 6-7 years of age in 102 contractures who underwent the removal of the deformities of bent contractures of the foot sole surface.

As seen from the table, in 814% of cases, the contracture was removed absolutely, in 137% there was an improvement and only in 49% of cases was there no improvement because of irreversible bone-joint changes and other factors.

Deformation type	Cases number observed	Good		Improvement		Without change	
		cases number	%	cases number	%	cases number	%
Mild type	18	18	100	-	-	-	-
Moderate type	41	36	87.8	5	12.4	-	-
Severe type	27	21	77.8	4	14.8	2	7.4
Mutilated type	16	8	50	5	31.3	3	18.7
Total	102	83	81.4	14	13.7	5	4.9

DISCUSSION

Scar deformities of the foot and ankle joint represent 5 to 7% of all post-burn deformities [5].

Post burn deformities in the foot sole appear as a result of skin injury damage as well as primary or secondary injuries of the deep tissue.

In the first case pathological scars may be formed, resulting in skin scar contracture, in the second case – arthrogene contracture and ankylosis.

Post burn deformities of the foot sole surface is mostly due to contact burns and is very difficult to treat.

There is a deficiency of thin tissue fit for plastic surgery repair and scar fields are spread on the surface.

Besides the basic surface needs for skin which can resist high pressure. The reconstructive restoration treatment of postburn deformities of feet demand (need) not only the full renewal of skin cover but also reconstruction of movement and the motion system in the tendon–muscular and bone-joint apparatus.

This problem is still occurring and many questions of surgical rehabilitation after receiving a burn trauma still need to be solved.

At present some authors offer the tactics of stage by stage treatment of burn deformities, i.e. in the first turn the elements of soft tissue form deformities are removed by a cut of capsule and chord (copula) if there is need and then in repeated surgeries (operations) the involvement of bone-joint apparatus is done [5-11].

We have worked out (elaborated on) the saving principle of the treatment of post burn foot deformities, after cut and removal of scars we tried to remove completely all the elements of the deformities in a single-moment operation. This principle allowed us in the future to use more economic surgical intervention on the bone-joint apparatus of burnt feet.

For all operated on feet, it is important to wear a long-period fixed plaster cast until damage position was not fully liquidated. That's why we tried to change as often as possible the plaster cast (langetus) after every bandaging (dressing) so as not to spoil the safety of fixation. Fixation by removable plaster cast was done during a 3 month period, 3-4 weeks after the operation the patients were recommended to undergo paraffin applications, massage and medical healing physical training.

PATIENTS

1) Patient A. Diagnosis: Bent Contractire of the V digit of the right foot with dislocation of the V toe of IV degree. Patient A. From mother's words, the child had received a sandal burn at the age of 1.2 years. When examined it was found that scars on the right foot sole surface at the bottom of the V digit were obstructed by the scar and fully fixed to the sole, and were bent under at an angle of 155-160° to the sole, the motion is within the limits of 10-12°. The serious flat and marked scars were cut all along their length and setting of the dislocated joints was done by hand. The digits were set, fixed in a position of moderate hypercorrection. The fixation of digits was done by joint installment according to Kirshner, then the plastic surgery cover was done by split transplantation parts. The plaster cast was put on.

On the 6th day the patient was sent home in satisfactory condition for clinical treatment.

The second examination was made 24 days after the operation. The patient's state was satisfactory the foot sole was healed, motion in the toes was limited, the patient was recommended for massage and medical physical training.

The next examination 3 months later:

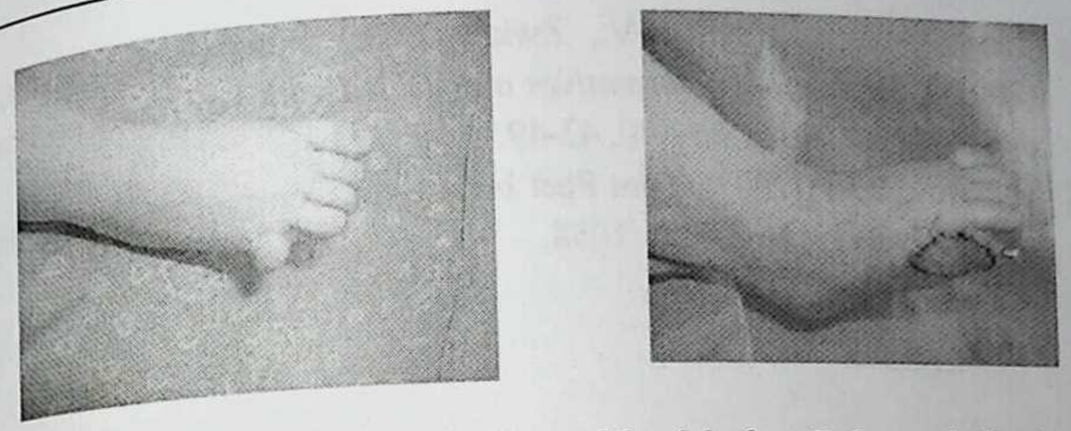


Figure 22.1. Flexion contracture of the V toe of the right foot. Before and after the operation.

The foot sole in satisfactory condition, motion in toes is good, the patient began to wear light shoes.

REFERENCES

[1] Shakirov, B.M. (2004). Sandal burns and their treatment in children. *J Burn Care Rehabil*,*25*, 501-505.

[2] Shakirov, B.M. (1996). (Some issues regarding treatment of deep burns of the ankle joint and foot.) In: Current Issues of Medicine. Collection of Scientific Works. Samarkand: Meditsina, 97-98.

[3] Shakirov, B.M.& Tursunov, B.S. (2005). Treatment of severe foot burns in children. *Burns*, vol *31*,No7, 901-905.

[4] Tursunov, B.S., Koraboev, H.K.& Nikulin, V.I. (1987).*Rehabilitation of early-aged children with burns*. Moscow: Meditsina, 1-26.

[5] Mirazimov, B.M., Tursunov, B.S.& Crishkevitch, V.M. (1991). Post burn Deformations of Extremities in Children. Tashkent; *Ibn Sino Publishing House*, 342.

[6] Povstyanoi, N.E. (1973).*Surgical rehabilitation of burn patients*. Moscow: Meditsina.

[7] Mirazimov, B.M.& Shamatov, N.M. (1978).*Surgical rehabilitation of burn deformity extremities*. Vol.*3* Moscow: Meditsina, 149-160.

[8] Tursunov, B.S. (1986). Treatment of burn contracture deformities children. *Clin. Surg*,*3*, 26-27.

[9] Erdogon, B., Gorgu M., Cirgin, Akoz T.& Deren. (1996)*Application of external fixators in major foot contractures J Foot Ankle*,*35*, 218-221.

[10] Steinwender, G., Sarap, V., Zwick, E.B., Uitz, C. & Linhart, W. (2001).*Complex foot deformatives associated with soft tissue scarring in children Foot Ankle Surg*,*40*, 42-49.

[11] Shakirov, B.M. (2007). Foot Post burn Bent Contracture deformities. *J. BURNS*, vol. *33*, No8,1054-1058.

INDEX

A

B

C

D

E

F

G

H

I

J

K

L

M

N

O

P

R

S

T

U

V

W

BABUR M. SHAKIROV, M.D.

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ISBN 978-1-62257-024-9