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Surgical Techniques Used for Correction of Post Burn Contractures and Deformities of the Foot

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Abstract

Scaring and foot and ankle joint contractures after burn are the result of deep partial and full thickness burns that affect foot motion, impair the lower extremity function, and often benefit from surgical reconstruction. One hundred twenty one cases and total number of 154 burn scar contractures and deformities of the foot were treated at the Inter Regional Burn Center and Burn Department of RCSUMA Samarkand, Uzbekistan.

Long term outcomes of operations performed suggest that the burned patient benefits from close observation to detect developing scar benefiting from intervention or slow growth of the injured extremity and the development of secondary changes of bones and joints. From our experience operations should be considered before development of severe scars to prevent secondary changes. In the case of severe contracture the procedure should be considered as soon as possible after detection.

The results of this report suggest that outcomes of operative interventions of the burn induced foot and ankle deformities depend on: (1) localization of scar contractures; (2) depth of injury; (3) presence of local uninjured skin for reconstruction, and (4) presence of osseous injury or osseous changes secondary to chronic scar contracture. Observations of location of foot and ankle joint contractures after burn, surgical procedure performed and results in our series are presented in this manuscript.

Keywords: Foot and Ankle; Joint contractures; Burn scar contractures

Introduction

Foot and ankle joint contractures after severe burn are the result of deep partial and full thickness burns that affect foot motion, impair lower extremity function, and benefit from surgical reconstruction [1,2].

Scar deformities of the foot and the ankle joint represent 5 to 7% of all deformities after burn. The dorsum of the foot and the ankle areas are injured more commonly [3-6].

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. Serious deformities of the foot and ankle joint may occur, and especially in our region in children after sandal burns. 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. Even today this traditional system is used; especially in the mountainous areas the winters are very cold, for heating the lower part of the human body. Contact with burning sandal woods typically causes these burns [7-9]. Sandal burns are characterized by such severe deep injuries because of a close contact of the body with live coals or woods and include not only skin injuries of various depths but also injuries to underlying tissues: subcutaneous fat, fasciae, muscles, and even bones. As a result, these children suffer severe burns followed by serious complications, such as contractures and amputations.

Trauma to an ankle joint affects function of the entire lower extremity (static posture maintenance, walking, etc) and may cause spinal column and pelvis distortion and other structural abnormalities [10].

The experience of the Inter Regional Burn Center in reconstruction of burn scars suggests that these deformities represent a separate group of severe orthopedic diseases [11,12]. However, in contrast to inherited or acquired diseases of the locomotor apparatus, burn scar deformities are developing on the basis of skin deficiency and scar transformations. In this kind of pathology, problems of reconstruction of lost skin coverage should be solved first and then interventions into deep tissue structures for reconstruction of the locomotor system should be performed. At this time, insufficient attention is paid to the stage of reconstruction in patients with severe deformities as a result of deep tissue disturbances.

Analysis of the effect of burn scars and the dynamics in children who are growing allowed us to determine those in whom rehabilitation is of benefit, principally those with deep burns limited to the foot ankle joint and those with deep burns even if they have no association with musculoskeletal structures, discharged from hospital but presenting loss of skin surface in the foot and ankle joint.

The experience obtained demonstrates that children in the above categories should be followed as an outpatient for a prolonged period until the growth is completed (age 18-19 years) even if there are no

initial burn deformities in the foot. Reasons lie in the regularity of growth, which is lacking in scars. Scars not obvious upon wound closure and having no effect on the foot ankle joints in the nearest 2-3 years may change to limiting scars in 5-6 years and more, and as a result can become the cause of formation of serious secondary deformities, development of dysfunction and bone dislocation. The joint is slow in growth; the bones become deformed causing damage of and dysfunction of extremities.

It should be noted that 70 percent of patients, who had suffered from foot burns, benefit from rehabilitation and many eventually undergo operative treatment [13,14]. Investigators routinely consider these deformities to separate locations as completed processes isolated from the general burn disease process. The significant number of patients undergoing operative reconstruction after burns suggests that the conservative methods of therapy currently in use are not always effective. There are studies on different aspects of reconstruction of extremity scars after burn [15-17]. According to our experience, the main cause of such limited progress in scar contractures treatment with local tissues in the insufficient study of the following aspects: contracture cause (scar surface deficit), and anatomical classification of burn scar contractures and deformities of the foot.

Materials and Methods

121 and a total of 154 burn scar contractures and deformities of the foot were treated at the Inter Regional Burn Center and Burn Department of the Centre of Emergency Medical Care (RCSUMA) Samarkand, Uzbekistan. The cases of the burn were Sandal burns 84 (70%), flame 11 (9%), scald 9 (7%), hot ash 8 (7%) and other 9 (7%). All treatments used in this study were approved by Research Ethics Board for the Samarkand State Medical Institute.

Among the patients, 79 were contractures from distant burns persisting for one to five years, 21 were contractures six to ten years and 21 were contractures over ten years old. Among the cases, 69 patients (57%) were under 14 years of age and 52 were over 14 years old.

Secondary bone and joint changes associated with burn scar contractures were found in 33 patients; 20 had changes due to insufficient bone growth, 8 had changes in the area of the ankle joint with valgus or varus deformities, and 5 in the area of the metatarsophalangeal joints. These patients basically were children came back very late to the hospital for a new surgery because of loss of ability of normal movement of extremities.

We found contractures of I, II and II degrees in 31 cases, III degree in 67 cases, and IV degree in 23 cases. Most surgeons assess scar related joint contracture using a scale proposed in 1946 which reflects the severity of joint dysfunction (Parin B.V. 1953), contractures are classified into four different degrees in reference to the neutral position of the foot. The amplitude of ankle joint movements is taken into consideration as a basis, normally equal to 65º-80º, i.e. 40º-50º of plantiflexion and 20º-30º of dorsiflexion. The extent of the contracture is determined in relation to the limitation of movement expressed in degrees. If the scars extended to a distal third of the dorsum of the foot, we found a significant limitation in digit flexion as well as dorsal subluxation and dislocation (13 cases). 53 deformities developed after skin grafting, when limited growth of skin graft scars and as a result plantar flexion contractures of the toes developed (Figure 1).

a *b*

Figure 1: Post burn foot deformity.

The anatomic features contractures of the foot were studied before surgery and during operation, noting contractures location and severity, contracture cause, and scars spread. The criteria were used: scar location caused contracture, surface surplus and healthy region, fold location in relation to joint surfaces severity of the contracture and deformities of the foot. The specific features were categorized into distinguished several types. During operations, the contracture cause was explored (scar surface deficit) for understanding of the shape of local flaps necessary for contracture elimination.

Results

Isolated contractures of the ankle joint

Burn scar contractures were caused by burns on the ankle; the resulting scars were located on the lateral, medial, and anterior surface or some combination. Using anatomical principles we distinguished the following contractures of the foot and ankle joint: dorsal flexion (11 cases), lateral surface (7), plantar flexion (8) and whole ankle joint (8). The scars limited motion in the joint which in turn decreased patient. In addition, irregular positioning of the foot due to scar caused secondary deformity. These factors could be eliminated with effective reconstruction before these events. The first task was to bring the foot to the regular position. Location, degree of scar contracture, the availability of adjacent uninjured skin determined type of reconstruction. Insufficient amount of soft tissues in the area of the ankle joint and decreased elasticity of skin limited reconstructive options. Those with the most options were in cases where folded and soft adjacent tissues were available as a reserve to cover across the scar.

Dorsal flexion: Dorsal scars due to third and fourth degree burns can cause dorsiflexion contractures of the foot and ankle as much as to 30º-40º, giving the clinical appearance of the foot being parallel to the leg. Dorsal contractures of the foot limited plantar flexion. Our patients walked on their heels as the joint gave less support. In 7 such cases we designed a pointed flap according to simple or multiple Z-plasty. However, we found that this operation was more effective in mild contractures. In case of significant adduction of the foot at the ankle, reconstruction with one or several trapezoid flaps or in combination with skin grafts had the best probability to form the active zone by using local tissues.

Trapezoid flap plasty, either pure or in combination with skin grafting (4 cases), was found to be the best method for creating a zone for active movement from local tissue. Our technique was to divide the sheets of flaps, to fold by longitudinal cut along its crest, and then to cut out trapezoid flaps, starting from the middle of the line or from the joint flexion. The ends of the cuts were given a fork like form for

more complete elimination of tightening and better functioning of the wound margins with the ends of the grafts. The grafts were displaced towards each other and sutured by touching sides. If the contracture was not eliminated completely, another pair of grafts was cutout.

Lateral contracture: In seven cases scars were located on the lateral surface of the ankle joint, occupying the area of the ankle and reaching the anterior median line of the joint. We found the best method was of reconstruction was single trapezoid flap plasty. Mild to moderate contracture with adjoining normal skin was addressed with one flap, prepared from the medial non scarred healthy skin from the anterior surface. Planning consisted of several line drawings: a line along the scar band, a perpendicular line on the scar edge with a Y shaped end anterior to the malleolus, and two lines depicting the borders of the flap in the ankle joint projection. With the first incision along the flap border, the sheets were separated. The following Y shaped incision was followed and lifted to the malleolus. After full ankle extension, a trapezoid wound was formed. The flap was transposed on the wound with moderate tension (Patient A)

Plantar flexion contracture: Plantar flexible deformations of the ankle joint are result of burn damage in the posterior surface of the leg with involvement of the Achilles tendon, leading to the development of equine varus deformity. Out of seven cases, one patient had injuries in the zone of the heel tendon and four had suffered deep burns with tissue defect in the affected zone with ulcerous scars. In these cases we used L shaped flap plasty from the lateral surface of the ankle and foot.

Whole ankle joints: Scars surrounding the ankle joint without bands can be hypertrophic or pathologic with ulceration. The scar surface deficit, responsible for contracture, is extensive; therefore, local flap technique is excluded.

Hypertrophic scars do not often develop in the ankle joint area, but they may cause severe dysfunctions and malformations. Scars tighten the joints and cause limited movements (8 cases). Such contractures are considered to be the most difficult. It is known that more severe shortening of scar bands leads to more severe deformities.

In this study, reconstruction was performed using wide scar excision with skin grafting. The scar was excised when mature, which allowed us to leave the subcutaneous fat layer *in situ* undamaged, with light bleeding. Skin grafts were fixed to each other and to the underlining tissue with U shaped sutures; a gauze bolster was tied above, creating compression on the graft. As a result, sufficient skin adhered to the underlying tissue providing a good functional and cosmetic outcome.

Extended contractures of the dorsum of the foot (digits, ankle joint)

Extended contractures of the dorsum of the foot (digits, ankle joint) were the most frequent type of disturbance (59 cases) with significant anatomical variability. The following groups of this disturbance were identified: (a) isolated injury to the dorsum of the foot; (b) disturbance with extension of scars on the digits causing dorsiflexion of the metatarsal phalangeal joints with or without involvement of ankle joint, with or without digit syndactyly. In terms of surgical reconstruction, it was important to prevent the development of bony deformities.

Therefore, at the beginning of subluxation and foot deformity, we sought to perform the operation no later than 6 months after healing of burn wounds. Through this strategy, functional disorders, and distortions were minimized using local tissues. We were able to perform most of these operations in one stage. Skin grafting and/or flap plasty was performed, depending upon scar extension, scar thickness, tissue reserve, and the degree of contracture.

In case of large scars causing severe contractures (grade III-IV) with subluxation of digits and syndactyly, oftentimes footwear was not used, though static and dynamic functions of foot were not disturbed. In these cases, pathological tissues were incised to the level of the metatarsophalangeal joints. As has been done on the hand, reconstruction webspace reconstruction was performed using trapezoid or z plasty. Simultaneously, subluxation and dislocations of digits which were gradually transferred into the position of plantar flexion at 60º-90º with retrograde Kirshner wires, particularly in grade III-IV contractures. If fixation with wires was not effective, the toes were attached through the nail phalanges by means of thick ligature to the plantar surface of the foot. The technique was effective in eliminating dislocations and subluxations of digits in all patients. Significant defects (up to 2/3 of the foot) were closed by skin grafting.

Plantar surface of the foot

A total of 20 patients were treated in our department for burns of the plantar surface of the foot. Depending on the location, extent and depth of tissue defects on the plantar surface of the foot, a proper method of reconstructive surgery was planned.

After elimination of the limited surface defects of the plantar surface located in the area of central loading of the foot (heel), we performed bilobed skin flaps in nine patients. The significance of bilobed skin flap plasty is the use of the most appropriate local tissues to fill the defects in the supporting foot area.

This method allows dissipating the tension of tissues when closing the donor wound in a large area remote from the center of the defect. This results in complete recovery of the skin, resistant to exertion, and without atrophy or newly formed scars.

In deep ulcers penetrating the calcaneus, the thickness of cutaneous flaps is often insufficient for formation of supportive surface. In deep defects reaching the heel bone in two patients, we performed a combined reconstruction a muscular one in combination with transfer of the skin fat flap or a free skin graft.

When reconstructing scars in the heel area and in distal part of the plantar surface directly on the bone, we used tube grafts in five cases. The Filatov and gluteal femoral tube graft method of plastic surgery by tube graftsrefers to transferring tissues on the sole. During reconstruction using a flat Filatov tube graft at the first stage, the skin and subcutaneous tissue were lifted using parallel incisions with preservation of both limbs. The donor wound was sutured and the tube wound was closed by split skin. Twenty to twenty five days later the distal limbs were divided; the tubed graft was flattened by longitudinal incision under the flap maintaining a uniform thickness not less than 1 cm. With this thickness of the tube graft, the scars were excised and closed with the tubed graft after connecting the posterior surface. After 3-4 weeks, the proximal limb was divided, the remainder of the tubed graft was flattened, and the flap was inserted in the plantar surface of the foot. In these five cases a good results were achieved and no complications were noted. The grafts were viable, sensibility was preserved and no marginal necrosis was noticed (Patient B).

In heel defects reconstruction on the weight bearing side of the foot, we chose in 4 cases to perform two stage reconstructions of the heel soft tissues by medial calf flap of the opposite leg.

Distal foot

The distal part of the foot was injured in 41 cases. Syndactyly was reconstructed by means of local tissues Pi-form, trapezoid, triangular grafts transplantation (26 cases). These operations decreased flexion contractures of digits, and adequately covered the plantar surface which did not interfere with foot development and reinnervation of the skin and gradual increase of exertion.

In plantar surface scars of the first and fifth toes, combined skin plastic surgery was performed (15 cases). Full thickness skin graft of the medial surface of the hallux or lateral surface of the 5th digit was used for coverage of deficits of the respective metatarsophalangeal joints. The digit was set in the position of moderate hypercorrection. The graft was transferred to the defect to cover the wound. There was no necrosis of grafts after this procedure.

After reconstruction of the foot and ankle joint, these were fixed with a gutter splint for wound healing, after skin grafting, a compression was created on grafts with dressings; 5-7 days antibiotic therapy was prescribed.

The 4th or 5th day after surgery, the patients were discharged from the hospital for outpatient treatment with outpatient physical therapy exercises recommended.

Results of operations: 121 cases were completely released in 102 patients. No flap loss took place. Marginal superficial necrosis of an adipose scar flaps end occurred in 12 patients and was treated with dressing without consequences. Skin transplants grew well with the underlying tissue. Foot and ankle motion remained restricted in seven patients as a result of arthrosis, but the scar contracture component was released completely. Follow up functional and cosmetic results became better with time.

Long-term results

Long-term results for over one to ten years were available in 97 patients (81%) with burn deformities of the foot. We considered the result to be good if the extremity was in correct alignment, normal movement, and grafted skin was stable.

In 72 patients (74.3%) the deformities were absent after reconstruction; in 17 patients (17.7%) the results were satisfactory and in eight patients (8%) the results were unsatisfactory. These findings were observed in patients with more than 8 years from the burn reconstruction. As a result of using this method of treatment for burned patients in our practice, the percentage of burn contractures with an impact on mobility and growth of the extremities was greatly reduced.

Discussion

Foot and ankle joint contractures are divided according to their function: flexion and extension. In spite of great years of medical history and research, the anatomy of scar contractures and deformities foot has not be sufficiently studied.

The problems of burn scar contracture are widely discussed in the literature. Ankle scar contractures are often combined with foot and leg deformities; therefore, more attention is given to foot reconstruction as a more severe complication. Thus, many aspects of post burn foot and ankle reconstruction remained not researched. 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 reconstruction strategy for patients with burn scar deformities, and ambulatory follow up treatment are problems of particular significance. The aim of the present study was to evaluate different reconstructive surgery techniques in patients with burn scar contractures and deformities of feet and ankle joints [18-20].

In Middle Asia, sandal burns are of special interest. Most of the patients with sandal burns have lower limb injuries [21].

The results of this report suggest that outcomes of reconstruction of the burn induced foot and ankle deformities depend on: (1) location of scar contractures; (2) depth of injury; (3) presence of local uninjured skin for reconstruction, and (4) presence of bony injury or osseous changes secondary to chronic scar contracture.

Before surgery, one must take into account that foot and ankle joints differ from other big joints and possess specific features carrying an important clinical meaning and application.

After skin grafting these patients receive treatment to avoid burn scar contractures which can affect mobility and growth of the extremities. However, the basis for reconstruction is skin grafting, flap reconstruction, or Filatov flaps. The first is used to treat foot deformities of any location, the second in case of exposed bones and joints, in cases when it is necessary to eliminate tissues defects, and also in case of osteotomy.

In summary, from the outcomes of the operations we came to the conclusion that the burn patient benefits from close observation to detect contracture development or slow growth of injured extremity and development of secondary of bones and joint deformities. When operative intervention is indicated, there are optimally done early to prevent secondary changes. In the case when contracture is severe the operation must be performed as soon as possible.

Scars that are not evident at the time of wound closure or even in the years thereafter may even after 5-6 years or more develop significant contractures that limit movement and consequently cause the formation of serious secondary deformities and the development of sprains and bone dislocation.

According to the severity of the contractures, four categories were identified by Leung [22] and Cheng:mild, moderate, severe, 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 trauma. Patients admitted to The Inter Regional Burn Center of Samarkand had a much larger variety of burn locations. Our clinical observations showed that anatomic features and classification is basis for diagnosis construction, operation planning, surgical technique choice and reconstructive methods, significant improving surgical rehabilitation of the foot.

Conclusion

Long term outcomes of reconstruction performed suggest that the burn patient benefits from close follow up to detect developing contractures during growth in children. Determination of reconstructive method to address contractures is not straight forward.

The operation is easy to plan and perform. It fully uses the local tissues, yields good stable results, and prevents flap loss and contracture recurrence. Reconstruction should be considered before severe contractures and secondary bony changes ensue.

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Conflict of Interest

No financial or personal relationships with other people or organizations exist with any of the authors that could inappropriately influence this work.

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