EVALUATION OF DIFFERENT SURGICAL TECHNIQUES USED FOR CORRECTION OF POST-BURN CONTRACTURE OF FOOT AND ANKLE

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SUMMARY. Post-burn contracture and deformities of the foot and ankle joint with respect to other localizations account for 3.5-5% of cases. Functional disturbances of the foot and ankle joint affect the functioning of the entire lower joint, its statics, and the patient’s gait and bearing, and can even lead to distorted pelvis, curvature of the spine, and other disturbances. Between 1990 and 2002 we treated 69 cases for a total number of 76 foot and ankle joint deformities enrolled in the study. The choice of plastic operation was made on the basis of the severity and localization of the injury - we used local uninjured tissues and soft scars to make trapezoid, Z-plasty or other shaped flaps and free grafts placed on the area of the excised scars. We observed the follow-up during a period of one to eight years in 57 patients with burn deformities of the ankle (82.6% of the overall number of patients observed in the clinic). In 41 cases (71.9%) the deformities were completely eliminated and in 13 cases (22.8%) the results were satisfactory; three patients (5.3%) had poor results. The victims of burns in the ankle joint must be kept under constant examination if scarring is present, with the danger of retarded growth of the burned foot joint and the development of secondary bone-joint changes. Early surgery is advised depending on severity of the contracture.

Keywords: burns, foot, post-burn foot and ankle contracture, surgical treatment of post-burn foot and ankle contracture

Introduction

The anatomical and functional peculiarities of the ankle joint, which is characterized by its complex structure and the absence of protective adipose and muscular tissue, may lead to severe contractures after deep burns. 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. 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. Sandal burns are characterized by such severe deep injuries because of a close contact of the body with live coals or wood and include not only skin injuries of various depths but also injuries to underlying tissues: subcutaneous fat, fasciae, muscles, and even bones.

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

Ankle joint 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 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 out-patient 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 joint. Although the literature has much to say on the various issues of rehabilitation and reconstructive surgery in the treatment of post-burn foot deformities and although surgical techniques are widely described in the literature, different opinions exist with regard to the choice of methods, depending on the localization of 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 treated 69 such cases for a total number of 76 foot and ankle joint deformities enrolled in the study. The causes of the burns were as follows: sandal burns, 38 (55.0%); flame, 11 (15.9%); scalds, 6 (8.7%); ash, 6 (8.7%); chemicals, 4 (5.8%); and electricity, 4 (5.8%). Among all the cases, 46 were old contractures persisting for one to five years, while 23 were contractures existing for six to ten years.

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

The main types of burn after-effects in the foot and ankle joint are presented in Table I.

<table>
<thead>
<tr>
<th>Position of deformity of patients</th>
<th>Number of joint cases</th>
<th>Foot and ankle joint</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Isolated contracture of foot-ankle joint</td>
<td>25</td>
<td>25</td>
<td>36.84</td>
</tr>
<tr>
<td>1. Dorsal flexion</td>
<td>8</td>
<td>9</td>
<td>11.84</td>
</tr>
<tr>
<td>2. Lateral surface</td>
<td>7</td>
<td>7</td>
<td>9.21</td>
</tr>
<tr>
<td>3. Plantar flexion</td>
<td>5</td>
<td>5</td>
<td>6.58</td>
</tr>
<tr>
<td>4. Whole ankle joint</td>
<td>5</td>
<td>7</td>
<td>9.21</td>
</tr>
<tr>
<td>II. Extended contractures of the dorsum of the foot (digits, ankle joint)</td>
<td>44</td>
<td>48</td>
<td>63.16</td>
</tr>
<tr>
<td>Total</td>
<td>69</td>
<td>76</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Results**

Isolated contracture of the foot and 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 operation was determined in relation to the location and spreading of the scars, the degree of contracture, and the intact skin located nearby.

Dorsiflexion

Dorsal contractures of the foot limit plantar flexion. Dorsal scars due to third- and fourth-degree burns can cause dorsiflexion contractures of the foot and ankle as great as to 30-40°, giving the 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 subcutaneous tissue. However, we found that this operation was more indicated in mild contractures.

Trapezoid flap plasty, either 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 operating 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 line of 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 cut out.

Flaps and sheets of scars that were not included were either removed or used as approach triangular flaps by plasty. In the follow-up 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 area of the ankle and reaching the 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 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.

Tissue was stored in the thickness of the folds and the scar sheets were deficient in length. This is what
caused the contracture. In this case (Patient A, a 16-yr-old boy admitted to Samarkand Inter-Regional Burn Center with the diagnosis of dorsal contractures of the right foot) the patient is shown before and after the operation (Fig. 1).

The best method was routine flap plasty. By practising a horizontal cut, the scar sheet was separated from the healthy skin, and the scars were cut in the direction of the ankle and further, passing round it like a fork. We cut 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 grew together with the youngster, thus preventing relapse of the contracture (Figs. 2, 3, 4).

Plantiflexion contractures

Plantar flexible deformations of the ankle joint are the result of burn damage in 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 waking, patients with equine foot exert their weight in 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 with ulcerous scars.

The operation was performed after conservative treatment and maturation scar connective tissue. In such cases, with tissue defects in the area of the tissue 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 off the full-thickness graft and used it to close the injury and heel tendon on three sides.

In the wound where we took the flap we performed free transplantation of skin.

Whole ankle joint

Thick keloid scars do not often develop in the ankle joint area, but they may cause severe 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 in 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 po-

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Fig. 1 - Patient A. Pre-operative scar contracture and result after surgery.

Fig. 2 - Patient B. Pre-operative deformity and post-operative result.
sition with free split-skin transplant. As a result skin lining grew, providing a good functional and cosmetic outcome.

Extended contractures of the dorsum of the foot (digits, ankle joint) were the most frequent type of disturbance (48 cases) with significant anatomical variability. The following groups of disturbance were identified: a) isolated injury to the dorsum of the foot; b) disturbance with extension of scars on the digits causing 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 deformity of the foot bones.

Therefore, at the onset of subluxation and foot deformity, the operation was performed, no later than six months after healing of the burn wounds. First of all, functional disorders, distortions, and tightening tissues deforming the foot were eliminated using local tissues (soft scar tissue in the folds, graft tissue). It was found that the operation had to be performed 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 scar extension, scar thickness, tissue reserve in the folds, and the degree of contracture.

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

These grafts were fixed with free ends at the level of the heads of the metatarsal bones. Simultaneously, we performed redressment and the elimination of subluxations and dislocations of digits, which were gradually trans-
ferred into the position of plantar flexion at an angle of 60-90° in the metatarsophalangeal joints. The position of the digits was maintained with retrograde Kirschner wires, particularly in third- and fourth-degree burn contractures. If fixation with wires was not effective, the toes were sewn 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. Wound defects developing in some patients affecting more than two-thirds of the foot dorsum were closed by split-skin transplants 0.3-0.4 mm thick.

The most recent results of rehabilitative/reconstructive treatment in the foot area were taken as the outcome of the operations performed, immediately before the patients were discharged from hospital. The anatomical aspect of the elimination of the deformities was taken into consideration.

As shown in Table II, 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% of cases there was no improvement. Negative results were due to deep tissue defect, irreversible changes in the bone- joints, late recourse to medical aid, and post-operative effects. We did not observe any ulceration of 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 patients followed-up in the clinic). In the evaluation of the follow-up results of the operative treatment we considered it to be a good result if the patient had no disturbances, the extremity was correct in form, the joint presented adequate amplitude of movement, and the transplanted graft was similar to normal healthy skin. The result was considered to be satisfactory if the form and functions of the extremities were considerably improved, but physiotherapeutic treatment or some small additional operations were necessary. If there were recurrences of contractures and the patients needed serious surgical treatment owing to impairment of functions after operations performed earlier, the follow-up results were considered to be bad. In 41 cases (71.9%) the deformities were eliminated completely, in 13 patients (22.8%) the results were satisfactory, and in three patients (5.3%) patients the results were bad.

**Discussion**

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

There are various studies in the literature on different aspects of rehabilitation and of the reconstruction of burn extremity deformities in patients.

Owing to the spreading of scars and the functional disorders they cause, post-burn contracture of the foot and ankle joint and the back of the foot was divided into four types.
degrees, on the basis of results in 85 patients.

These results suggest that, in the treatment of ankle-join deformities caused by burns, differential plastic surgery should be used in relation to 1. the localization and expansion of the scars, 2. the presence of skin, and 3. the presence of bones that are not injured or changed.

Patients with ankle joint burns must be monitored carefully if there are scars and there is the consequent 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 as the result of growth of their organism allowed us to determine which patients were to be rehabilitated, i.e.:

- patients with limited deep burns of the foot-ankle joint;
- patients with deep burns or third-degree burns in the foot-ankle joint;
- patients with deep burns even if they have no disjunction of the skeletal muscular apparatus, discharged from hospital but presenting loss of skin surface in the foot-ankle joint.

The experience obtained proves the fact that children in the above categories should be followed up as outpatients for a long period of time and until the end of growth (18-19 years) even if there are no initial burn deformities in the foot-ankle joint. The reason for this is the frequent observation that while children are still growing, scar growth falls behind. Loose scars and scar areas that are invisible when patients are discharged from hospital and have no effect on the foot/ankle joint in the first two or three years post-burn may - even after 5-6 years or more - change to contracting scars that limit movement and consequently cause the formation of serious secondary deformities and the development of sprains and bone dislocation. The joint is slow to grow and the bone becomes crooked, damaging the extremities and causing.

The main role has to be played by rehabilitation centres, where all methods of treatment are available (medical and physical training, ultrasound, kenalogy, radon, other medical (pyrogenal, lidazi, triamcinolone) and physical treatment (ultrasound, magnetic waves, compression), and balneotherapy (radon and hydrogen sulphide baths).

Conclusion

In surgical treatment the principles of the elimination of burn deformity elements must be straightforward. As for the restoration of skin coverage, various methods of skin plasty can be employed, the choice depending on the type of wound that has developed and the degree of involvement of deep structures.

RÉSUMÉ. Les contractures post-brûlure et les déformations de l’articulation du pied et de la cheville constituent 3,5-5% des cas par rapport aux autres localisations. Les troubles fonctionnels de l’articulation du pied et de la cheville conditionnent le comportement de toute l’articulation inférieure, la condition statique, et la démarche et l’allure du patient, pouvant même provoquer des distorsions du pelvis, la courbe de la colonne vertébrale, et d’autres problèmes. Entre 1990 et 2002, nous avons traité 69 cas pour un nombre total de 76 déformations du pied et de la cheville incluses dans l’étude. Le choix de l’opération de chirurgie plastique a été fait sur la base de la sévérité et la localisation de la lésion - nous avons utilisé les tissus locaux non lésés et les cicatrices molles pour créer des lambeaux trapézoïdes ou des plasties en Z ou bien des lambeaux de forme et des greffes libres que nous avons posés sur la zone des cicatrices excisées. Nous avons observé le suivi pendant une période d’un à huit ans chez 57 patients atteints de graves déformations de la cheville (82,6% du nombre total de patients observés dans notre clinique). Dans 41 cas (71,9%) les déformations ont été complètement éliminées et dans 13 cas (22,8%) les résultats ont été satisfaisants; dans trois patients (5,3%) les résultats étaient médiocres. Les patients atteints de brûlures dans l’articulation de la cheville doivent être contrôlés avec insistance s’ils présentes des phénomènes de cicatrisation, vu le risque de la croissance retardée de l’articulation du pied brûlé et du développement d’altérations secondaires des articulations osseuses. En fonction de la gravité de la contracture, les auteurs conseillent une intervention chirurgicale plus ou moins précoce.

Mots clés: brûlure, pied, contracture post-brûlure du pied et de la cheville, traitement chirurgical de la contracture post-brûlure du pied et de la cheville.

BIBLIOGRAPHY


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