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Early reconstruction of the burn contractures and sequels

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SUMMARY

The goal of burn reconstruction should be to preserve, restore, maintain function, and improve appearance so the patient can be reinserted to society. The major problem after burn is hypertrophic scar and contractures. Prevention starts early during the acute phase of the injury and continues to the rehabilitation period. Early excision and grafting improves skin quality and decreases scar hypertrophic formation. The use of splints, pressure garment and rehabilitation may help to prevent contractures. Burn contractures are tight and are due to a shortened scar that limits joint movement. Burn contracture needs to be released in several important areas of the body. Surgical procedures were performed in the acute phase to correct ectropion, microstomia, and to release burn scar contractures in the neck, axilla, and hand. Surgeries began 6 to 12 months after discharge and the purpose was to decrease hypertrophic scar and release contractures. Ablative fractional CO_2 laser has revolutionized the scar treatment, decreasing the thickness of the scar, and improving mobility in the patients. We review the surgical procedures performed by plastic and reconstructive surgery during the acute and post-acute burn phase.

Key words: *Burns, scar, contractures, flaps, grafting*

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RESUMEN

El objetivo de la reconstrucción de quemaduras consiste en preservar, restaurar, mantener la función y mejorar la apariencia para que el paciente pueda reinsertarse en la sociedad. El principal problema después de la quemadura son las cicatrices hipertróficas y las contracturas. La prevención comienza temprano durante la fase aguda de la lesión y continúa hasta el período de rehabilitación. La escisión y el injerto tempranos mejoran la calidad de la piel y disminuyen la formación de cicatrices hipertróficas. El uso de férulas, prendas de presión y rehabilitación pueden ayudar a prevenir contracturas. Las contracturas por quemaduras son tensas y se deben a una cicatriz acortada que limita el movimiento de la articulación. La contractura de la quemadura debe liberarse en varias áreas importantes del cuerpo. Se realizaron procedimientos quirúrgicos en la fase aguda con el fin de corregir la ectropión, microstomía y para liberar las contracturas de las cicatrices por quemaduras en el cuello, axila y mano. Las cirugías comenzaron de 6 a 12 meses después del alta y el propósito fue disminuir la cicatriz hipertrófica y liberar las contracturas. El láser de CO_2 fraccional ablativo ha revolucionado el tratamiento de las cicatrices, disminuyendo el grosor de la cicatriz y mejorando la movilidad de los pacientes. Se revisan los procedimientos quirúrgicos realizados mediante cirugía plástica y reconstructiva durante la fase aguda y pos-quemadura aguda.

Palabras clave*: Quemaduras, cicatriz, contracturas, colgajos, injerto.*

INTRODUCTION

The 2016 Burn Incidence Fact Sheet of the American Burn Association reports that 486 000 patients with burns received medical treatment each year, producing 40 000 hospitalizations and 60 % treated in the 128 burn centers in the USA. The most frequent etiology is fire/flame (43 %), scalds (34 %), contact burns (4 %), electrical (3 %), and chemical injury (3 %). Home is the place where most of the burns occur (73 %), followed by occupational burns (8 %), streets/ highways (5 %), and recreational/sports (9 %). The survival rate is 96.8 %, being more susceptible to get burns infants and geriatric populations and patients with comorbidity. The number of people reported dead by burns was 3 275 the majority occurred in residential fires (2 745), 310 in vehicle accidents, and 220 by other causes (1-3). The World Health Organization (WHO) fact sheet revised in March 2018 accounts for an estimated 265 000 burn deaths annually in the world. An estimated 180 000 deaths every year are caused by burns – the vast majority occur in low- and middle-income countries and almost two-thirds occur in the WHO African and South-East Asia regions, and they are an important cause of disability (4).

Treatment of the burned patient during the acute or the reconstructive phase is a challenge for the general surgeon or the reconstructive plastic surgeon. The goal should be a focus on achieving survival with the least amount of contractures, hypertrophic scar, and sequelae. The reconstructive surgery of the burned patient is the most varied surgery applied to a single pathology. Preventing sequelae in the acute phase plays a key role in analyzing the result obtained at the end of treatment. Early excision and grafting of the deep second and third-degree burns ensure better skin quality incorporating patients to rehabilitation schemes earlier (5,6).

The major burn problems are the hypertrophic scar (7,8) and the contractures (9-11). The use of positional and dynamic splints guarantees the correct position of the joints and prevents retractions, that once established must be treated surgically (7-11). Certain reconstructive surgeries on the burned patient are urgent to prevent major sequelae in the acute phase and to preserve a lost function that allows the patient to perform daily life activities. Desirable reconstructive surgeries may start between six and twelve months postburn. Patients need a reconstructive plan and surgeries performed every 3 to 6 months (8).

The plastic and reconstructive surgeon corrects ectropion, microstomia, and release neck, axilla, and hands contractures in the acute burn period (12). Ectropion is due to burning scar contraction of upper and lower eyelids. The procedure needs to be preform early to prevent corneal exposure and damage. The eyelid releases are cover with a skin graft. Patients with pathological mouth opening or microstomia need a release of the perioral area. A commissure plasty keeps a normal mouth opening. This procedure allows the patient to eat again, to perform better mouth cleaning, and make easier the airway management during anesthesia. Neck contracture release also ensures better airway control and allow better and secure intubation. During the acute phase, other important sites need to be released, like the underarms (axilla), antecubital fossa, and hands to ensure the adequate performance of daily life movements and activities (12).

The vast majority of our pediatric patients at Shriners Hospital for Children and adults at the Burn Blocker Burn Unit- University of Texas Medical Branch in Galveston return 6 to 12 months after discharge to begin their desirable functional reconstructive surgeries.

Recently, the use of fractional ablative CO_2 laser has revolutionized the treatment of burn sequelae and hypertrophic scar (13,14). Its sequential use reduces the thickness of the hypertrophic scar, turning the burn scar more flexible, pliable, allowing better mobility and function in the laser-treated areas (13,14).

Reconstructive surgery of the burn patient lasts a lifetime. Especially if the burn occurred early in lifetime. Inseparable bonds between the patient and the reconstructive surgeon are established. The reconstructive plastic surgeon should offer the patient in addition to his expertise a good dose of optimism and compassion along this long journey.

HYPERTROPHIC SCARRING

In the burnt patients, the most common cicatrix formed following a burn is the hypertrophic scar, the prevalence of which has been reported as being as high as 70 % (7,8). Patients with these massive burns develop hypertrophic scars in areas that restrict movements, produce itching, pain, and create discomfort. The hypertrophic scar is part of the greatest unsolved challenge of the burned patient, after reaching the increasing survival seen in recent decades (7,8). Burn patient wound healing is significantly altered since the hypertrophic scar results from perturbation of collagen production and/or degradation; this dysregulation results in disorganized bundles of collagen cross-linked tightly, while type I collagen expression is reduced and type III collagen is over-synthesized, which is not degraded properly during the remodeling phase of the wound healing (7,8). Additionally, cutaneous wounds occurring in areas experiencing higher tension and greater stretching are more likely to form hypertrophic scars, due in part to tension inducing myofibroblast differentiation, which creates a vicious cycle, more contracture, and more hypertrophic scar (7,8).

POST-BURN CONTRACTURES IN THE PEDIATRIC AND ADULT PATIENT

Contractures in burn patients are a major cause of morbidity and cause functional alterations. Interferes with the normal development of pediatric patients and prevents life activities in adults. Studies have shown that 20 % and 30 % of burned patients developed at least one joint contracture sequel at discharge (9-12). Most are mild; especially in burn centers, where splints used to avoid flawed positions and where early rehabilitation scheme is incorporated. More than 30 % of patients have moderate sequelae that warrant surgical treatment. Joint contractures in both pediatric and adult are common in the armpit; followed by the elbow joint that affects the antecubital fold, wrist, knee-hollow popliteal, and ankle (9-12).

In our two centers, it was performed more than 2 000 reconstructive surgeries every year in burned children and adults. Reconstructive surgery in the burned patients is a priority (12). Several procedures are frequently performed in the acute phase and the reconstructive surgery continues every 3 to 6 months after discharge for functional improvement (12).

RECONSTRUCTIVE SURGERY IN THE ACUTE PHASE

Ectropion

Palpebral retractions prevent eyelid closure, exposing the cornea and facilitating the appearance of ulcers or opacity. The retractions need to be addressed as soon as possible. The burned tissue is release at the ciliary edge reaching the supra-tarsal plane. The release should be wide, overcorrection up to 200 %, allowing the eye to close again to its full extent and without any tension (Figure 1). The defect is cover with a split-thickness skin graft (STSG) in the upper eyelid and full-thickness skin graft (FTSG) in the lower eyelid. Bolsters or a tied dressing maintains the pressure on the graft-wound interface to ensure skin engraftment (5,6). Tarsorrhaphy or pseudo-tarsorrhaphy may prevent eyelid mobility to improve graft taken.

Microstomia

Microstomia in burn patients causes serious problems. First, it makes it difficult to control the airway, to perform endotracheal intubation during anesthesia, and hinders the administration of oral-enteral nutrition. The contracture in the perioral area is characterized by retractable bands in the corners of the mouth that prevent opening. The use of flaps, like the Y-V flaps, allows the advance of mucosa and orbicularis muscle to space where the retractable band was severed, allowing a significant increase in the oral opening (Figure 2).

Neck contractures

Severe neck contractures also make it difficult to manage the patient airway. The burn contracture in the neck region creates lower lip retractions, tooth deviations, and alter jaw growth in children.

Figure 1. Burn contracture in the lower eyelid needs to be released and grafted with a full-thickness graft to correct the ectropion.

Figure 2. Commissuroplasty to treat microstomia. To open the commissure a flap Y-Vwith mucosa and orbicularis muscle in advance into the release area to improve the oral opening.

The contracture needs to be released widely, splitting the retractable bands and severing the platysma muscle partially or completely (Figure 3) (12). The use of deferred flaps ensures the survival of longer flaps. The defect size is the limiting factor of the type of graft to use for reconstruction (Figure 4). Small releases can be treated with FTSG, in wide releases an STSG, or the combination of a composite dermal substitute (Integra® or BTM®) with STSG.

Armpit (Axilla) contractures

The axillary region is the most common joint affected by a contracture in the burned patient (children and adults). Early treatment is recommended and every effort to maintain the open space at 90º angle with the use of an airplane splint. Anterior, posterior, or total axilla contractures needs to be treated (12,15). In the case of a single band contracture a Y-V flap, Z-Plasty, multiple Z-plasty, or the Star-Flap can be used (Figure 5). Combined anterior and posterior contractures demand a wide release. After the graft or flap has been taken properly, passive and active rehabilitation will begin to maintain space and mobility.

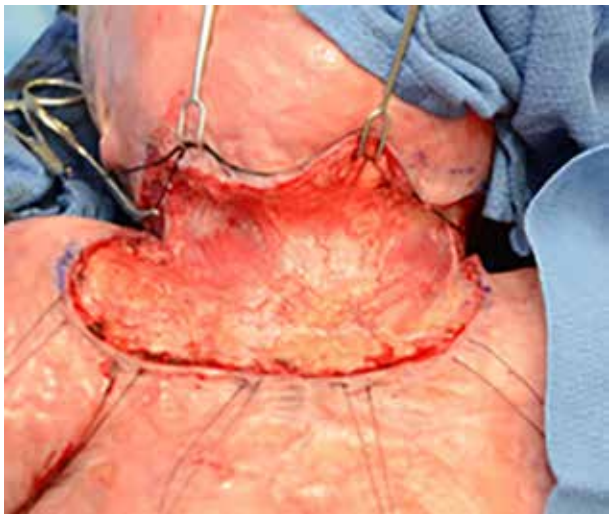

Figure 3. Neck region contractures are common in the acute phase and need extensive releases. The defect may be graft with partial thickness, full-thickness grafts, or composite grafts using BTM® (18) or Integra®.

Skullbone exposure

Patients with full-thickness electrical burns to the scalp may have cranial bone exposure. Scalp axial flaps represent a solution for defect coverage (Figure 6). The donor area can be cover with STSG if the pericranium is intact (16). The Alopecic area may be treated later with serial excision.

RECONSTRUCTIVE SURGERY IN THE POST-ACUTE PERIOD

Six months after discharge from the burn center and the scar tissue is stable we can start improving the burn scar with laser and restoring function. Reconstruction aimed at restoring function in any affected area and restoring non-cosmetic-oriented function.

Figure 4. Severe neck contractures cause alterations to the development of the mandible. The use of composite grafts decreases the contraction in the area.

Figure 5. Axillary contractures prevent abduction and flexion of the shoulder. The "Star Flap" allows normal skin in the contracted area after the excision of the retractable band.

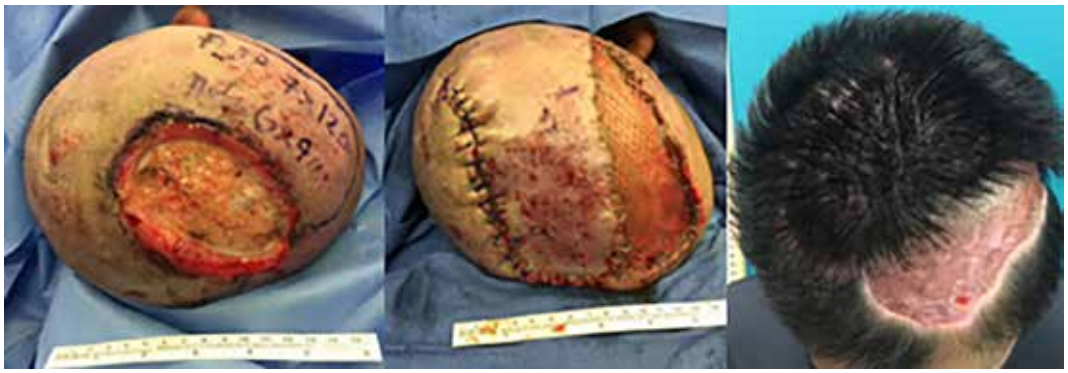

Figure 6. Cranial bone exposures are common in electrical injuries. Axial scalp flaps cover the bone defect. The donor site area is grafted over the pericranium. The Alopecic area may be excised serially.

Hands

Hand contractures are of particular attention in the burn patient. The opening of interdigital spaces is essential in web-space contracture, sometimes referred to as syndactyly. The "jumping men" flap is a combination of two Z-plasty and a Y-V flap in the center of the flap and uses to improve the opening of the first webspace. Interdigital spaces may be treated with Y-V flap or a Z-plasty with FTSG is needed (17). Contractures of the dorsal and volar aspect of the hand and the fingers split and cover with FTSG or composite dermal substitutes like Integra® or BTM® (Biodegradable Temporizing Matrix) (18). The outer layer in Integra is silicone and BTM® is a polyurethane (Figure 7). Kirschner wire (KW) is normally used to maintain the finger straight and avoid movements. The KW should be removed 10 to 14 days post-operation.

Z-Plasty and variations

Z-Plasty is a suitable technique and it is considered one of the oldest tricks of plastic surgery (15). The goal of Z-Plasty is to lengthen the scar and decrease the tension. Also, to break the contracture band and by transposing the flaps elongate the scar, decreasing tension and improving mobility. Changing the direction of the scar and making it more favorable with the Langer's lines of no tension. A 60º angle Z-Plasty produces an elongation or gain of tissue of 75 % (15). Serial Z-Plasty is successive small Z-plasties, having small flaps may have better blood supply and survival. Variations like the "Star Flap" allow the incorporation of healthy tissue in the axilla after releasing the retractile band (15).

Partial resections

Another method to treat burn scar is serial excision. Wide release, mobilization, and advance of healthy tissue allow partial or complete scar excision. This procedure can be used in not-so-extensive burn patients, where enough healthy tissue that can be mobilized (6).

FRACTIONAL ABLATIVE LASER

Fractional CO_2 Laser

The incorporation of the ablative fractional CO_2 laser into the treatment of hypertrophic burn scar decreases scar thickness and increases flexibility in the affected areas (13,14). The CO_2 fractional laser with a 10,600 nm wave (Ultra Pulse® Encore, Lumenis, Israel) creates micro holes and targeting water molecules in the tissues. The laser evaporates the scar creating

Figure 7. Complex hand retractions need to be released. The use of composite dermal substitutes may decrease contracture. The use of Kirschner wires may help graft integration.

columns of approximately 120 μm. Hundreds of micro-channels created in the scar to a depth of 4 mm surround by tissue that becomes a source of viability aiding in neocollagenosis.

The use of the SCAAR FX (Advanced Resurfacing Coagulation and Ablation Synergy) modality creates microchannels and generates a positive effect on the patients. Postoperative the patient feels a decrease in tension, as well a significant decrease in the scar hardness. Microchannel heals quickly and type III collagen is replaced by type I collagen, with less inflammation (13,14).

ACTIVE FX mode produces a sweep over the scar surface improving appearance, homogeneity, and decreasing scar pigmentation. The energy of 60-100 mJ, frequency of 125 Hz, and a density of 3 % are our settings. More than 1 000 lasers every year on burnt children were performed, with an interval of 3 to 6 months between lasers, according to the observed effects in the scar. Three to five lasers can be arranged for two years (13,14). Patients are discharged the same day as the laser surgery. At home, they should wash twice daily and keep moist and hydrated using moisturizing creams five times daily for two weeks. Then, they should apply sunscreen with

higher than 30 PFS to prevent hyperpigmentation. Currently, a laser with reconstructive burn scar releases procedures is used (13,14) (Figure 8). Also, the use of topical or injected steroids may help to further decrease the thickness of the scar.

Figure 8. Fractional CO_2 laser has substantially improved scar quality. Top left, microcolumns ablation of the scar (SCAAR FX), right (ACTIVE FX) sweep the epidermis. Topically or injected steroids are used to decrease further the scar thickness. (Ultra Pulse® by Lumenis, Israel).

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