Seminar on Reconstructive Surgery

Reconstructive surgery for burn patients

C. M. Ho, L. K. Lam and William I. Wei

Abstract

Reconstructive surgery in burn patients is difficult because of the intense scarring and the necessity to carry out multiple operative procedures for different reconstructive needs in a single patient. The primary aim of the surgeon is to prevent hypertrophic scar by early wound closure, and proper postburn treatment using a combination of silicone gel, splinting, and pressure therapy. Reconstructive procedures should be deferred until the wounds have matured. Accurate preoperative assessment and appreciation of the true tissue deficiency, appropriate application of different reconstructive options, and the establishment of the priorities of reconstruction in relation to individual requirements are essential for a successful outcome. In general, functional needs have to be met before attending to aesthetic concerns and priority should be given to restore active before passive function. Different reconstructive options using direct closure, skin grafts, flaps, free tissue transfer, and tissue expansion are discussed.

Keywords: Burn; Hypertrophic scar; Reconstruction

Introduction

Survival after severe burn injury has improved substantially during the past 50 years because of the refined fluid resuscitation and nutritional feeding regimens, the use of topical antimicrobial agents, and early operative therapy. Despite the improvement in survival rate, it is inevitable that thermal injury to the skin, except for very superficial burns, results in permanent scarring,. In fact, proliferative scar formation, either hypertrophic scar or keloid, is a common sequel of burn injury, especially in Oriental patients.

Prevention of hypertrophic scars

The most effective treatment of hypertrophic scar is prevention. Scar hypertrophy typically begins about three weeks after final wound closure and is most exuberant by the second or third month. The scar then slowly regresses over the next 12 to 24 months. Hypertrophic scars appear to be related to wound contraction, which is a normal process of wound healing. It is neither possible nor desirable to prevent wound contraction but it may be possible to prevent the abnormal continuation of wound contraction leading to a contracture or deformity.

At present we have enough evidence to believe that hypertrophic scarring is most likely in patients whose wound healing is delayed for more than 21 days. Deitch and his colleagues' noted that the best prognostic indicator of subsequent hypertrophic scar formation was the time required for healing. When the wound healed in less than 21 days, 33% resulted in hypertrophic scars, compared to 78% of those requiring more than 21 days to heal. Robson [2] also demonstrated that hypertrophic scars were related to the amount of time that the wound was allowed to remain in the inflammatory phase before moving into the proliferative phase. He suggests that burn wounds should be excised and closed very early to decrease the length of the inflammatory phase. For the same reason, it is important to have a successful skin graft 'take' at the time of initial excision and grafting during the acute care of the burn wound. These

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advantages are best shown in hand burns where aggressive surgical management together with proper splinting and early mobilization is responsible for the good long-term results. This is because the oedema, inflammation and immobility that accompany a thermal injury can render the hand useless through rapid joint stiffening with attendant adhesions and scar contracture.

Another technique to decrease hypertrophic scarring is the application of pressure. It has been shown that in hypertrophic scars treated with pressure, the collagen nodules common in untreated hypertrophic scars disappear and the collagen bundles become oriented and aligned through mechanical traction until the fibres are parallel to the force of stress.[3,4] Pressure garments customized to the individual patient should be applied as soon as possible after the wound is completely healed. Pressure therapy should be given for the total period of scar maturation, a process that often takes one to two years.

In addition to pressure garments, silicone gel could be applied directly on the scar. The gel improves the scars to a greater degree and much faster than pressure alone and keeps the skin soft and supple.[5,6]

As previously mentioned, the process of scar maturation takes one to two years. It is therefore important to have splinting and exercises after the burn wound heals while the scar is still immature. Without the splintage and exercises, wound contraction will act unopposed and promote distortion producing disfigurement and functional limitation.

Management guidelines

Reconstructive procedures should be deferred until the wounds have matured. This may take up to two years in adults and even longer in children. During this time, external pressure by means of splints and elastic masks is recommended to minimize scar hypertrophy.

Early reconstruction should be performed only if the deformity is progressive or causes functional deficit, which occurs not infrequently. An example is severe ectropion of the eyelid where early reconstruction is necessary to prevent exposure keratitis. Lip release and reconstruction may be necessary to prevent sagging, drooling and poor nutritional status from an inadequate oral aperture. Complete neck release may also be required to facilitate anaesthesia during subsequent operations. It also helps to minimize extrinsic facial contractures in the perioral region, cheek, and lower eyelids.

In a severely burned patient, multiple procedures are often required and may take several years to reconstruct. A surgeon should document every deformity accurately and carry out a precise analysis of structures or tissues that are missing or displaced. The deformity could be caused by contraction of an adjacent structure, e.g., ectropion from a burn of the cheek, or the injury and contraction of the part itself, such as the shortening of the lower lid from a burn. It is important to appreciate both the extrinsic and intrinsic factors causing the deformity. Reconstruction involves release of the extrinsic contracted scar and resurfacing the area of intrinsic contracture. Appreciation of the true tissue deficiency, particularly after releasing the intrinsic or extrinsic contractures, may be the most important step in reconstruction.[7]

A long-range plan has to be formulated to establish priorities, ration donor sites, and combine complementary procedures. The patient has to be considered as a whole in relation to his/her age, lifestyle, occupation, and physical demands. In principle, functional needs should be met before attending to aesthetic concerns and higher priority should be given to restore active before passive function. However, cosmetic reconstruction may also improve the patient's function and daily activities and help him/her to return to work earlier.

It cannot be overemphasized that post-operative splinting and/or pressure garments should be given after each reconstructive procedure. Lack of attention to these details jeopardizes optimal functional and aesthetic results. Patients should also be advised to protect the new scars and grafts from ultraviolet radiation to avoid hyperpigmentation.

Once the priorities of reconstruction have been determined, the techniques available are numerous and diversified. The most simple method which will produce the desired result should be chosen. Direct closure, skin grafts, flaps, free tissue transfer, and tissue expansion are the main armamentarium of the reconstructive burn surgeon.

Direct closure

Direct closure after excision of the scar is the most simple method in burn reconstruction. In planning scar revision, it is important to appreciate the normal wound healing process and the factors that make a scar less than optimal. The common reasons why scars are unacceptable are: failure of proper dermal approximation, direction of the wound not parallel to relaxed skin tension lines, and a pathological extension of normal wound contraction resulting in a contracture. During scar revision, the new wounds should be realigned to the skin creases or hidden in the hairline when applicable. The skin closure should be meticulous and accurate approximation of skin edges is important.

Z-plasty is a technique by which two triangular skin flaps are interchanged in position to gain length along a scar or skin-fold at the expense of the adjacent

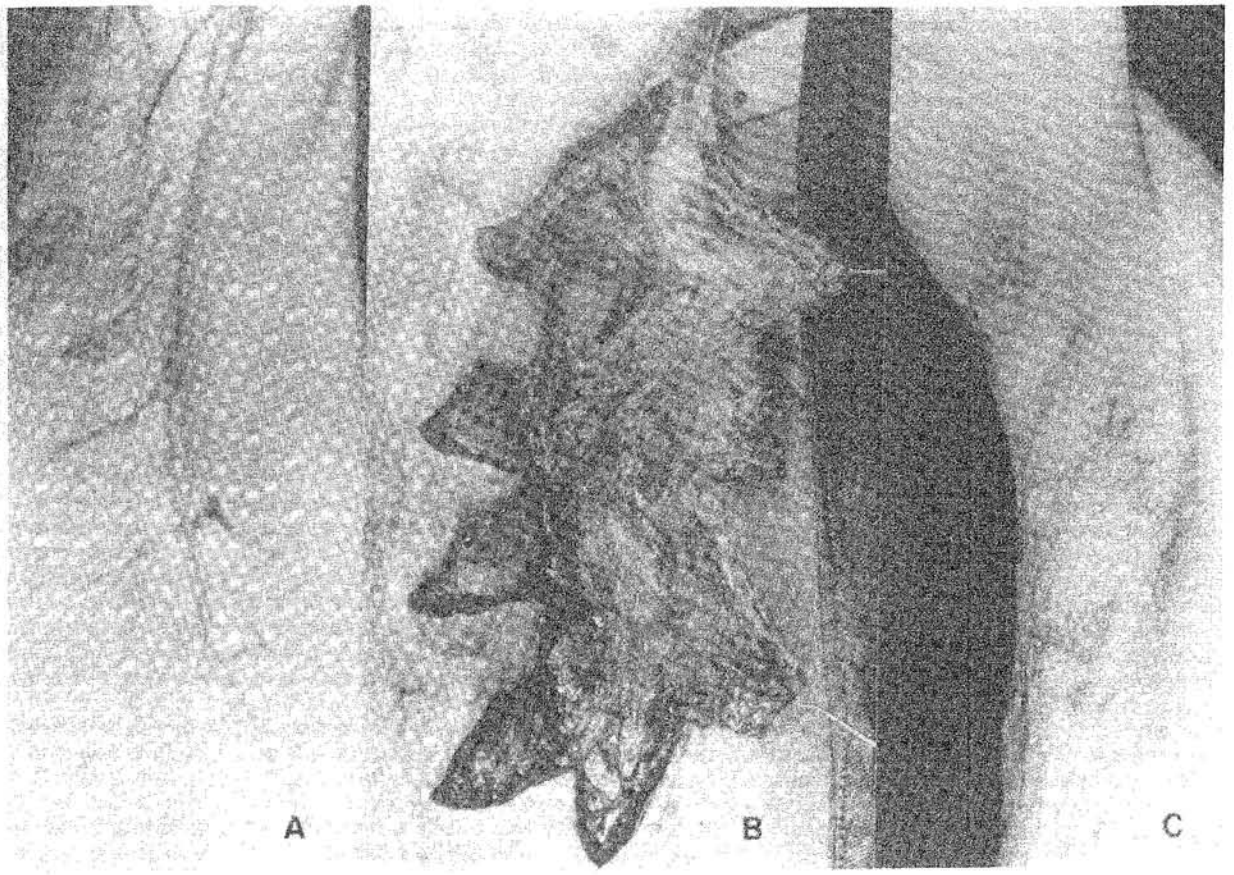

Fig. 1. (a) Multiple Z-plasty planned to release web contracture of axilla.
(b) Contracture released and multiple flaps raised.
(c) Result at three months after operation.

tissues. Its appropriate use allows the reconstructive surgeon to lengthen a contracted scar (Fig. 1), obliterate a web contracture, add to an area of deficient tissue, and change the direction of a scar.[8]

Skin grafts

When a scar contracture is incised or excised, the edges retract widely and make tissue deficiency apparent. In most instances, direct closure is impossible and skin grafts are the next most common technique. A split-thickness or full-thickness skin graft will replace the deficiency and improve the scar. A full-thickness skin graft will provide a better quality and colour match but the availability of the donor sites is limited (Fig. 2).

When choosing the donor site, the colour, texture, vascularity, thickness and hair-bearing nature of the skin need to be considered. In general, the nearer the donor site is to the recipient site, the more closely the skin will match. This is particularly true in reconstruction of the face. Although the facial skin is obviously the best match, it is seldom available. The adjacent area above the nipple line gives the next best colour match.

Whether to use skin grafts or skin flaps in facial resurfacing continues to be controversial. Proponents of skin grafts argue that grafts are not bulky and do not mask facial expression. Grafts, on the other hand, tend to contract and hyperpigment with time, and even the best grafts lack a normal surface texture. In general, a burned cheek in an unscarred face is best resurfaced with a flap because a graft would look like an alien patch, even if replaced as an aesthetic unit. If the entire face needs to be resurfaced, a graft is more appropriate than a flap. If not enough 'blush' skin is available, the entire reconstruction should be performed using skin of the same colour and texture.

Full-thickness or very thick split-thickness grafts are preferable in total facial resurfacing because the thicker the graft, the milder the contracture and the better the surface texture. In order to achieve a satisfactory result, virtually 100% 'take' of a graft is needed for a satisfactory result. It may be wise to wait 24 hours after scar excision to ensure perfect haemostasis before applying the skin graft.

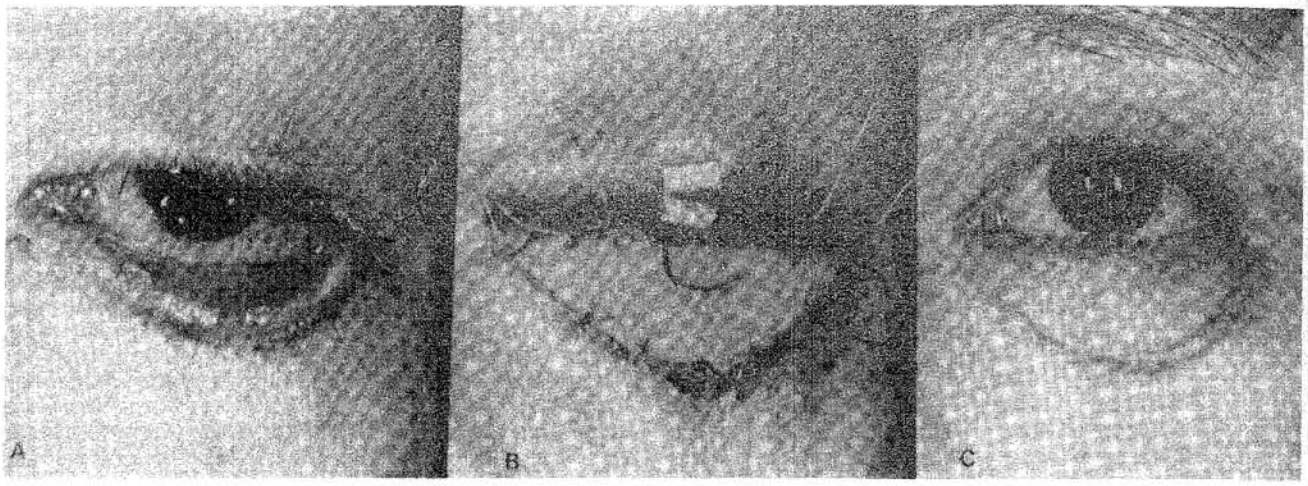

Fig. 2. (a) Ectropion of the left eye causing conjunctival injection and epiphora
(b) Release of the ectropion and tissue deficiency replaced by a full-thickness skin graft.
(c) Result at four months after operation.

Flaps and free tissue transfer

In certain instances, the area in need of reconstruction may lack the vascularity to support the skin graft, e.g., bare tendon, bone, cartilage, and ischaemic wounds. There are also occasions when a skin graft could theoretically close the defect or correct a deformity, but is not the most desirable type of reconstruction. Such is the case when deeper tissue is desired for contouring or padding over bony prominence, future surgery will be necessary beneath the reconstructed area, near-normal sensation is required of the reconstructed area, or the hoped-for aesthetic result cannot be achieved by a skin graft. In all these circumstances, reconstruction can be better effected by a skin flap.[7]

In comparison to skin grafts, skin flaps carry a greater bulk of non-contractile, mobile tissue into the area and shorten the post-operative period of immobilization. A good example is the use of latissimus dorsi fasciocutaneous flap as described by Tolhurst and Haeseker.[9] Apart from the advantages of flap thinness and pliability common to all fasciocutaneous flaps, it is easy to raise and can reach the axillary fold. It has been considered to be the first-line reconstructive option in burn contractures of the axilla.[10]

Flaps can be transferred with their pedicles still attached to the donor site or by dividing the vascular pedicle and reanastomosing it in a recipient site as a free flap. Harii and his associates pioneered the use of free tissue transfer for burn wound reconstruction. Ohmori[11] reported a large series of free flaps in 1978. With the rapid improvement of microsurgical technique and the understanding of flap physiology, free tissue transfers of composite tissue from distant areas are almost routinely successful.

Free tissue transfer provides a number of advantages. It makes possible the transfer of a large free skin flap of almost any shape or composition in one stage and thereby the hospital stay is greatly shortened. A second advantage is that tissues that have been difficult to transfer, such as muscles and toes, can be transferred under physiologically favourable conditions. The disadvantage of free tissue transfer lies chiefly in its technical difficulties and the importance of in-depth training in microvascular surgery has to be stressed.

As a result of the reported successes in late reconstruction, surgeons begin to extend the application of free tissue transfer to the management of acute burn wound. It is probably rarely needed as when cortical bone or bare tendon is exposed. However, this occurs more frequently in electrical burns. Wang[12] was able to salvage 60% of the ischaemic limbs when early vein grafting was used in the management of electrical injuries to the upper extremities. Silverberg[13] and his colleagues have reported the use of free flaps in the acute wound management following electrical injury. They felt that electrically-induced endothelial damage was not a problem if large vessels outside the immediate zone of electrical damage were used as recipient vessels.

Free tissue transfer is invaluable where local tissue is not available because it is included in the area of injury. When used judiciously, it should solve many problems which previously resulted in limb amputation.

Tissue expansion

Tissue expansion is based on the observation that tissue expands in the biologic conditions of preg-

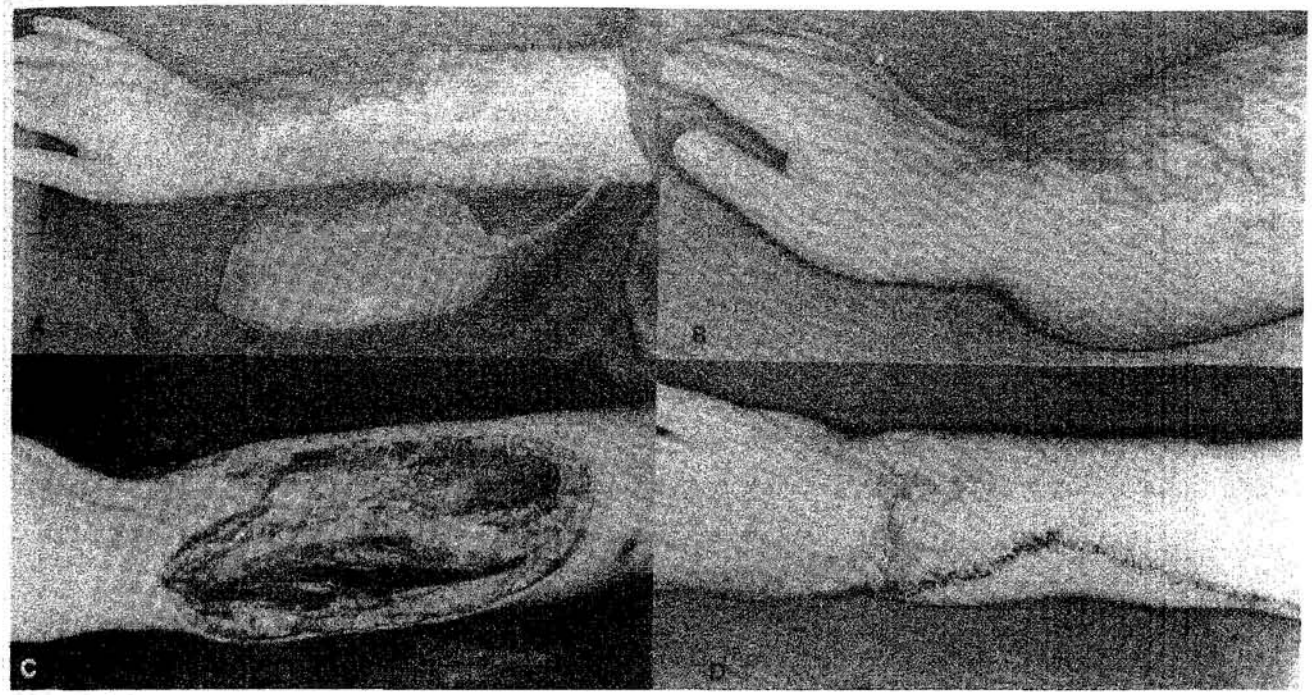

Fig. 3. (a) Burn scar of the dorsum of right forearm. A tissue expander is to be inserted under the ventral surface to expand the unburned skin.
(b) Expansion completed three months later.
(c) At the second operation, scar excised except for the distal part across the wrist joint.
(d) Expanded ventral skin advanced to close the defect.

nancy, obesity, and pathologic conditions such as tissue overlying neoplasms. In 1957, Neumann described the use of a subcutaneously placed implant in an attempt to reconstruct an external ear deformity. Working independently in 1975, Radovan and Austad developed the concept of tissue expansion with a silicone implant.

Most of the information regarding the biology of tissue expansion has been derived from animal experiments, since human tissue is difficult to obtain. It appears that gradual stretching of the skin can occur without the risk of cell necrosis and dermal rupture. Epidermal cells and the thickness of the epidermis are essentially unchanged. The dermis thins and there is an increase in the number of fibroblasts and myofibroblasts. There is significant thinning of the subcutaneous tissue and atrophy of muscle whether the expander is placed above or below the specific muscle. None of these changes would seem detrimental to the use of expanded skin for reconstruction. In fact, Cherry and his associates[14] demonstrated a dramatic increase in vascularity during tissue expansion. Comparing expanded flaps to delayed flaps and acutely raised flaps, they were able to show that flaps elevated in expanded tissue had the greatest increase in survival length, averaging 117% over control flaps.

The use of tissue expansion in burn reconstruction Is not without complications.[15, 16] Minor problems were encountered in 10 to 29% of the patients, but the original goal of the reconstruction was obtained. In 12 to 19% of the patients, major complications interrupted the planning and the procedure might have to be abandoned. However, the benefits of a decrease in the necessity to graft the flap donor site, an increase in the vascularity of the expanded tissue flap, and the provision of skin of similar colour, texture, thickness, and composition outweigh the risks. In the successfully managed cases, the results are frequently far superior to those made possible with available alternative techniques (Fig. 3).

Tissue expansion has become the method of choice for reconstruction of scalp defects.[17] It is the only procedure that allows the development of relatively normal hair-bearing tissue to cover areas of alopecia. Tissue expansion allows closure of large defects in a shorter time than previously required with multiple procedures and many serial excisions. Another common application of this technique is in the face and neck reconstruction where skin colour and quality match are of particular importance (Fig. 4). Tissue expansion has also been used to provide a large full thickness skin graft and allow the donor site to be closed primarily.[18]

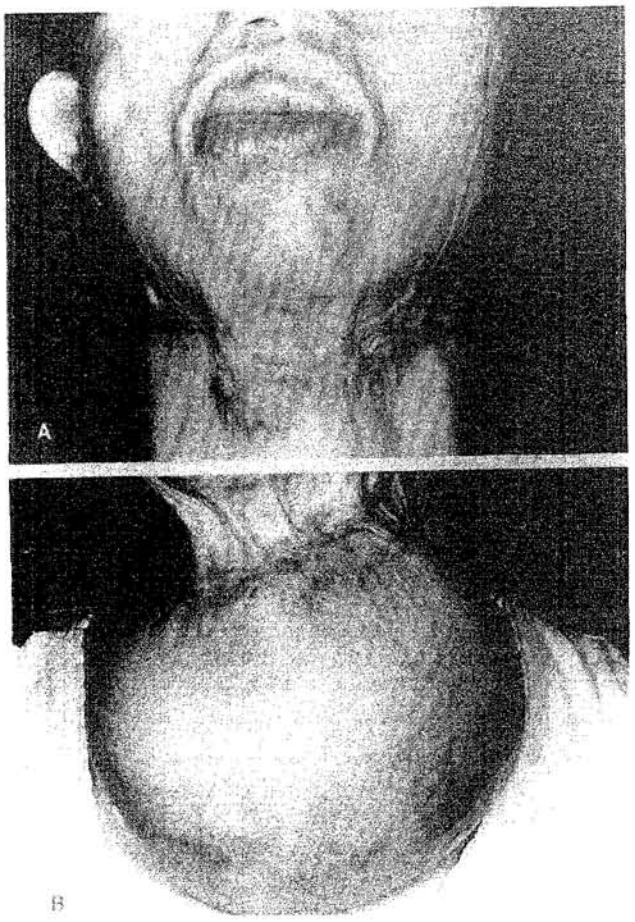

Fig. 4. (a) Severe scarring of the chin and submental region causing extrinsic perioral contracture.
(b) Neck skin expanded to provide skin with good quality and color match.

Conclusion

Reconstruction in burned patients is difficult because of the intense scarring and the necessity to perform multiple procedures for different reconstructive needs in a single patient. The preoperative assessment, planning of reconstruction and the establishment of reconstructive priorities are essential for the desired outcome. With the modern techniques of skin expansion, microvascular tissue transfers, myocutaneous and fasciocutaneous flaps, the treatment of established burn contractures could be highly successful.

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