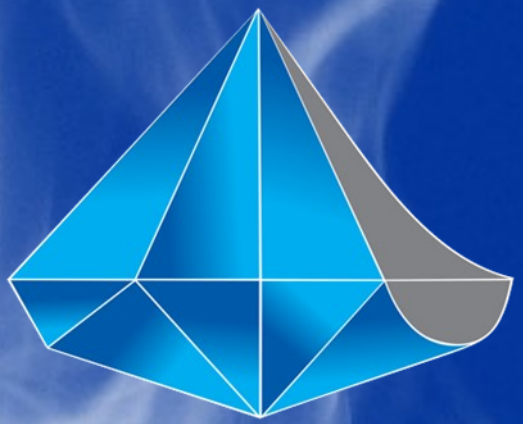

Burn Reconstruction eBook

FORWARD

These notes on burn reconstruction are specifically for Physiotherapy and Occupational Therapy students as well as Medical students. You will see blue bars along the left margins of section that are critically important and deserve more than one read through.

This entire document is now available as a PDF eBook which can be downloaded from my website and be viewed on most tablet devices or computers.

If you have any comments or suggestions to improve this resource, please share them with me.

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DR MJ MURDOCH
PLASTIC SURGEON

Introduction

The management of burns is often very poorly performed, but many of the critical steps are just common sense.

The management takes place in **2 phases**, which often overlap each other. These are the **acute (often life saving) management** and **subsequent reconstruction**. The acute interventions start at the scene of the burn and continue during the resuscitation and later hospital stay. The reconstructive efforts may begin at a very early stage – this is important if maximal function is to be achieved.

Basic Burn Pathology

The severity of a burn is determined by both **the length of exposure** and the **intensity** of the source. Human tissue has a high water content and therefore has a **high heat capacitance** – this mean that it **cools slowly**.

By way of analogy, human tissue is much like tomatoes in a grilled cheese and tomato sandwich. It is always the tomatoes which burn you because they are able to "store" much more heat than the cheese and transfer it effectively.

There are 3 "zones" in a burn injury which make up a target-like shape :

- The central **"Zone of coagulation"** which contains irreversibly damaged and non-viable tissue
- The middle **"Zone of stasis"** which contains marginally viable tissue where changes to the cells and their micro-circulation have occurred. With good burn management some of the tissue in this zone may be salvaged, resulting in a smaller defect.
- The outer **"Zone of hyperaemia"** which contains viable but oedematous and inflamed tissue.

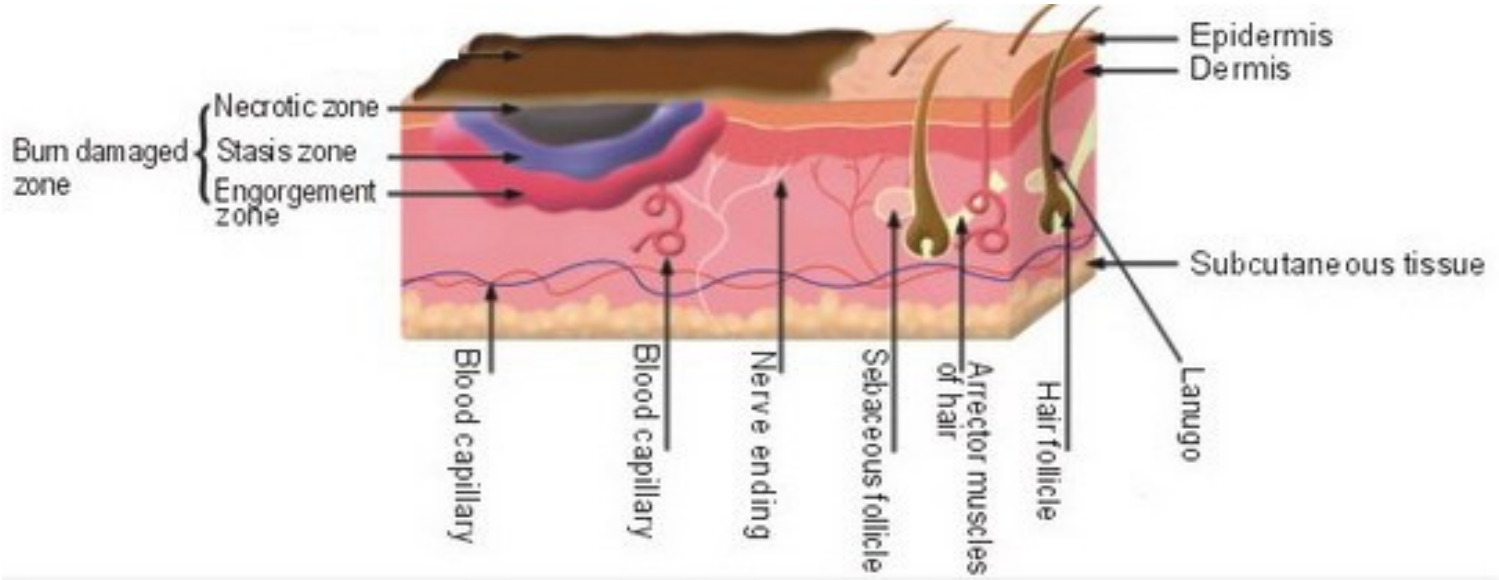


FIG 1

Basic First Aid

The management of burns **starts at the scene** of the burn. The **source** of the burn should be identified and **controlled** to prevent further injury to the victim and **ensure the safety** of the rescuers. It may also provide clues about **additional injuries**, such as inhalational injury in closed space fires or myocardial injury in electrical burns. If possible, the duration of the burn should be ascertained. The first thing to do after controlling the source and securing the area is to begin the **basic life support algorithm** :

A is Airway – inhalational injury and most burns greater than 50% will most likely require intubation at some stage – it is better to intubate earlier, rather than allow the airways to become oedematous, when intubation may be difficult or impossible. It is important to remember that burn victims may have an **associated cervical spine injury** and should be treated as such (c-spine control when moving etc).

B is for Breathing – significant burns of the chest and abdomen limit chest wall movement and thus impair the ventilation. **Emergency escarotomy** should be undertaken (see later). Humidified oxygen should be administered.

C is for Circulation – massive fluid loss should be expected and fluid administered to keep up with losses. 2 Large-bore peripheral venous access cannula should be inserted, preferably through non-burned skin. During the **first 24 hours only crystalloid fluids** should be used and **no glucose containing solutions** should be given as the patients often have impaired glucose tolerance due to the metabolic stress response.

Fluid is calculated according to various formulae, but the Parkland (or modified Brooke) formula is the most popular :

For the first 24 hours :

4ml x patient weight (Kg) x % of Burn

EXAMPLE : 4 x 70 x 50 = 14 000ml !!!

Administer Half (7000ml in the example) in the first 8 hours and the other half in the next 16 hours. This works out initially at 875ml / h !

For the second 24 hours :

2ml x weight x % burn

D is for Disability. Preventing further damage to the patient's tissue is critical. Often the ABC's can be rapidly assessed on the scene and this important step undertaken early.

Cooling the tissue is key to limiting the burn (see the pathology of burns on page 3 as to why). As the skin is a heat capacitor, cooling often takes much longer than anticipated – after minor burns at home, **cooling with cold running tap water** (not ice) for up to 20 minutes is required.

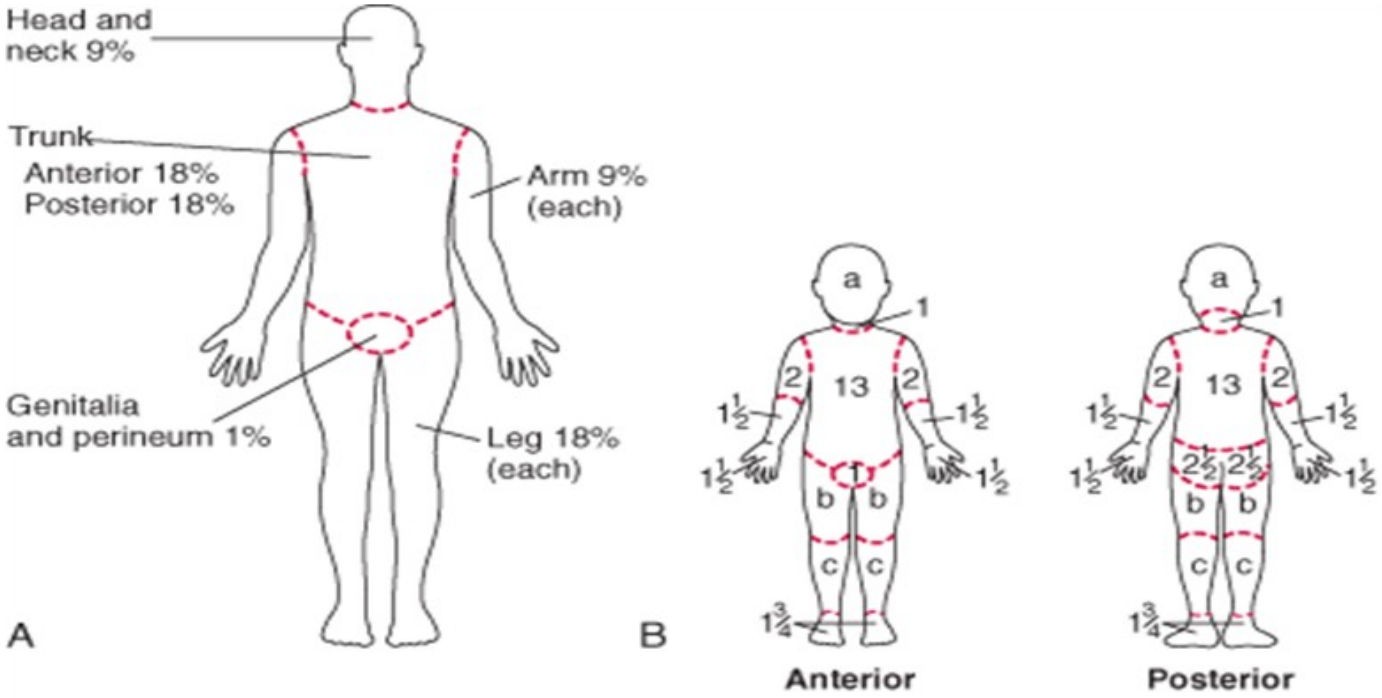
[Do NOT apply 'burnshield' until the tissue is sufficiently cooled]. Beware of excessive cooling and the **risk of hypothermia** in massive burns.

Chemicals should be irrigated off the skin with lots and lots of running tap water. The only exception to this is white phosphorus burns, where water may ignite the phosphorus and cause further burns.

After this resuscitation the patient should be stable enough to undertake an extensive search for any associated injuries (**the secondary survey**) – for example cervical spine, and other fractures should be excluded, carbon monoxide poisoning ruled out and inhalation injury diagnosed and managed. At this stage, an initial assessment of the area and the depth of the burns should be undertaken. Due to expansion of the "zone of stasis" the initial assessment may change significantly in the following hours to days.

Assessing the Area of the Burn

A good rule of thumb is that the **surface area of the patient's palm** (no fingers) is about **1% of the total** body surface area (TBSA). The **Rule of 9's** (see diagram below) is a useful tool in adult patients, however as children have proportionally larger heads, an age related modification of the rule of 9's is used – this is known as a **Lund & Browder Chart**.



Relative percentage of body surface area (% BSA) affected by growth

	Age				
Body Part	**0 yr**	**1 yr**	**5 yr**	**10 yr**	**15 yr**
a = 1/2 of head	9 1/2	8 1/2	6 1/2	5 1/2	4 1/2
b = 1/2 of 1 thigh	2 3/4	3 1/4	4	4 1/4	4 1/2
c = 1/2 of 1 lower leg	2 1/2	2 1/2	2 3/4	3	3 1/4

FIG 2

Assessing the Depth of a Burn

In the past, the burn depth was classified by degrees. Presently however, to simplify matters, we use a **descriptive classification**, which is not only easier to remember but provides a guide to management. Remember that the depth of a burn may change depending on the initial management. Burn depth is classified as follows:

Superficial thickness. This is a burn which involves **ONLY the epidermis**. The involved area is **red** and very **painful**, but healing takes place **in 2-5 days**. **No scarring results** from such as burn. An example of this would be a non-blistering sunburn.

Partial thickness. These are burns which involve the **epidermis AND** a variable thickness of the **dermis**. This group is further sub-divided into:

- **Superficial Partial thickness.** This involves the epidermis and the upper dermis, but the **dermal appendages** (hair follicles, sweat gland etc) are undamaged. Re-epithelialization occurs from the dermal appendages within **3 weeks and minimal scarring results**. Any **blisters** on a burn would indicate a superficial partial thickness burn.
- **Deep Partial thickness**. These burns involve the **epidermis and a large portion of the dermis** and do not have the ability to re-epithelialize from appendages, but only from the unburned surrounding skin, which takes **weeks to months** and results in **moderate to severe scarring.**

Full thickness. These are burns where the **full thickness of BOTH** dermis and epidermis are irreversibly damaged and **must be replaced** to avoid severe scarring and contactures.

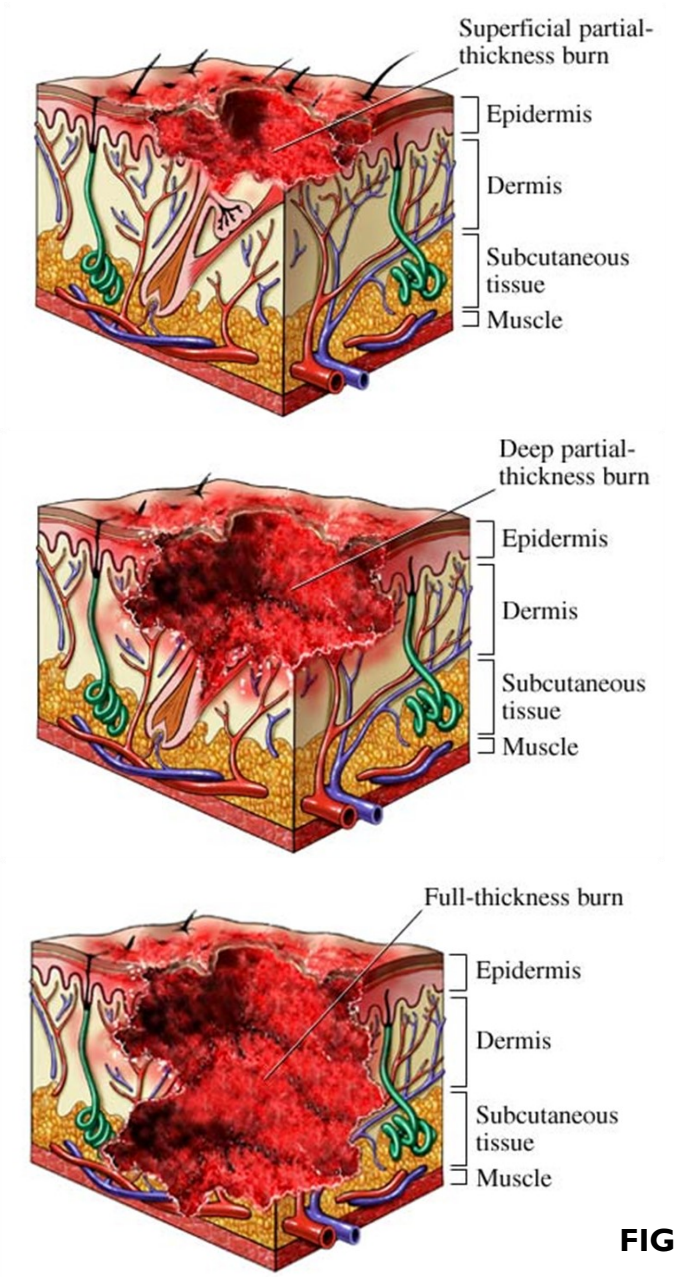


FIG 3

Introduction : Burn Reconstruction

The goals of any reconstructive surgery are two-fold: maximise the patient's **function** and minimize the patient's **disfigurement**. In light of these two aims, the approach to burn reconstruction is ordered by priority: Urgent, Essential and then Desirable.

Urgent Reconstruction

These are procedures which are undertaken to prevent the loss of life, or major morbidity to the patient. These procedures are often **emergencies** and may be performed shortly after the initial stabilization of the patient. The **role of the trauma surgeon** is central during this phase of the reconstruction. Examples include escharotomy and escharectomy and the **coverage of irreplaceable structures**, such as brain, cornea, nerves and major blood vessels.

Escharotomy is the **incision** of thick non-viable skin and subcutaneous tissue which may be **limiting** breathing or causing occlusion of blood flow to a limb. It is **not painful** (the skin is charred and the nerve endings not working) and the cut tissue **does not bleed**. It does not have to be done in theatre.

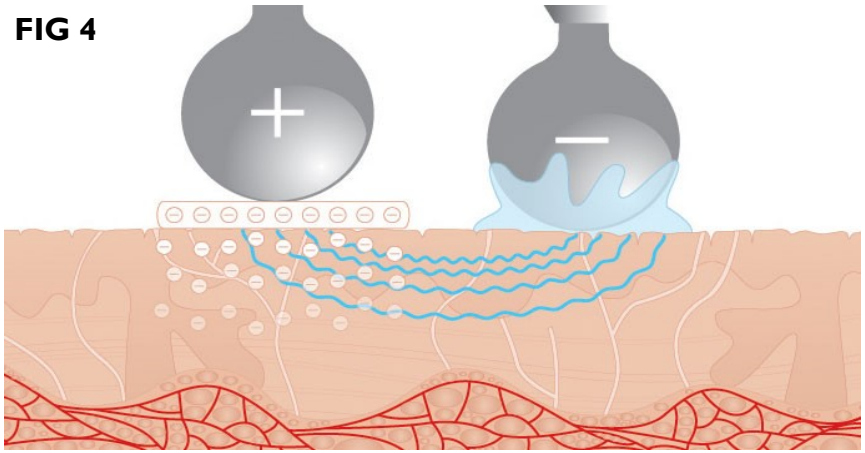
Escharectomy is the **excision** of non-viable burned tissue to healthy tissue with subsequent early graft closure. It is **painful** and often associated with **profuse bleeding** and is thus done in theatre. This is started 2-4 days after the initial stabilization and is done in **multiple stages**, limiting each stage to a maximum of 10% TBSA to prevent **hypothermia and excessive blood loss**. The technique of early excision and closure is associated with lower wound infection rates, decreasing associated morbidity and improved survival.

Protection or coverage of the other vital structures may involve moisture chambers, or flap cover, depending on the severity and stability of the patient. The plastic surgeon is often called to assess the requirement for such procedures.

The treatment of Suppurative Chondritis

Acute bacterial infection of burned ears is very common, when the ear cartilage is denuded of skin. Rapid **destruction of the cartilage** occurs and may be impossible to reconstruct later. A useful modality in the management is **gentamycin iontophoresis**. The basic principle of electricity, that **like charges repel and opposite charges attract** each other (Coloumb's Law) could be used for **local *ionized* drug administration** through tissue borders. Thus, in order to deliver a negatively charged drug, the negative electrode (cathode) is placed on epithelial surface where it is repelled and is attracted towards the positive (anode) one, which is placed elsewhere on the body. For **Gentamycin, which is positively charged**, the positive electrode is placed over the soaked swab or gel on the ear and the negative electrode is placed on the opposite side of the head. This technique allows the **local tissue concentration** to exceed that which may be achieved by intravenous use **without systemic toxicity**.

FIG 4



Essential Procedures

These procedures are undertaken to **achieve the goals** mentioned above. Although all members of the burn team are involved in the management of the burned patient during this phase of reconstruction and the role of the allied medical disciplines is critical to success. Such procedures can start as soon as the patient is stable enough (in the correct order of priority though).

The Role of the Allied Medical Disciplines

Physical and occupational therapists play an essential role in the acute management of all burn patients, even those who are critically ill. If a body part is left immobile for a protracted period**, capsular contraction** and **shortening of tendon and muscle groups** that cross the joints occur. This process can occur very rapidly. Passive ROM exercise and anti-deformity splinting can prevent this.

Range of Motion

This is best done **twice daily**, with the therapist taking all joints through a full range of motion. The therapist must be sensitive to the patient's **wounds**, the status of extremity **perfusion**, the state of **pain and anxiety**, and the security of the patient's airway and vascular access **devices**. **Medicating the patients** before therapy sessions is often useful to increase their efficacy and decrease their discomfort. Ranging can **be timed to coincide** with dressing changes and wound cleansing, minimizing the need for medication.

Splintage

Properly performed anti-deformity positioning minimizes shortening of tendons, collateral ligaments, and joint capsules and reduces extremity oedema. Although splints are not a panacea to joint contractures, several **predictable contractures** that occur in burn patients can be prevented by a properly performed **splinting program**. These contractures generally are associated with the **flexed position of comfort**. The hands, with extension of the MCPJs are an exception. **Flexion deformities of the neck** can be minimized with **thermoplastic neck splints** and **correct patient positioning** on the mattress. In critically ill patients, positioning the neck in slight extension is often all that can be done. It is also important not to allow ventilator tubing to pull the head such that a contracture develops. If proper care is not taken, a rotary contracture can develop, with the patient turned toward the ventilator.

Axillary adduction contractures can be prevented by positioning the shoulders widely abducted with axillary splints or support devices mounted to the bed. It is important **not to overstretch the axilla** and cause a traction **brachial plexus injury** – abduction should be limited to less than 90 degrees. **Elbow flexion contractures** are minimized by **statically splinting** the elbow in extension. These splints can be alternated with flexion splints to facilitate retention of full range of motion. **Flexion contractures of the hips and knees** are particularly common in young children but can be prevented by **careful ranging** and positioning. Flexion contractures are important to prevent even in infants, as they can interfere with subsequent ambulation. **Prone positioning**, although poorly tolerated by some, can assist in minimizing hip flexion contractures, and knee immobilizers can minimize knee flexion contractures.

An **equinus deformity of the ankle** is a serious problem that can occur during protracted periods of bed rest with the ankle in extension, **even if the ankles are not burned**. The ankle flexors shorten resulting in disabling contractures. This can be prevented with static positioning of the ankles in neutral and twice daily ranging.

It is important to note that poorly fitted splints can cause **pressure injury over the metatarsal heads or calcaneus** – a pressure ulcer in these areas are difficult to treat and adds to the patients morbidity load.

Therapists who care for patients with serious burns must establish a **long-term relationship**, which the goals and responsibilities of each partner is clearly communicated. Both patient and family are grateful for regular communication and updates as to progress made and problems encountered. This **teamwork approach** helps to ensure compliance and prevent psychological disability.

The Role of the Plastic Surgeon

During this phase, there may be large areas of tissue denuded of appropriate cover. The **early** provision of **stable durable cover** goes a long way to the prevention of excessive scarring, fibrosis and contractures. The range of motion, safe position for splintage and the concept of 'aesthetic units' may guide the surgeon in the provision of appropriate cover. Again, the **order of priority** is critical. Areas of exposed bone and tendon or joint surfaces are considered 'hard areas' and often left until other areas are covered – this is a management error and can considerably impact on the patient's future reconstruction.

The **replacement of the lost dermis** is key to the **prevention of excessive fibrosis** and scarring, while **the replacement of the lost epidermis** is key to the **prevention of loss of fluid and protein** which increases the metabolic demands of the patient. **Split thickness skin graft** has traditionally been the reconstructive method of choice as it achieved both of the above. However, recent developments in **tissue engineering** have made both an epidermal and a dermal replacement available.

Bio-engineered Dermis

So called "**dermal regeneration templates**" comprised of a sheet of porous **bovine collagen** and **chondroitin-6 sulphate** matrix overlaid with a **thin silastic sheet**. It acts as a **scaffold** for dermal regeneration. Its unique action essentially **inhibits granulation** (and subsequent hypertrophic scarring) and promotes the growth of **neo-dermis** through the matrix. The **silicon sheet prevents the loss of fluid and protein** from the wound surface and acts like an epidermal barrier 9it not as effective though). Following application to a freshly excised wound, the collagen layer **is biointegrated** within the wound to form a vascular 'neodermis', a process that takes approximately 3–6 weeks. Once this stage has been reached, the silastic layer can be removed and an **ultrathin split-skin graft applied**. The matrix is poorly resistant to infection and the wound must be clean prior to application. Several such products are available in South Africa, such as Integra, Pelnac and Dermagen. Cost implications are an important drawback to their widespread use.

Bio-engineered Epidermis

These products consist of a bilaminate membrane of **nylon mesh fabric** bonded to a **thin layer of silicone**. The nylon mesh is **coated with peptides** derived from porcine type I **collagen**, in order to aid adherence to the wound bed and fibrovascular ingrowth. The silicone is semi-permeable. As the wound heals, the **nylon mesh separates**, and can readily be peeled away from the surface. It is **used for superficial partial-thickness burns** (where the epidermis is lost) or as a temporary cover for freshly excised full thickness burns. It is best reserved for clean wounds. When used in this manner, superficial partial thickness burns can be expected to **heal much faster**. There is also **significantly less pain, fluid loss** and metabolic derangement.

Two products are available in South Africa, Keragen and Biobrane. As above, cost is their major drawback (a single hand 'glove' of engineered epidermis is R7000).

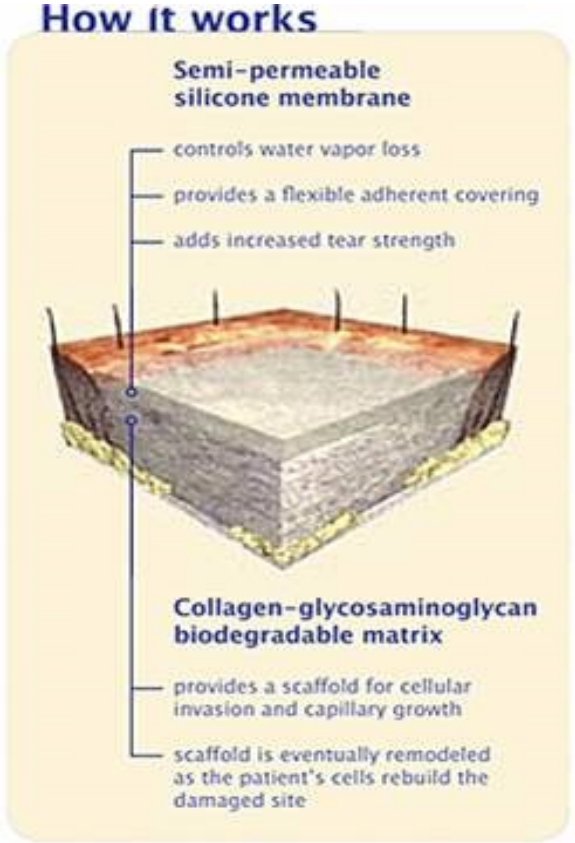


FIG 5

Desirable Procedures

These are procedures which are often undertaken in the late phase of a burn, or electively once the patient has been discharged. It is during this phase when the role of the Plastic Surgeon is most appreciated.

Face : Reconstruction of burned areas takes place within well defined '**aesthetic units'** which allow the placement of scars at natural boundaries to minimise their impact. **Nasal reconstruction** is usually by means of a flap – **the paramedian forehead flap** (the Indian method) is the gold standard, but may not always be available. Prevention and treatment of **burn ectropion of the eyelids** is essential to prevent **corneal dryness and ulcers** which may lead to visual loss later on. **Full thickness skin grafts** from the retro-auricular area usually provide the best colour match. **Reconstruction of the eyebrows** is an underutilized effort but is always greatly appreciated by patients. **Full thickness grafts, flaps and microfollicular grafting** are applicable methods. **Ear reconstruction** in burns is often difficult and may be impossible in some badly burned patients. In these cases, a **prosthetic ear** may be of great value to the patient. Consideration of **an osseo-integrated implant** (with a magnet to hold the ear in place) should be done, as the glue is messy and may melt in the summer

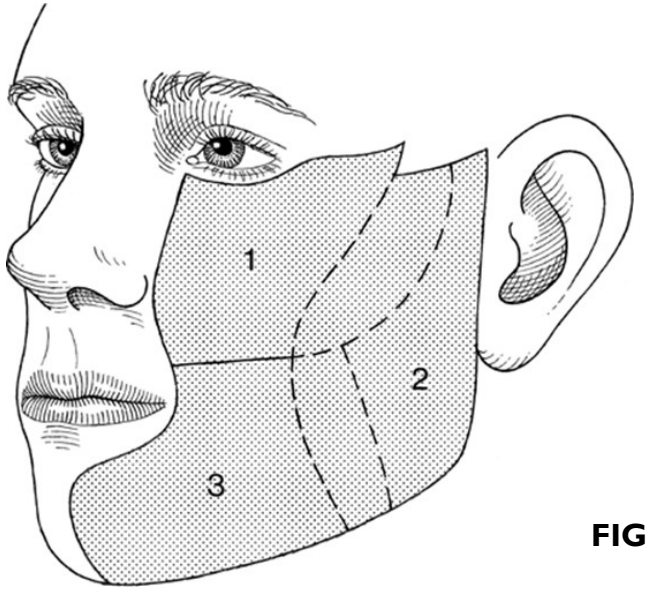


FIG 6

Upper Limb : Late reconstruction is undertaken in **multiple stages** using a **proximal to distal sequence**. The use of flaps, skin grafts and z-plasties are common. In general, it is preferable to prevent upper deformities, than to reconstruct them secondarily. Aggressive ranging and splintage are essential, but occasionally, **Kirchner pin fixation** of the joints in a maximally function position is required. The provision of stable cover is a management priority. In late cases with severe deformities, **arthrodesis or amputation** may be offered to the patient. In highly selected cases, the use of **pollicisation** (the use of a finger to make a thumb) or **microvascular toe-to-hand transfers** may be applicable.

The Role of the Therapist

The principal components of burn therapy during this phase are :

- Continue passive ranging
- Increase active ranging and strengthening
- Minimizing oedema
- Perform activities of daily living

  Prepare for work, play, or school

Long-term favourable outcomes require hard work during this period. The therapist should not push too hard (alienating the patient), but optimal function for the patient is important to achieve. Intraoperative ranging can be undertaken when reconstructive procedures are scheduled.

Oedema Management

Burned and grafted extremities have **lingering oedema** that can contribute to joint stiffness. The use of custom-fitted compressive garments in the early phase is unjustified as they need to be frequently altered. Tubular or circumferential **elastic wraps, elevation**, and retrograde **massage** are useful in extremity oedema.

Scar Management

This is an essential aspect of outpatient burn therapy. **Hypertrophic scarring** is seen in **deep dermal burns** that are allowed to heal with dressings only. This seems especially true in areas of **highly elastic skin**, such as the lower face, submental triangle, and anterior chest and neck. **The wound hyperaemia** that is universally seen following burn wound healing should begin to **resolve approximately 9 weeks** after epithelialisation, increasing redness is a sign of impending hypertrophic scar and is due to increased angiogenesis. A number of methods may be useful to improve the appearance and function of burn scarred tissue. These interventions include scar massage, compression garments, topical silicone, steroid injections, and of course surgery.

FIG 7

Scar massage

This can be quite effective in limited areas of scarring and can be performed by either the patient of a family member. This is done **several times** each day as **firm, slow, circular massage**. The pressure need not be excessive – a blanching is all that is required. The use of **moisturizing skin emollients** is beneficial in **reducing friction**, protecting the **fragile burned skin and improving the dryness**.

Compression Garments

Although controversy remains over the issue, experience supports the use of garments to **facilitate control of broad areas of hypertrophic scarring**, particularly in young children in whom this process seems to be more severe. Compression garments should be **worn 23 hours a day** until such time as wound redness subsides, usually **12-18 months after injury**. Growing young children require frequent **refitting** and replacement. Garment fit must be verified after manufacture, as a poorly fitting garment is less effective and can be uncomfortable.

Topical Silicone

This should be applied to **healed wounds only**. It is available as **sheets** or as a **topical gel**, which dries to a thin film. The **exact mechanism is still uncertain**, but the current theory is that the **prevention of transdermal moisture loss** is the mechanism of action. Silicone sheets can be placed beneath compression garments or can be held in place by a number of elastic devices, however **firm pressure is not required** for the silicone to be effective.

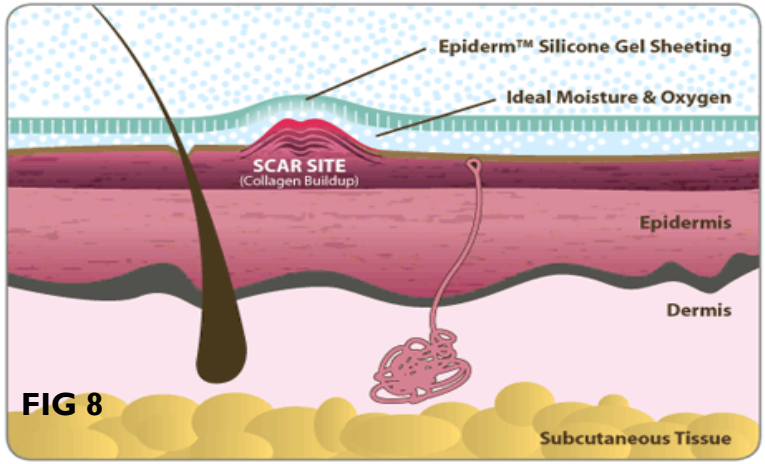


FIG 8

FIG 9

Steroid Injection

Steroid injection [I use **depo-medrol** (methyl-prednisolone acetate) as it is much more potent than celestone-soluspan] **directly into hypertrophic scars** is effective in many, but not all patients. With high dose steroids, some **hypopigmentation** is inevitable and the steroid injections themselves are **very painful**. The total dose should be limited **to 80—120mg (2—3 vials)** and can only be **repeated every 4 weeks,** for a period of **6 months**.

Pruritis Managment

Pruritus (itching) is a frequent part of burn wound healing. This typically begins shortly after the wound is healed**, peaks in intensity 4-6 months** after injury, and then gradually subsides in most patients. It can be very **troubling at night**. It may be managed with **massage**, **moisturizer**s, and **oral antihistamines** at night. Topical selective anti-histamine (H1 blocker) is effective and Lycoderm Labs (pharmacist@lycoderm.co.za) will be able to mix 5% Doxepin on order. Localized highly pruritic scars often respond to a steroid injection.

Conclusion

Historically, the goal of the burn team was survival, however presently the ultimate goal of all burn care is reintegration. Burn care does not stop with wound closure. Ideally, the patient should be returned to their family and community. This may not be possible and special needs groups and "burn camps" may provide a much needed starting block for burn survivors. Successful burn care requires hard work by a focused multidisciplinary team over the continuum of care, from resuscitation through reconstruction, rehabilitation, and reintegration.