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Article *in* Plastic & Reconstructive Surgery · September 2002

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International Clinical Recommendations on Scar Management

Authors:

International Advisory Panel on Scar Management

October 2000

International Clinical Recommendations on Scar Management

Authors: **International Advisory Panel on Scar Management**

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Introduction and scope

The management of hypertrophic scars and keloids is characterised by a wide variety of techniques. Many have been proven through extensive use over the last two decades, however, few have been supported by prospective studies with adequate control groups, and in some cases even safety data are lacking. Many new therapies have been proposed and showed early promise in small-scale trials, but these results have not been repeated in larger trials with long-term follow-up. Judgement of efficacy has further been limited by the difficulty in quantifying change in scar appearance, and the natural tendency for scars to improve over time. Thus, cutaneous scar management has relied heavily on the experience of practitioners rather than the results of large-scale randomised controlled trials and evidence-based techniques.

This paper reports a qualitative overview of the available clinical literature using standard methods of appraisal, and where studies are insufficient, expert consensus on best practice. These recommendations for scar management are the result of this exhaustive review based on over 300 published references. While focussing primarily on the management of the most significant clinical manifestations of scarring, namely hypertrophic scars and keloids, the recommendations are internationally applicable in a range of clinical situations.

Data collection

An initial systematic Medline and Embase search (1996–2000) on scar management therapies took place using the keywords “scar treatments”, “surgery”, “silicone gel sheeting”, “intralesional corticosteroids”, “radiotherapy”, “cryotherapy”, “pressure therapy”,”laser therapy”. In addition all review papers on the management of hypertrophic scars and keloids were accessed in these databases. A further search on scar evaluation methods took place using the keywords “scar”, “assessment”, “evaluation”, “scale” and “model”. In most cases the references were restricted to English language publications. A secondary hand search of citations in the accessed papers was also conducted.

These searches yielded over 300 references with Medline being the principal source. The authors provided additional review papers, clinical studies and recent unpublished data and these, in turn, revealed further useful cited references in English and other languages.

All references were reviewed and those providing original data on the efficacy of scar management techniques were graded according to ‘hierarchy of evidence’ methods to reflect the reliability of data in each study (Guyatt *et al*., 1995; Piantadosi, 1995; Olkin, 1995). These data are displayed in tables in the appendix to support the panel’s conclusions.

The drafts of this manuscript were reviewed by the chairman and panel during a series of teleconferences and by electronic communication.

Definitions and classification

Scar Classification

Scar classification schemes need to be as clinically relevant as possible and the panel have extended standard terminology for this paper.

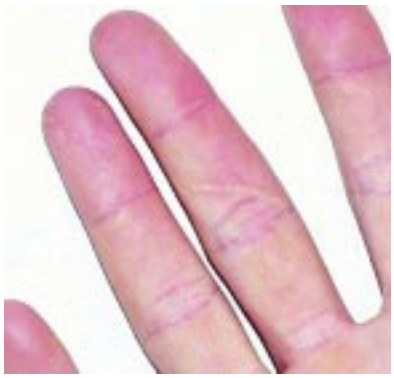

Fig.1

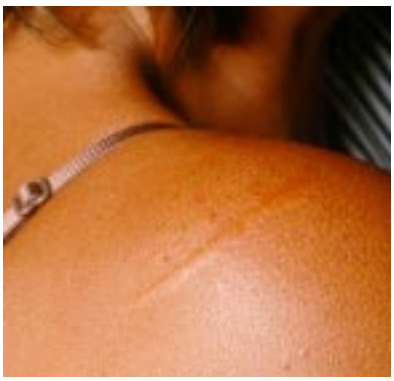

Fig.2

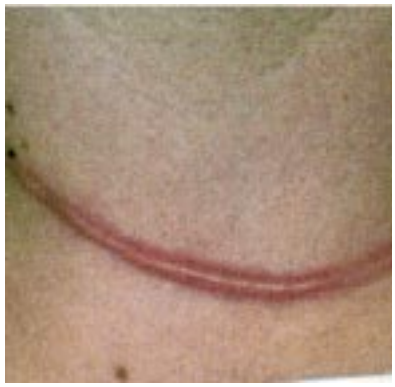

Fig.3

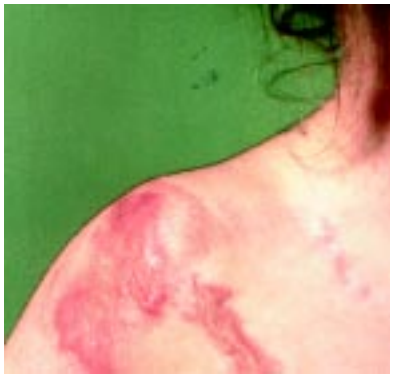

Fig.4

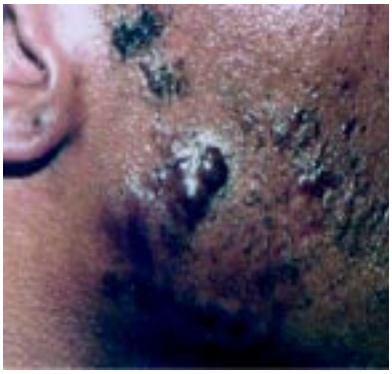

Fig.5

Fig.6

Mature scar - A light-coloured, flat scar. (Fig.1)

Immature scar – A red, sometimes itchy or painful, and slightly elevated scar in the process of remodelling. Many of these will mature normally over time and become flat, and assume a pigmentation that is similar to the surrounding skin, although they can be paler or slightly darker**.** (Fig.2)

Linear hypertrophic (e.g. surgical/traumatic) scar – A red, raised, sometimes itchy scar confined to the border of the original surgical incision. This usually occurs within weeks after surgery. These scars may increase in size rapidly for 3–6 months and then after a static phase, begin to regress. They generally mature to have an elevated, slightly rope-like appearance with increased width, which is variable. The full maturation process may take up to two years. (Fig.3)

Widespread hypertrophic (e.g. burn) scar – A widespread red, raised, sometimes itchy scar that remains within the borders of the burn injury. (Fig.4)

Minor keloid – A focally raised, itchy scar extending over normal tissue. This may develop up to 1 year after injury and does not regress on its own. Simple surgical excision is often followed by recurrence. There may be a genetic abnormality involved in keloid scarring. Typical sites include earlobes. (Fig.5)

Major keloid – A large, raised (>0.5 cm) scar possibly painful or pruritic and extending over normal tissue. This often results from minor trauma and can continue to spread over years. (Fig.6)

Grading systems

A number of grading systems have been suggested over recent years (Davey *et al*., 1999; Powers *et al*., 1999; Beausang *et al*., 1998; Yeong *et al*., 1997. The most widely-used system is the Vancouver Scar Scale (Sullivan *et al*.,1990; Baryza *et al*., 1995; Nedelec *et al*., 2000) . This is a useful clinical and research assessment tool that provides an objective measurement of burn scars and assists prognosis and management. This has been shown in Table 1. Generic measurement tools and record forms have been developed to help use this scale (Smith & Nephew and Davey, 2000).

The SCAR method is a simple new alphanumerical system suitable for scar coding and may be a useful way to evaluate the effectiveness of scar management approaches. SCAR is an acronym for Symptoms, Colour, Appearance and Restriction, and each attribute is rated from 0 to 5 according to severity. This approach combines assessment of physical features, functional aspects and impact on quality of life to provide a clinically relevant scar classification system (Cooter, unpublished observations).

It is anticipated that classification systems will extend over time to incorporate cellular features, possibly using ultrasound and biochemical indicators. As treatments become more targeted, classification may denote underlying pathology, for instance the persist-

Table 1. Vancouver Scar Index

Pigmentation (M)

0	Normal – colour that closely resembles the colour over the rest of one's body
1	Hypopigmentation
2	Hyperpigmentation

Vascularity (V)

0	Normal – colour that closely resembles the colour over the rest of one's body
1	Pink
2	Red
3	Purple

Pliability (P)

0	Normal
1	Supple – flexible with minimal resistance
2	Yielding – giving way to pressure
3	Firm – inflexible, not easily moved, resistant to manual; pressure
4	Banding – ropelike tissue that blanches with extension of the scar
5	Contracture – permanent shortening of scar, producing deformity or distortion

Height (H)

0	Normal – flat
1	<2 mm
2	<5 mm
3	>5 mm

Amended Index

Pigmentation (M)

0	Normal
1	Hypopigmentation
2	Mixed pigmentation
3	Hyperpigmentation

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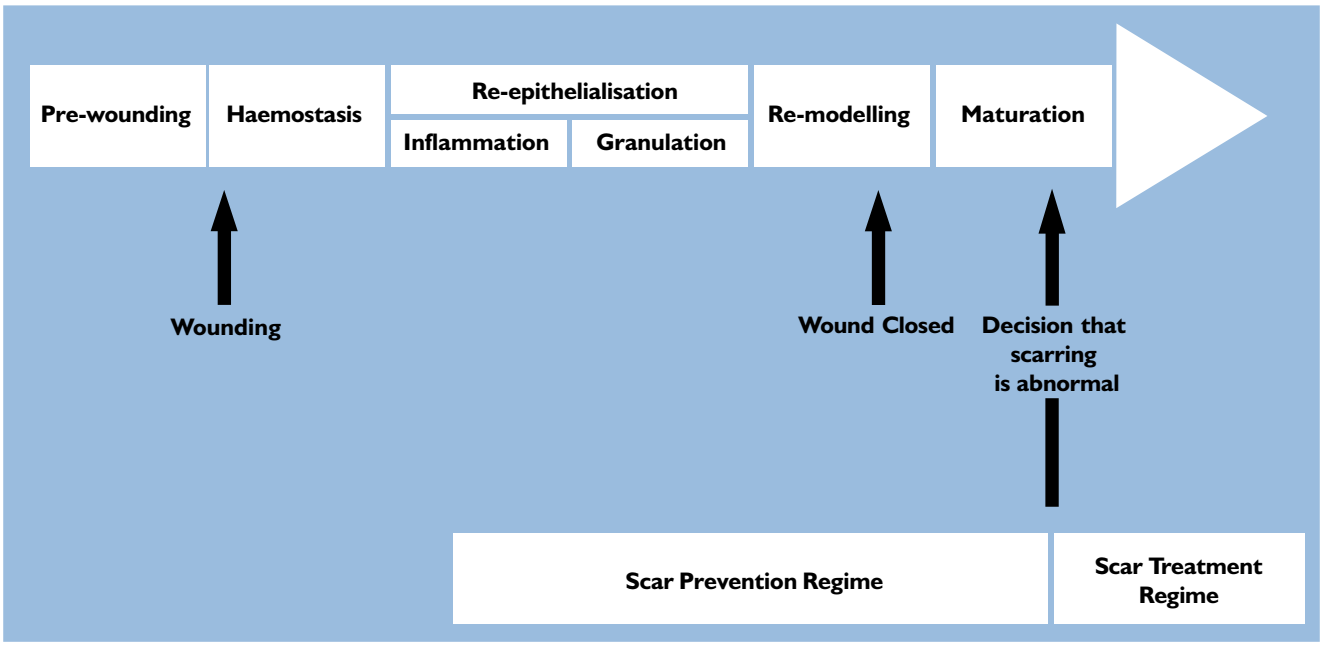
Fig. 7 Scar classification within the context of wound healing (not to scale)



ent inflammatory process of a hypertrophic scar to the tumour-like activity of a keloid which is extending over normal skin.

Response to therapy

Comparison between treatment modalities and clinical studies is difficult as defining an adequate response to therapy remains a relatively neglected area. A mild partial response, which may still leave a cosmetically unacceptable scar, is accepted as a therapeutic success in most studies. Indeed, this can be complicated by patient's over-expectations. Scars never disappear and in many cases only partial response is possible. This limitation must be kept in mind in evaluating any of the therapies below.

Prevention or Treatment

It is much more efficient to prevent hypertrophic scars rather than treat them. Prevention implies using a therapy with the aim of reducing the risk of a problem scar evolving. The transition to a treatment regime takes place when a true hypertrophic scar or keloid, and is not an immature hypertrophic scar, is diagnosed. The recommendation section determines the panel's indicators that a treatment regime should be applied. Fig. 7 shows this in the context of the wound healing process. However, conceptually and practically, treatment and prevention regimes can be similar and the following section presents the clinical data for both.

Therapies

A comprehensive review of the clinical literature published over the last 30 years on scar treatments was undertaken and the panel reached a consensus on the quality of the available evidence. This evaluation is presented for each modality. The efficacy of two scar management techniques (silicone gel sheeting and injected corticosteroids) have been demonstrated in randomised, controlled trials.

Surgery

Surgical excision of hypertrophic scars or keloids is a common and important management option when used in combination with steroids and/or silicone gel sheeting. However, excision alone of keloids results in a high rate of recurrence (45–100%) as the new wound is subject to the same mechanical, immunological and biochemical forces as the original scar (Berman and Bieley, 1996; Darzi, 1992; Lawrence, 1991; Berman and Bieley, 1995). A small study suggests that intralesional excision of keloids is more successful than extralesional excision (Gailloud-Mathieu *et al*., 1999).

Combining surgery with steroid injections reduces the recurrence rate of keloids to less than 50% (Berman and Bieley, 1996; Uroiste *et al.,* 1999) with the combination of surgery and perioperative radiation therapy reducing the recurrence rate to 10% (Berman and Bieley, 1996). However as a result of the long-term risks of radiation therapy it is usually reserved for abnormal scars resistant to other treatments.

If hypertrophic scarring results from wound complications such as infection or wound separation, then surgical excision can be highly successful, especially when combined with surgical taping and silicone gel sheeting.

Scars that are subject to tension by location (chest), motion (shoulder or knee) or by tissue loss (i.e. by excision of a large lesion) require substantial physical support. The most effective way of splinting scars is by surgical closure with sutures for at least 6 weeks and up to 6 months. Scars that stretch subject to tension will double their width between 3 weeks to 3 months, and will increase another 50% between 3 and 6 months (Sommerlad and Creasey, 1978).

Surgical techniques such as W-plasty and Z-plasty improve the appearance and mobility of contracted burn scars (Sherris *et al*., 1995) but are not appropriate for immature hypertrophic scars.

Silicone gel sheeting

Silicone gel sheeting (Fig.8) has been a widely used clinical management option for hypertrophic scars and keloids since the early 1980s (Perkins *et al*., 1982).

The most probable mechanism of action has been suggested to be hydration and occlusion (Sawada and Sone, 1990 and 1992; Chang *et al*., 1995). Earlier, Quinn *et al.* (1985) found that any beneficial effect of silicone gel sheeting is not due to properties related to pressure or oxygen tension. There is no clear evidence of silicone absorption from histological (Ahn *et al*., 1989) or spectrophometric studies (Quinn, 1987, Branagan et al, 2000). Electrostatic charge is difficult to measure and has been excluded (Hirshowitz et al, 1998).

Quinn et al. (1987) also found that silicones could raise skin surface temperature by up to +1ºC of normal skin and Su et al. (1998) have proposed that this could increase collagenase activity as it is a highly temperature sensitive enzyme which could prompt remodelling. Evidence for a dermal temperature change could provide support for this theory.

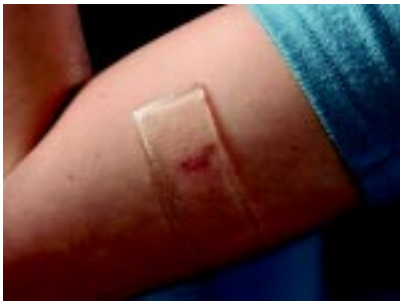


Fig. 8

There is a growing evidence explaining a mechanism via occlusion. Vaporisation of water from skin under silicone gel sheeting is half that of exposed scar tissue (Carney *et al*., 1994). Under silicone gel sheeting the stratum corneum's water content increases to more than 60% after 5 hours of contact, versus 15% for normal exposed skin and about 30% for a highly permeable hydrophilic polyurethane dressing (Branagan *et al*., 2000). Another recent study shows that the increase in hydration from silicone gel sheeting was less than that achieved with plastic film occlusion (Suetake *et al*., 2000). This lead the authors to suggest that silicone gel produces favourable conditions by protecting the skin from various environmental stimuli while keeping the stratum corneum in an adequately but not over-hydrated condition. However, it is not known how this hydration of the stratum corneum alters scarring which is presumed to be a dermal process.

Some researchers have suggested that an abnormal epidermal permeability barrier in the stratum corneum may at least partially explain the effectiveness of silicone gel sheeting (Suetake *et al*., 1996; Elias *et al*, 1996). The epidermis may play a pivotal role in scar control as clinical experience attests to the poor scarring from delayed epithelisation. An intact epithelium also appears to be important in reducing wound contraction (Walden *et al*., 2000). It is well known that keratinocytes produce growth factors and *in vitro* studies with a keratinocyte-fibroblast culture system dem-

onstrated that hydrated keratinocytes inhibited the underlying fibroblast proliferation (Chang *et al*., 1995). Presumably soluble signalling molecules produced by the basal epithelium in response to hydration can impact the proliferative state and matrix production of the underlying dermis.

Although the degree of occlusion appears to be very important in scar management, totally occlusive dressings (e.g. polyethylene films) are not efficacious (Quinn, 1987). Similarly, in an established rabbit ear animal model (Morris *et al*., 1997), semi-occlusive dressings such as polyurethane films or tape were ineffective in treating hypertrophic scars (Saulis and Mustoe, unpublished observations). In addition, non-adherent silicone sheeting was less effective than pure adhesive silicone dressing (Saulis and Mustoe, unpublished observations). Evidence of the effectiveness of other materials such as glycerin and other non-silicone based dressing is mixed (Ricketts, 1996; Baum and Busuito, 1998; Bieley and Berman, 1996. To date, most trials have been undertaken on pure adherent silicone gel sheeting and there is little evidence that the results are transferable to other fabric/polyurethane dressings with silicone adhesive or to non-adherent silicone products. One randomised, controlled trial showed that treatment with hydrocolloid dressings for 2 months resulted in symptomatic improvement, but no change in physical parameters to hypertrophic and keloid scars (Phillips *et al*., 1996). In practice, silicone products vary considerably in composition, durability and adhesion. Some products have shown advantages over others in terms of greater durability and patient acceptability (Donald, 1995; Carney *et al*., 1994).

Silicone gel sheeting is a safe and effective management option for hypertrophic scars and keloids (Su *et al*., 1998). A number of small studies show silicone gel sheeting to be effective in preventing hypertrophic scars following surgery (Gold, 1994; Cruz-Korchin, 1996) and in preventing cobblestoning in vitiligo (Agarwal, 1999). Other controlled studies show the efficacy of silicone gel sheeting in healing surgical (Ahn *et al*., 1991) and hypertrophic burn scars (Ahn *et al*., 1989). This evidence for efficacy comes from randomised, controlled trials as the patients served as their own control, with randomly selected treatment and control sites. Most of the surgical scars had not yet hypertrophied thereby providing evidence that silicone gel sheeting prevents scar hypertrophy. Additional studies demonstrate that silicone gel sheeting prevents recurrence of abnormal scarring in 79–100% of patients (Dockery, 1994; Katz 1992). Recent trials have confirmed the prophylactic efficacy of silicone gel sheeting and its efficacy in treating a range of hypertrophic scars and keloids (Gold *et al*., 2000; Borgognoni *et al*., 2000). A small trial suggests that silicone gel sheeting may prevent recurrence of keloid growth following excision with a carbon dioxide laser (Gold *et al*., 1994).

Sproat *et al*. (1992) conducted a prospective, randomised trial in patients with symptomatic hypertrophic sternal scars. Silicone gel sheeting provided earlier symptomatic relief, a more aesthetic scar and was preferred by patients to corticosteroid injections. Their preference for silicone gel sheeting was primarily due to the absence of pain normally associated with steroid injections.

Management of existing scars has also been shown to be effective. After 2 months 56%–95% of scars improved and further improvements were reported after 6 months (Quinn, 1987; Carney, 1994; Katz 1995). These scars did not 'relapse' when treatment ceased. Beneficial effects on the elasticity and appearance of burn scars were reported after one month of treatment and maximal benefit was seen after two months. No relapse occurred with three months of follow-up (Ahn *et al*., 1989). Some types of silicone gel sheeting are indicated for use in scars up to 20 years old. Benefits have also been reported in the reduction of redness, itchiness and tenderness, as well as improved softening of hypertrophic and keloid scars (Berman and Flores, 1999).

Silicone gel sheeting is easy to use and may be especially useful in children and others who cannot tolerate the pain of other management procedures. Pure silicone products are available in a variety of formulations including gel sheets, self-adhesive silicone gel dressings and silicone oil. Some formulations of silicone oil have been shown to be effective on minor hypertrophic scars (Sawada and Sone, 1990; Wong *et al*., 1996), although these studies have limitations in their design.

Data on most silicone products are restricted to small trials and case study reports. However, results from at least 8 randomised, controlled trials and a meta-study of 27 trials (Poston, 2000) suggest that silicone gel sheeting has an important role in scar management.

Corticosteroid injections

Corticosteroid injections are a first-line therapy in the management of hypertrophic scars and keloids (Rockwell, 1989; Niessen *et al.*, 1999; Urioste, 1999; Alster and West, 1997; Murray *et al*., 1994; Kelly, 1988; Murray, 1993; Griffith *et al*., 1970). They appear to inhibit fibroblast growth and inhibit alpha-macroglobulin, resulting in collagen degradation (McCoy, 1980) as well as having anti-inflammatory properties. However, despite the use of injected corticosteroids in scar management since the mid 1960s (Ketchum *et al*., 1966) the actual mechanism of their action remains unclear.

Intralesional injections are usually administered every 4–6 weeks for several months or until the scar has flattened. Response rates vary from 50–100% with a recurrence rate of 9–50% (Niessen *et al*., 1999). Results are improved when corticosteroids are combined with other therapies. When combined with surgery the recurrence of hypertrophic scars and keloids falls below 50% (Berman and Bieley, 1996; Lawrence, 1991; Tang YW, 1992). Combination with cryotherapy has also been shown to produce synergistic benefits (Hirshowitz, 1982; Whang *et al*., 1997). When steroids are injected at the time of surgery there is a significant incidence of wound dehiscence. However, triamcinolone (40 mg/ml, up to 1 ml) layered into the wound without injecting into the tissues appears to be efficacious without significant side-effects (Mustoe, personal experience).

Intralesional corticosteroid injection is associated with significant injection pain, even with standard doses of insoluble triamcinolone (40 mg/ml), and up to 63% of patients experience side-effects that include skin atrophy, depigmentation and telangiectasias (Sproat *et al*., 1992). Therefore, compliance may be poor although addition of a local anaesthetic makes the procedure more acceptable. A study comparing silicone gel sheets with corticosteroids for management of sternal scars showed equivalent efficacy (silicone gel sheeting providing earlier symptomatic relief), but due to corticosteroid injection pain the majority of patients preferred silicone gel (Sproat *et al*., 1992).

Topical steroid creams have been used with varying success (20–100%) (Yii and Frame, 1996; 41 patients). A prospective, randomised study shows that topical steroids have no beneficial effect in reducing scar formation in post-burn deformities (Jenkins *et al*., 1986; 111 patients).

In summary, despite relatively few randomised, prospective studies there is a broad consensus that injected triamcinolone is efficacious and is first-line therapy for the treatment of keloids and second-line therapy for the treatment of hypertrophic scars if other easier treatments have not been efficacious.

Radiotherapy

Radiotherapy inhibits fibroblast proliferation and collagen synthesis and may induce apoptosis in some active cells in a healing wound and damage connective tissue stem cells. It has been used as monotherapy, and in combination with surgery, for hypertrophic scars and keloids. However, monotherapy remains controversial (Urioste *et al*., 1999, Norris, 1995) because of anecdotal reports of carcinogenesis following radiotherapy although Ketchum *et al.* (1974) reported no evidence of carcinoma induced by this use of radiation. Use of high energy 10–20 Mev machines allows precise dosimetry with sparing of surrounding tissue when combined with appropriate shielding. If the skin can be easily monitored any future development of skin cancer can be treated effectively.
Response to radiotherapy alone is 10–94 % with a keloid recurrence rate of 50–100% (Berman and Bieley, 1996; Lawrence, 1991). Such high recurrence rates are understandable given the resistance of these cases to other management options. The recurrence rate may be related to the total amount of radiation with best results achieved with 1500–2000 rads over 5–6 sessions in the early postoperative period (Cosman *et al*., 1961; Brown and Pierce, 1986).

There have been mixed results from radiotherapy after surgical excision of keloids with a significant objective response reported in 25–100% of patients (Neissen *et al*., 1999). Levy *et al.* (1976) achieved an 88% success rate with a follow-up to 2 years while Edsmyr *et al.* (1973) reported an 80% success rate with a 1-year follow-up.

A small randomised, prospective study suggests that radiotherapy may be more effective than corticosteroid injections in preventing recurrence of earlobe keloids following surgery (Sclafani *et al*., 1996). However, it should be noted that poor compliance with corticosteroid therapy resulted in only 25% of the steroid-treated patients completing their treatment schedule.

Radiotherapy is difficult to evaluate as most studies are retrospective, do not define the term 'recurrence', and use a variety of radiation techniques with varying follow-up (6–24 months). In addition, there are no randomised, prospective studies with long-term follow-up. Although the risk of carcinogenesis is low, and can be limited to the treated skin without impacting deeper tissues, the risk can never be completely eliminated. Therefore, most investigators agree that radiotherapy has no place in the routine first-line management of established keloids and it is mainly reserved for adults and keloids resistant to other management modalities.

Laser therapy

Laser therapy has been used as follows:

- Non-specific destruction of tissue to produce less scarring. This approach has been largely discredited following mixed results in larger long-term trials (Carbon dioxide and argon lasers).

- More recent wavelength-specific lasers to selectively ablate blood vessels (YAG and pulsed dye lasers)

Early successes in small studies have been followed by mixed results in larger trials. For instance, carbon dioxide lasers showed early promise in the excision of keloids (Bailin, 1983) but failed to suppress keloid growth and recurrence in later studies (Apfelberg *et al.*, 1989). As a result these lasers are now generally only used to debulk large keloids prior to another management option (Norris, 1991).

Two newer types of CO_2 laser are in use. Small non-controlled studies, limited by lack of long-term follow-up show that high-energy short-pulsed CO_2 lasers and scanned continuous wave CO_2 lasers are effective in postsurgical hypertrophic/keloidal, traumatic, acne and varicella scars (Bernstein *et al*., 1998). They may be useful in excision of earlobe keloids (Kantor *et al*., 1985). Scanning CO_2 lasers have been used to debride burn wounds, but without clinically improved scar outcome (Sheridan et al, 1999). However, it should be noted that thermal injuries and scarring can result from laser therapies (Grossman *et al.*, 1999). These claims need to be assessed in long-term studies.

Argon lasers were first used in the 1970s for the management of keloids but studies failed to show long-term improvements (Apfelberg, 1984; Hulsbergen-Henning, 1986). They produce more non-specific thermal damage than CO_2 lasers and are associated with higher levels of keloid recurrence (Kantor *et al*., 1985).

Nd: YAG lasers (neodymium: yttrium-aluminium-garnet) have response rates between 36–47% (Abergel *et al*., 1984a). In a recent study of 17 patients with keloids, nearly 60% of scars were completely healed after 3 months' therapy with Nd: YAG laser irradiation (Kumar *et al*., 2000). Further large comparative studies with longer follow-up are now required.

Flashlamp-pumped pulsed dye lasers have shown promise in elimination of erythema and flattening atrophic and hypertrophic scars (Alster and Williams, 1995; Alster *et al*., 1993; Alster, 1994; Dierickx, 1995). Improvements in appearance of hypertrophic scars and keloids have been noted in 57–83% of cases (Niessen *et al*., 1999). Improved results have been noted when laser therapy is combined with intralesional corticosteroids (Goldman and Fitzpatrick, 1995). However, a recent single-blind randomised, controlled study in 20 patients with hypertrophic scars showed that improvements following laser therapy were no better than in those with no treatment (Wittenberg *et al*., 1999). Further controlled studies are required in this area.

Pressure therapy

Pressure therapy (Fig. 9) has been used in management of hypertrophic scars and keloids since the 1970s (Staley *et al*., 1997). It has been standard therapy for hypertrophic burn scars and is still first-line therapy in many centres. Pressure on scars is maintained by a variety of devices such as fitted garments, bandages and pressure earrings (for earlobe keloids). Elastomer inserts with thermoplastic backing have also been used to decrease facial hypertrophic scar formation (Ward *et al*., 1991a). Pressure may facilitate scar healing by decreasing blood flow and oedema while increasing collagen breakdown although these effects are poorly documented. There is increasing evidence that

Fig.9

fibroblasts respond to mechanical forces with signal transduction, alteration in collagen turnover, and remodelling.

It is generally recommended that pressure should be maintained between 24–30 mm Hg for 6 –12 months for this therapy to be effective (Neissen *et al*., 1999; Tilley *et al*., 2000). However, this advice is largely empirical. Long-term compliance is a significant issue. One study reported that only 41% of patients using pressure garments were compliant (Johnson *et al*., 1994) although other trials report much higher rates (Kealey *et al.*, 1990). Effectiveness is related directly to the duration of pressure with a success rate of 85% in compliant patients (Rose and Deitch, 1985).
Correctly managed pressure therapy in combination with physiotherapy may minimise joint contracture and other deformities resulting from hypertrophic burn scars (Ward, 1991b; Tredget, 2000; Nedelec *et al.*, 2000). It has been shown to be particularly effective in treating earlobe keloids (Brent, 1978; Rauscher, 1986; Agrawal *et al*., 1998). The combination of pressure garments with silicone gel sheeting has been found to be more effective and preferred to pressure garments plus intralesional steroids (Sarma, 1998).

Overall, the evidence supporting the speed of scar maturation and enhancement of cosmetic outcome is variable. For example, in a prospective randomised study in 122 burns patients, pressure garments did not increase the speed of wound maturation or decrease the duration of hospital stay (Chang *et al*., 1995). There is a large amount of clinical experience with pressure therapy and it remains one of the main scar management options, particularly for extensive burn scars (Linares, 1996; Rayner, 2000).

Cryotherapy

In this technique, a refrigerant such as liquid nitrogen is used to cause cell damage, tissue necrosis and sloughing with tissue flattening (Rusciani *et al*., 1993). The process may take 2–10 sessions with 20–30 day gaps between sessions.

Cryotherapy alone results in keloid flattening in 51–74% of patients after two or more sessions and it is beneficial for the management of severe acne scars (Layton *et al*., 1994; Ciampo and Iurassich, 1997; Zouboulis *et al*., 1993). Total or partial treatment success was seen in 64% of 336 patients with keloids (Ernst and Hundeiker, 1995). In combination with intralesional steroids the success rate is 84% (Ceilley and Babin, 1979).

Limitations include the delay of several weeks required for postoperative healing and the commonly occurring side-effect of permanent hypopigmentation which is undesirable in patients with darker skin. Other side-effects include hyperpigmentation, moderate skin atrophy and pain (Rusciani *et al*., 1993). As a result, cryotherapy is generally limited to management of very small scars.

Miscellaneous therapies

There are anecdotal reports on a number of additional therapies but there is no adequate published information on which the panel can evaluate their efficacy and safety or make recommendations. These therapies include:

- Adhesive microporous hypoallergenic paper tape (Reiffel, 1995; 64 patients) which is widely regarded as useful, particularly in scars close to joints, but this is not supported by clinical evidence. However, many experienced clinicians, including this panel, find them to be useful and apparently efficacious in reducing the risk of hypertrophic scars occurring after routine surgical incisions in patients at risk (young patients, those with previous history, or familial incidence). An uncontrolled study has reported on good response to a regimen of adhesive stretchable tape, with silicone cream for resistant cases and silicone gel sheeting in the most difficult to treat cases (Davey *et al*., 1991).

- Topical vitamin E which may inhibit collagen synthesis while decreasing fibroblast proliferation and inflammation. It shows no beneficial effects on surgical wound healing and scar formation (Havlik, 1997). For example, a prospective, randomised study shows no reduction of scar formation in post-burn deformities (Jenkins *et al*., 1986; 111 patients). Baumann *et al.* (1999) discouraged topical vitamin E application on surgical wounds due to its lack of efficacy and the high incidence of contact dermatitis.

- Topical retinoic acid which is believed to have an inhibitory effect on fibroblast DNA synthesis (Janssen de Limpens, 1980; 28 patients) and may improve colour, symptomatic relief and flattening of lesions.

- Colchicine which inhibits collagen synthesis, stimulate collagenase and effect myofibroblasts (Peacock, 1981; 10 patients).

- Systemic antihistamines which can stabilise mast cells and reduce histamine levels (Topol, 1981).

- Onion extract cream which did not improve scar erythema and pruritus (Jackson *et al*., 1999; 17 patients).

- Skin equivalents which incorporate artificial dermis constructs have been used to resurface scar excision sites but long-term assessment of their results are awaited.

Experiments have been conducted with a number of other agents for scar management including cyclosporin (Duncan *et al*., 1991), intralesional verapamil (Lawrence, 1996; 35 patients; Lee *et al*., 1994, 5 patients), allantoin-sulfomucopolysaccharide gel (Scalvenzi *et al*., 1998; Magliaro *et al*., 1999), glycosaminoglycan gel (Boyce *et al*., 2000) and creams containing extracts from plants such as *Bulbine frutescens* and *Centella asiatica* (Widgerow *et al*., 2000).

Other physical management options studied include hydrotherapy, massage, ultrasound (Walker, 1983), static electricity (Hirshowitz *et al*., 1998, 30 patients) and pulsed electrical stimulation (Reich *et al*., 1992). However, further long-term studies are required before these can be evaluated for daily clinical practice.

Emerging evidence

Four therapies provide emerging evidence of efficacy. These now require further large-scale randomised controlled studies.

- Interferon (IFN-a, IFN-b and IFN-g) which has been shown to increase collagen breakdown (Granstein, 1990, 8 patients; Larrabee *et al*. 1990, 10 patients; Pittet *et al*., 1994, 14 patients). Tredget et al (1998, 9 patients with 27 matched controls) found that IFN-a2 b injections three times weekly resulted in significant mean rates of improvement of hypertrophic scars versus control and also reduced serum TGF-b levels which continued post-treatment. Interferon injections are reported to be significantly better than triamcinolone acetonide injections in preventing post-surgical recurrence of keloids (18.7% *vs* 58.5% recurrence) (Berman and Flores, 1997; 81 patients). However, these painful injections may require regional anaesthesia.

- Intralesional 5-fluorouracil which has been used successfully

as monotherapy as well as in combination with intralesional corticosteroids to treat hypertrophic scars and keloids (Fitzpatrick, 1999; Urioste, 1999 (numbers not provided). It may warrant further investigation.

- Bleomycin injections show evidence of efficacy in managing surgical/traumatic hypertrophic scars (Bodokh *et al*., 1996; 36 patients; Larouy, 2000; 3 patients). Patients with older scars resistant to intralesional corticosteroids showed good response to bleomycin, 0.01% injections every 3–4 weeks. Although published research is limited, there is considerable clinical experience in using this modality in some European countries. Adverse effects have not been reported for this indication although side-effects in the treatment of warts with bleomycin include nail loss and Raynaud's phenomenon (Smith *et al.*, 1985; Epstein 1985).

- Experimental animal studies suggest that there may be a role for transforming growth factor (TGF) modulators in improving healing and thus scar outcome (O'Kane & Ferguson, 1998). Tranilast , N-(3,4-dimethoxycinnamoyl)anthranilic acid, has been shown to inhibit TGF-â1 release from fibroblasts (Yamada et al. 1994) and a controlled trial on 75 post-congenital cardiac surgery patients found that Tranilast reduced redness of hypertrophic scarring but not its frequency (Nakamura K et al., 1997).

Treatment timing

Early diagnosis of a problem scar can considerably impact on the outcome. The panel considers that the most successful treatment of a hypertrophic scar or keloid is achieved when the scar is immaturebut the overlying epithelium is intact.

Early application also applies to pharmacologically active products, as can be dependent on the age of the wound and its state of epithelialisation. Takeuchi et al (1999) found that there is a window of opportunity for use of interferons just prior to re-epithelialisation. This may also apply to use of corticosteroid injections.

Management recommendations

These management recommendations are based primarily on the clinical evidence reviewed above and reflect the practice of the panel members. Cost plays an important role in the choice of therapy but cost-effectiveness cannot be analysed until there is an objective method of evaluating efficacy. Cost-effectiveness is becoming an increasingly important criteria for choice of therapy, and this remains difficult in scarring because of the considerable intangible benefits of improved functionality and cosmetic appearance. The psychological impact of scarring should not be underestimated.

The recommendations have been summarised in simple management algorithms (Figures 10 and 11).

Prevention

Every effort must be made to prevent the development of hypertrophic scars or keloids after surgery or trauma. The importance of excellent surgical technique and efforts to prevent post-surgical infection cannot be underestimated (see Box 1 and for further information see Harahap, 1999, Surgical Techniques for Cutaneous Scar Revision). Early wound closure, maximum dermal salvage and other features of preventive burns care are important in optimising burn scar management.

Special attention should be given to high-risk patients i.e. those who have previously suffered abnormal scarring, or are undergoing a procedure with a high incidence of scarring, such as breast and thoracic surgery (Box 2). To our knowledge there has been no large-scale assessment of scar outcomes and risk factors.

Preventive techniques are recommended for patients at high-risk of abnormal scarring.

Based on the panel's experience, use of hypoallergenic microporous tape with elastic properties should be considered to minimise the risk from shearing. Use of taping for a number of weeks following surgery is standard practice for the majority of panel members. Although there is no evidence in the literature to support this practice for scar management it does provide a protective layer that prevents wound trauma from scratching and UV exposure.

Silicone gel sheeting should be considered as first-line prophylaxis based on clinical evidence and is recommended for all high risk patients. Use of silicone gel sheeting should begin soon after surgical closure, when the incision has fully epithelialised, and be continued for at least one month. Silicone gel sheets should be worn for a minimum of 12 hours daily, and if possible for 24 hours per day, with twice daily washing. Specific silicone products differ in thickness, adhesion and convenience, all of which may influence compliance and efficacy. Silicone ointments may be preferable for the patient, particularly on the face and neck regions, although unlike silicone gel sheeting, their efficacy in preventing scarring is unsupported by controlled trials.

The panel recommends concurrent intralesional corticosteroid injections as second line prophylaxis for more severe cases. The effectiveness of alternative therapies is limited to anecdotal evidence.

Those patients at low risk of scarring should maintain normal hygiene procedures, and be provided with counselling and advice if concerned about their scar.

Scar management

When patients present with a troublesome scar, appropriate therapy should be selected based on scar classification and patient history. Scar classification is the primary decision criteria for treatment selection. Patient history, however, provides particularly important information about the risk of the scar worsening should treatment fail, therapies which have previously been tried and the patient's likely compliance. The degree of erythema has been identified as being of great importance in predicting the activity of the scar and response to therapy.

Management with silicones and corticosteroids has been shown to be effective in randomised, controlled trials and can be carried out in primary care. Treatment should be commenced as early as possible after the problem scar has been diagnosed to improve the outcome, preferably when the scar is immature but the overlying epithelium is intact.

Associated symptoms
Pain and itchiness are commonly reported symptoms associated with scarring, In burn scarring this can be considered abnormal and disturbing by 65% of patients (Wood F, unpublished observation). Pruritis can decrease over time, possibly because of desensitization or reduced vascularity.

Pruritus is a symptomatic problem and evidence of management methodologies remains anecdotal. Silicone gel sheeting has been shown to reduce itching in numerous case studies (Poston, 2000

Fig. 10 - Prevention of surgical/trauma scarring

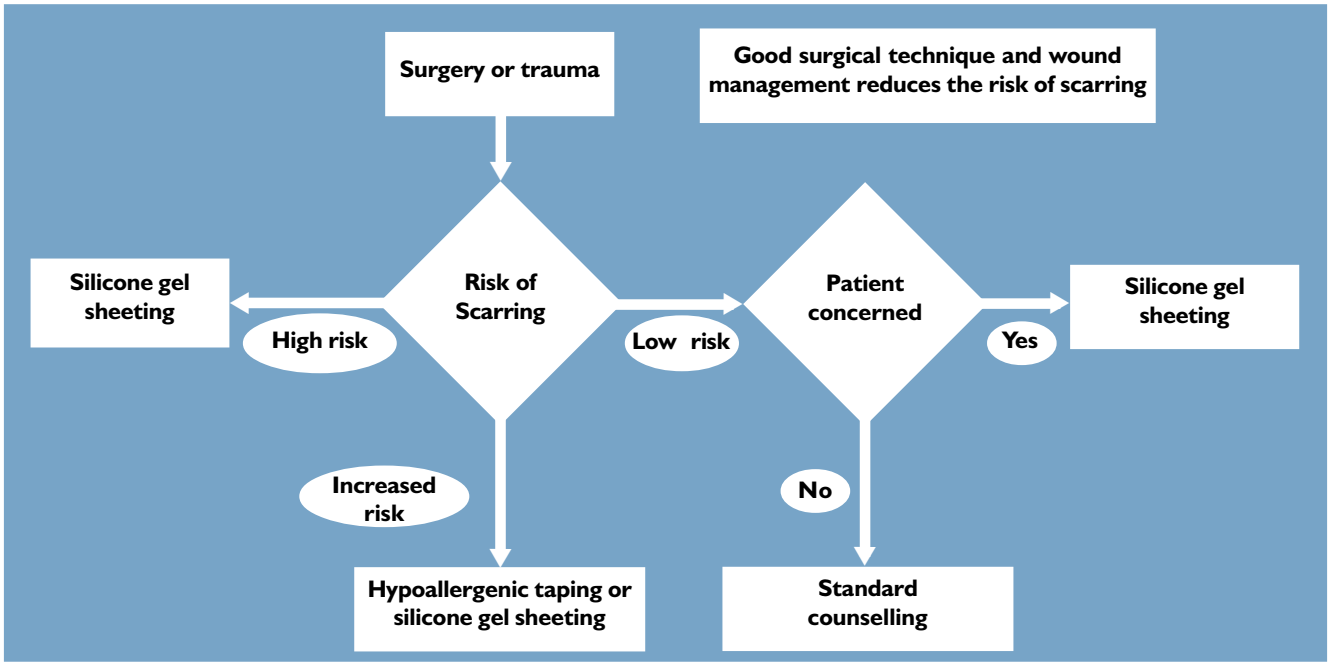
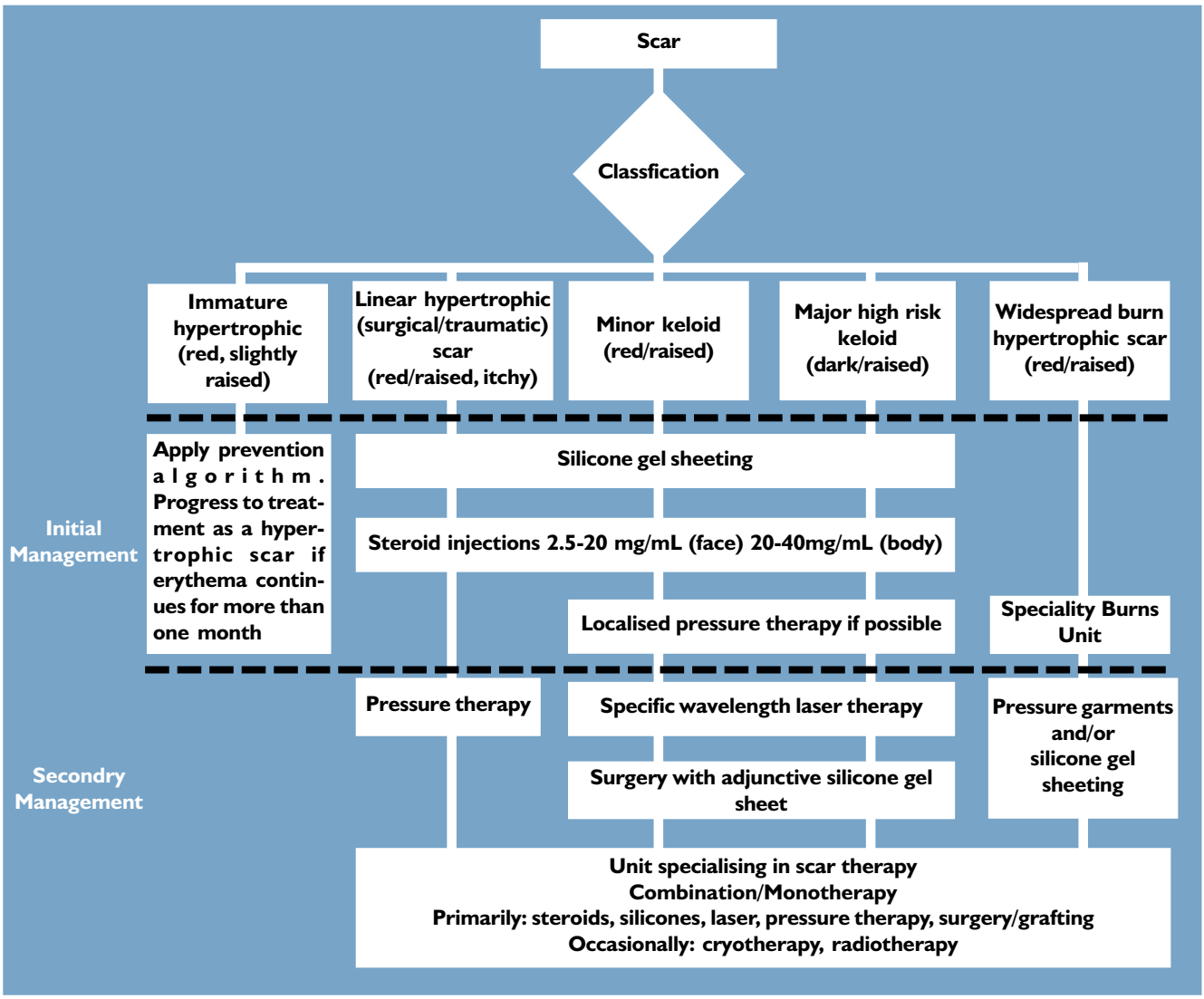


Fig. 11 - Complete management algorithm



Box 1: Optimal surgical technique for scar prevention (Table 3)

· **Scar alignment**	Attention to scar alignment is important and every effort should be made to keep incisions parallel to the relaxed skin tension lines of the skin. Surgical skin incisions should be made at right angles to the skin surface to produce least dermal damage; exceptions to this rule include hair-bearing areas (e.g. eye brows) where incisions should parallel hair follicles to prevent scar alopecia.
· **Skin closure**	Meticulous atraumatic techniques for tension-free skin closure should employ the least reactive suture material (e.g. monofilament) swaged onto cutting needles (usually reverse cutting).
· **Sutures Ideally**	skin wounds should be closed with dermal approximating sutures (absorb able, with deeply buried knots) and superficial wound closure with the least number of epidermal penetrations to ensure the lowest amount of residual iatrogenic scarring from skin puncture marks. Recommended methods include inter rupted sutures combined with surface tapes, intradermal suturing (subcuticular) with a monofilament absorbable thread with commencement and completion of the running suture within the wound. Early removal of any sutures that traverse the epidermis will prevent keratinocyte downgrowth along suture pathways and thereby reduce the scar load.
· **Excisions**	When excising lesions, the surgical ellipsoid planning should have a long axis to short axis ratio of 3:1 to produce a flat linear scar at closure. For skin flap designs, from a final scarring perspective, it is best to design the skin flap as large as practicable because small skin flaps have a high 'scar:flap' volume ratio.

Box 2: Characteristics of patients at risk of developing abnormal scarring (Table 4)

Increased risk

Young age (<40 years old)

High risk

Family history of bad scarring or personal history and more than one of the following risk factors:

- Racial characteristic: African American, Asian, Middle Eastern, Latin American, Australian Aboriginal
- Geographic location: chest, shoulder, neck
- Closure of incision under tension
- Scar with delayed epithelisation (greater than 7–10 days)
- Scar with prolonged inflammation for any reason (i.e. infection, UV exposure, foreign body, scratching, shaving, metal piercing)

and Shakespeare, unpublished clinical trial, 17 patients). Hydrocolloid dressings provided a 70% response in reducing itching in considerable number of patients in the burns clinic (Wood F, unpublished observations**) .** Pulsed dye lasers may have value in reduction of itching although more cost-effective options are preferred at this stage. Other treatments have been shown to improve symptoms; these include moisturisers, systemic antihistamines, topical corticosteroids, antidepressants, massage, steroid silicone foil and hydrotherapy.

Whilst the use of moisturisers is a key element in managing itching, particularly in post-burn patients, care should be taken with hypersensitivities to moisturising products such as lanolin.

It should be remembered that a number of simple environmental management techniques are of value. Good hygiene and minimising early exposure to sunlight will benefit the scar healing process.

Initial management

Immature hypertrophic scar (red, slightly raised):
It is often difficult to predict whether this type of scar will resolve or develop into a hypertrophic scar. In the panel's experience, the techniques described above in the prevention section should be followed. If erythema persists for more than one month the risk of true hypertrophy increases and management should be as for a linear or widespread hypertrophic scar as appropriate (see below).

Linear hypertrophic (e.g. surgical/traumatic) scar (red, raised):
Silicone gel sheeting should be used as first-line therapy, in line with results from randomised, controlled trials. If the scar is resistant to silicone therapy, or the scar is more severe and pruritic, the panel recommends further management with corticosteroid injections.

Insoluble triamcinolone has been the most commonly-used steroid. Injections in the face and neck are usually limited to 2.5–20 mg/mL concentrations to reduce risk of skin atrophy and telangiectasias. Concentrations of 20–40 mg/mL have been used to treat abnormal scars on the body trunk. Techniques to reduce the discomfort of injections include pre-injection with local anaesthetic, mixing the insoluble steroid with local anaesthetic, and the use of very fine needles. Care should be taken to ensure the steroid is injected into the scar and to avoid injecting outside the scar boundary as this will almost certainly result in atrophy and may take more than one year to reverse.

Subsequently more aggressive techniques such as surgical re-excision combined with intralesional corticosteroids or silicone gel therapy may well be required (see below).

Widespread burn hypertrophic scar (red/raised):
These scars require specialist management in a burns unit (see below).

Minor keloids:
The consensus view from the literature and the panel is that first-line therapy for most minor keloids is a combination of silicone gel sheeting and intralesional corticosteroids. Treatment of keloids is difficult with a significant recurrence rate for even the most experienced practitioners. If there is no resolution, referral for surgical excision and further therapy may be required. Localised pressure therapy such as ear-clips on earlobe keloids has been shown to be helpful as second-line adjunctive therapy in small trials and compression garments are also commonly used.

Major keloids:
Major keloids are a most challenging clinical problem and many are resistant to any treatment. A trial of silicone gel sheeting and corticosteroid injections may be worthwhile, but these scars may require surgical excision and more specialist management (see below). The risks of keloid regrowth after surgical excision must be clearly relayed to the patient pre-operatively.

Secondary management

The following therapy recommendations are subject to the experience and resources of each care facility. Different treatments may be used, often as combination therapy, in a systematic manner until one is successful in managing the scar.

Immature hypertrophic scars (red):
These scars may benefit from a course of pulsed dye laser therapy, although this therapy requires further long-term trials.

Surgical/traumatic hypertrophic scars (red/raised):
If silicone gel sheeting, pressure garments and intralesional corticosteroid injections are not successful after 12 months of conservative therapy and no discernible improvement, surgical excision with concurrent use of silicone gel sheeting should be considered. An option for more severe scars is re-excision with layering of triamcinolone acetonide, long-term placement of deep sutures and subsequent corticosteroids.

Specific wavelength laser therapy and cryotherapy have been used by the panel in this area, but require further controlled studies.

Widespread burn hypertrophic scar (red/raised):
Widespread burn scars should be treated in a specialist unit with first-line therapy of silicone gel sheeting and pressure garments, although there remains limited significant evidence for the efficacy of pressure garments.

The treatment of burn scars is difficult and often requires a combination of techniques including individualised pressure therapy with customised garments, massage and/or physical therapy, silicone gel sheeting, selective use of corticosteroids on particularly difficult areas, and surgical procedures such as Z-plasty, excision and grafting or flap coverage. Scar contractures across flexural creases require the interposition of well vascularised tissue that extends past the mid-axial line on each side of the zone flexion. If longitudinal scar junctions are left anterior to the mid-axial line then scar contractures may reform. For wide scars some improvement may be possible with surgery but may require serial excisions or pre-operative tissue expansion with subsequent excisions.

A variety of other adjunctive therapies such as massage, hydrocolloids and antihistamines to relieve pruritis are also used. Pulsed dye laser therapy, in association with pressure garments, may be of value.

Minor keloid (red/raised):

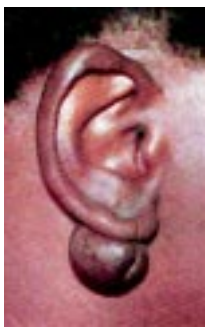


Fig.12

If silicone gel and intralesional corticosteroids are unsuccessful, surgical excision should be considered. In the panel's experience, surgical excision should be done within the boundaries of the keloid to avoid resulting in a larger lesion in the event of recurrence. If all other therapies are unsuccessful, specific wavelength laser therapy could be considered, although its efficacy is not well established.

Earlobe keloids present a unique problem

because of their location and surgical excision can be recommended as first-line therapy followed by combination therapy of corticosteroid injection and silicone gel sheeting. It must be emphasised that surgical excision without careful follow-up and use of other adjunctive measures will result in a high recurrence rate, and if the surgery is done without careful attention to preserving normal architecture, the resulting deformity after recurrence may be worse. The panel's experience is that excision of difficult recurrent keloids with grafting of skin taken from the excised keloid followed by immediate radiation therapy can be successful**,** but that the long-term risks of radiation must be carefully weighed.

Major keloid:
If first-line therapy with silicone gel sheeting, pressure therapy and intralesional corticosteroids is not successful in treating major keloids, specific wavelength lasers and then surgical excision are indicated. Surgical excision is recommended if some antecedent event, such as irritation or infection, has led to scarring. These lesions are very difficult to treat. Extensive counselling with the patient is required before embarking on a surgical solution because the recurrence rate is so high. For some patients, symptomatic treatment with antihistamines and good hygiene may be all that is possible. These patients are best treated by clinicians with a special interest in this area.

Ongoing patient counselling and advice on prevention are essential components of this therapy. Combination therapy is routinely used, particularly with surgery, to prevent re-scarring (see prevention section).

Non-responding scars:
In the panel's experience a number of scars, possibly up to 2%, will not respond to more conventional techniques. In this case fail, radiation therapy may be useful when combined with surgery for limited areas, although there are no randomised, prospective studies with long-term follow-up. New bio-engineered dermal replacement products are showing promise in resurfacing defects after excision of major, usually keloid, scarring. However, major keloids remain a difficult management problem. It is in this area that the new, experimental regimes are most likely to be trialled initially.

Conclusions

Management choices should depend on the patient's individual requirements and evidence-based findings. There remains a significant need for further randomised, controlled trials of all available scar therapies and systematic, quantitative reviews of the literature to ensure optimal management of scarring. The recommendations of the panel are based on the best available evidence in the literature, particularly randomised, controlled trials, supported by clinical experience. Many management techniques have limited data to support their use and these recommendations support a move to a more evidence-based approach in scar management.

This approach highlights a primary role for silicone gel sheeting and intralesional corticosteroids in the management of a wide variety of abnormal scars. A number of other therapies that are in common use and emerging therapies require further large-scale studies with long-term follow-up before being recommended as alternative management for abnormal scarring.

Acknowledgements

This paper was compiled by an International expert panel, with complete editorial freedom. None of the panel have received remuneration for their contribution or activities within the panel. Editorial assistance has been provided by Mr Jeremy Bray, a professional medical writer. A small unrestricted educational grant was provided by Smith & Nephew Medical Ltd and used by the panel for co-ordination and communication.

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