Spectrum of abnormal skin scars and their clinical management

Skin scars vary from a fine line which is the best outcome that surgery can achieve to a variety of abnormal scars. Scarring can cause physical, cosmetic and psychosocial consequences producing significant emotional and financial costs to the patient, physician and the health-care system. This article reviews the spectrum of abnormal scar types, and offers advice on assessment and treatment with current and potential future therapies.

Skin scars are the natural result of skin tissue repair following injury and all wounds except the most superficial leave a scar. In most individuals, there is no detrimental effect in the long term and scarification may even be considered a welcome adornment in some cultures (Bayat and McGrouther, 2005). However, for some a scar may have lasting physical or psychological consequences (Bayat et al, 2003). An abnormal scar may be referred to a specialist such as a plastic surgeon for treatment, but most doctors will need to consider the process of scarring and its management at some point in their clinical practice. Knowledge of the treatments available may help to alleviate the distressing symptoms of scarring and allow the patient to be informed of possible treatment and its limitation.

Method

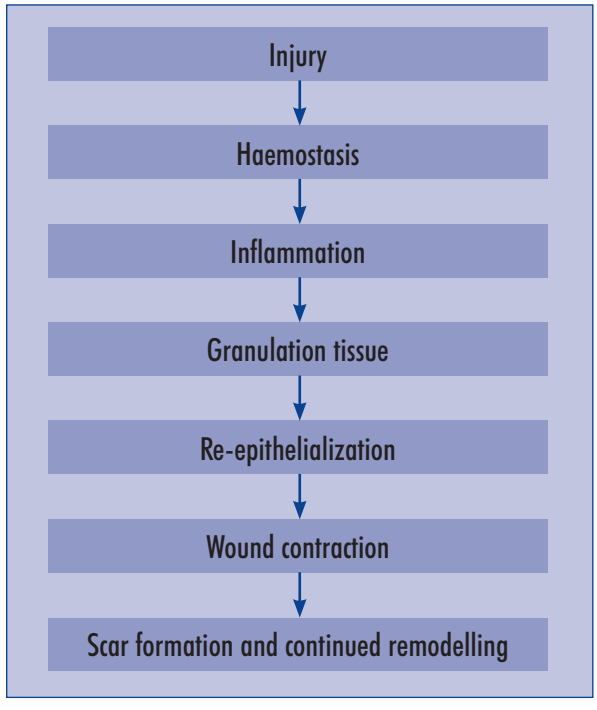
This article is a collection of the authors' personal scientific and clinical experiences in the investigation and treatment of scars. A literature search was carried out in relevant science and clinical journals, including plastic and reconstructive surgery, dermatology and wound healing journals. Key terms for the search included: keloid disease, hypertrophic scarring, scar contracture, diagnosis, prevention, therapy, and management.

Scar formation

Injury to the skin such as trauma or surgical incision disrupts the normal tissue structure and function. A complex healing process is initiated in order to seal off the wound, preventing infection and fluid loss (Bayat and McGrouther, 2005). Wound healing involves several overlapping stages before tissue integrity and function are restored (*Figure 1*).

The first stage in wound healing is inflammation, when growth factors such as platelet-derived growth factor (PDGF), transforming growth factors alpha and beta (TGF-α, TGF-β), and fibroblast growth factor are released, stimulating the reparative phase. New blood vessels are formed resulting in a red healed scar (Bayat and McGrouther, 2005). Angiogenesis also occurs in open wounds to form granulation tissue and a characteristic red appearance. Fibroblast cells proliferate and synthesize a loose extracellular matrix composed of fibrin, collagen, fibronectin and glycosaminoglycans, which acts as a scaffold for re-epithelialization. The fibroblasts also form links between cells, which apply tension to the surrounding matrix and cause the wound to contract and close. Epithelial cells, or keratinocytes, from the wound border proliferate and migrate across the matrix, filling the wound inwards and reforming the basement mem-

Figure 1. Major events taking place during the healing process in incised and open wounds.



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brane to restore stability (Diegelmann and Evans, 2004; Baum and Arpey, 2005; Greenhalgh, 2005). The open wound therefore heals by a combination of contraction and epithelialization.

The wound is now intact but scar formation and remodelling continues for much longer until the scar reaches its ultimate strength (Bayat and McGrouther, 2005). It may be 2 or 3 years before the scar reaches its final colour and strength (Bayat et al, 2003). Scar formation is a dynamic process in which collagen is synthesized by fibroblasts and degraded by proteolytic enzymes from inflammatory cells thus remodelling the scar morphology (Diegelmann and Evans, 2004; Baum and Arpey, 2005; Greenhalgh, 2005). As the scar matures the numbers of fibroblasts and inflammatory cells decrease and the rate of remodelling is reduced. The type of collagen deposited also changes over time and the matrix becomes more dense and is better organized (Bayat et al, 2003; Diegelmann and Evans, 2004; Baum and Arpey, 2005; Greenhalgh, 2005). The end result is a normal fine line scar that is the best outcome that is possible to achieve (*Figure 2*).

Abnormal scars

Abnormal scars do not resolve to a fine line but remain visibly different to the surrounding skin in size, colour, contour and texture. There are four main types of abnormal scars (*Table 1*).

Stretched or widespread scar

A stretched or widespread scar is a pale, widened scar that occurs when tension is placed on a wound as it heals such as on the knee, mid-sternal, mid-abdominal or shoulder after surgery (*Figure 3*). It is usually symptomless but treatment may be requested to improve the aesthetic appearance (Bayat et al, 2003).

Atrophic scarring

Atrophic scarring is often the result of acne or chickenpox and appears as a small round depression that is below the level of the surrounding skin but often of a similar colour (*Figure 4*) (Bayat et al, 2003).

Figure 2. A normal fine line scar on the forearm.

Table 1. An acronym for the four main types of abnormal scars

Stretched (widespread)
Contractures
Atrophic (depressed)
Raised: keloid or hypertrophic

Contractures

Contractures can occur when a wound crosses a joint or skin crease (*Figure 5*). Across joints they usually develop on the flexor surface while at skin creases they develop where the wound crosses the flexion crease. The main problem with scar contractures is that a tight scar limits

Figure 3. A stretched (widespread) scar on the shoulder.

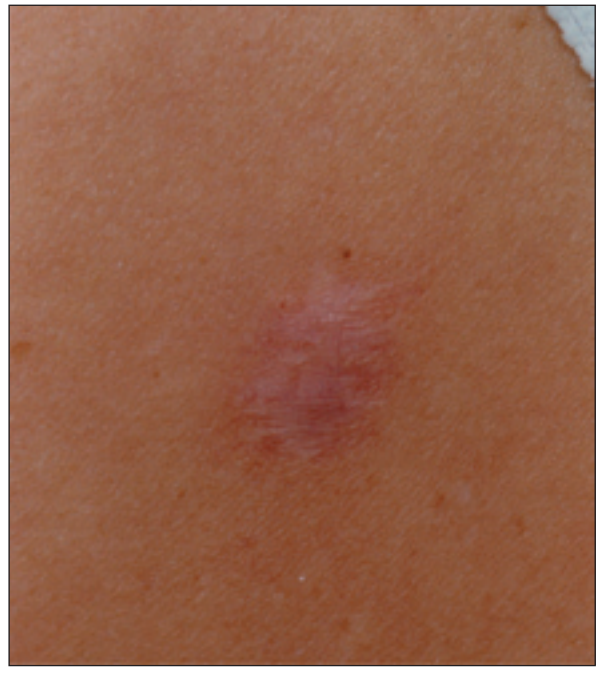
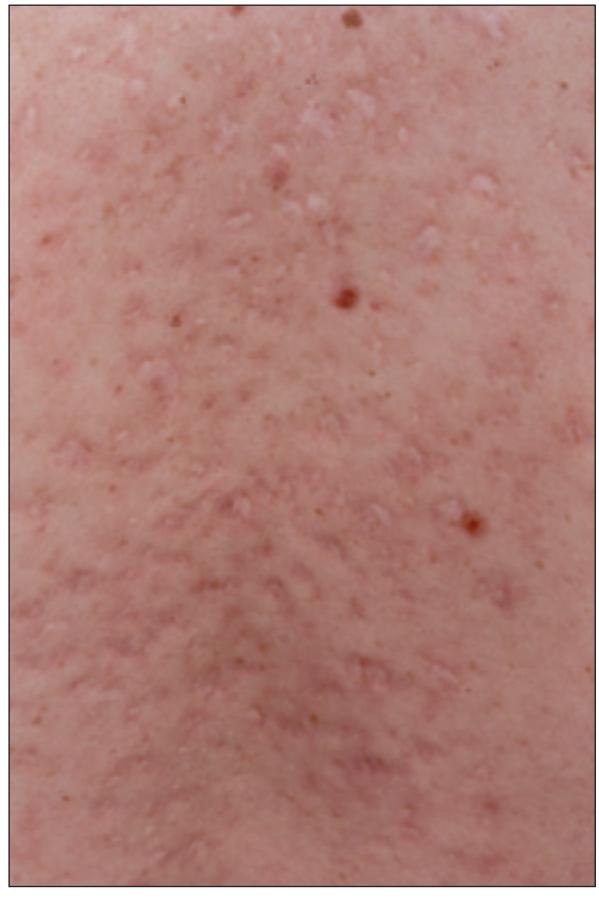


Figure 4. Atrophic scars on the back.



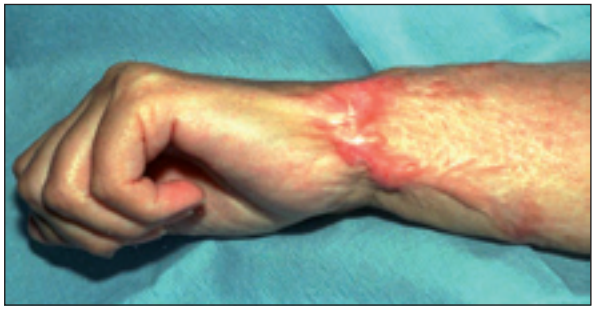


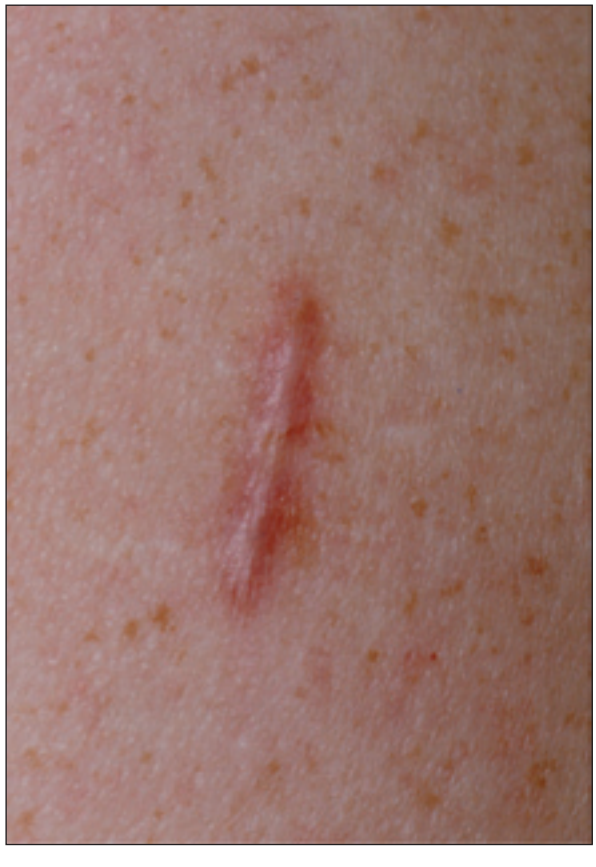
Figure 5. Scar contracture on the wrist.

movement and can be disabling. Contracture occurs while the scar is still immature, especially following burns (Bayat et al, 2003).

Raised scars

Raised scars are above the level of the surrounding skin and are caused by excessive growth of scar tissue. The incidence is the same in both sexes and is highest in the second decade (Bayat et al, 2003; Bayat and McGrouther, 2005). There are three types of raised scars: hypertrophic scars (*Figure 6*), which are raised but confined to the original lesion and to some extent this is a normal phenomenon in all scar formation; keloid scars (*Figure 7*), which characteristically spread beyond the boundaries of the original wound, and which may be so trivial as to have been forgotten; and intermediate scars that fall between the two raised scar categories, and appear like hypertrophic scars but behave more like keloid scars (*Figure 8*).

Figure 6. A linear hypertrophic scar on the upper arm.



Treatment is different for each raised scar and it is important to differentiate between the different types. Crucially, keloid and intermediate scars will recur following simple excision and, if suspected, surgery may be contraindicated in the first instance. Unfortunately, many are mistaken for benign skin lesions and are excised in error.

Hypertrophic scars usually occur within 4 weeks of the initial injury and resolve over time with some improvement expected in most patients by 12 months post injury (Bayat and McGrouther, 2005). They are often red, itchy and painful. Hypertrophic scars are particularly common after thermal injury (Bayat et al, 2003; Bayat and McGrouther, 2005).

Figure 7. An ear lobe keloid scar.

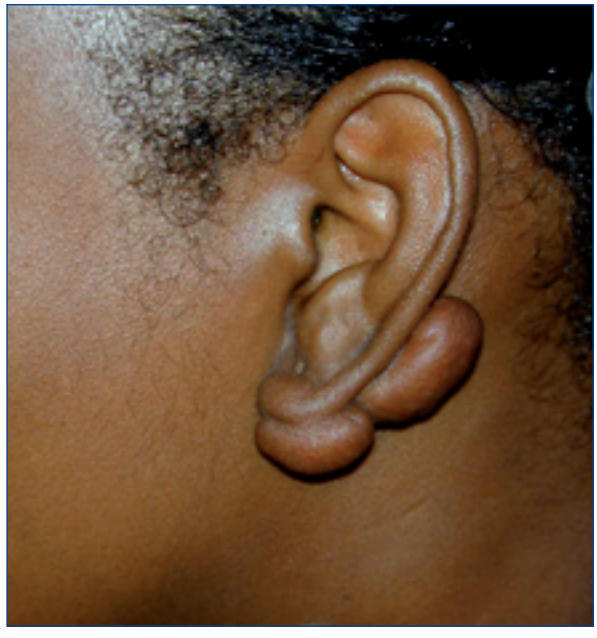
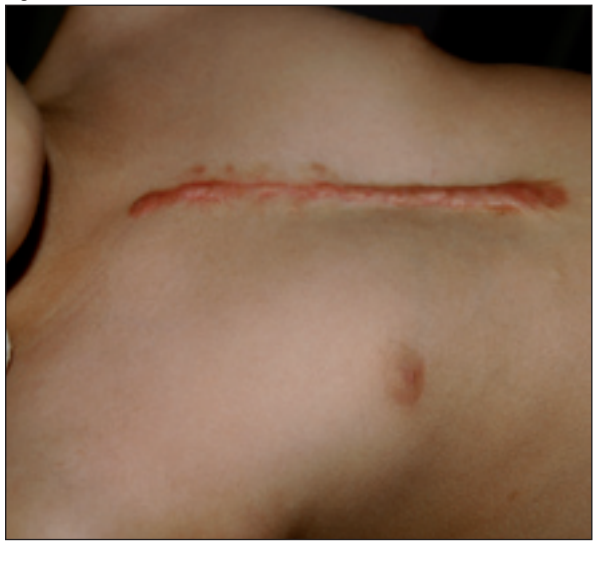


Figure 8. An intermediate raised scar in the sternum.



Keloid scars can appear at any stage either early or late (Bayat et al, 2003; Bayat and McGrouther, 2005). A key feature that differentiates keloid from hypertrophic scars is the lack of any spontaneous resolution over time. People with darker skin are more susceptible to keloid scarring than those with lighter pigmented skin, although keloids do occur in all racial groups. There may be a strong family predisposition to keloid scarring with a variable inheritance pattern; keloid scarring appears to be a complex gene disorder (Bayat et al, 2005).

It is thought that abnormal scars are the result of derangement during the wound healing process (Bayat et al, 2003; Diegelmann and Evans, 2004; Baum and Arpey, 2005; Bayat and McGrouther, 2005; Greenhalgh, 2005). Lower vertebrates such as amphibians are able to regenerate even quite large wounds completely. Human embryos are also able to do this in the first trimester because the structure of the skin is not yet established. Early in the second trimester wound healing does not produce scarring although the normal skin structure is not completely restored after injury. Children and young adults are prone to a vigorous scarring response manifest as either a raised or contracted scar (Bayat et al, 2003). Older people are much less likely to get an abnormal scar but wounds may be slower to heal and there may be co-morbidity (Ashcroft et al, 2002). Any factor that tips the balance in favour of collagen deposition rather than degradation will predispose to excessive scar tissue formation. Prolonged inflammation, family history, foreign body, and lack of wound closure are all risk factors (*Table 2*).

Effects of scarring

The physical symptoms of scarring such as pain, redness and itching (Bayat et al, 2003) have long been known to cause considerable distress to the patient and many treatments aim to provide relief. Less is understood about the psychological effects of scarring and indeed of skin disease in general. Anxiety, depression and reduced self-esteem may all result from disfigurement but research has shown that this may not be related to the severity of the scar (Chren et al, 1996; Bayat et al, 2003; Partridge and Rumsey, 2003).

Table 2. Key features in the history which can influence therapy choice, compliance and outcome of treatment

The presence of positive family history
Previous poor response
Multiply recurrent scar
Specific anatomical locations (e.g. sternum)
Large scar size
Irregular, non-geometric scar morphology
Prolonged active inflammation
Severe symptoms (e.g. tenderness, constant itching)
Psychological
Social history

Scar assessment

First, is it a scar at all? The differential diagnosis may include dermatofibroma, sarcoidosis, foreign body granuloma and possibly skin cancer. It is therefore important to take a good history from the patient and examine the scar carefully. Once a scar has been diagnosed, an assessment of its severity will allow the clinician to assess the patient's progress with a particular course of treatment. In assessing the quality of a scar, several important factors must be considered. Some key features should be determined at the initial consultation (*Table 3*).

Scar assessment is a complex process in which much of the outcome should be measured in terms of any physical and psychological impairment that the patient has as a result of his/her scar or scars. This measurement can be highly subjective. Objective and reliable scar assessment tools are valuable clinically and may also aid in the research and evaluation of new treatments. A validated scar assessment scale is integral to objective measurement of the clinical appearance of any scar (*Figure 9*) (Sullivan et al, 1990; Beausang et al, 1998; Teot, 2002). For example, the Vancouver scar scale is often used to assess the severity of burn scars and the validated Manchester scar scale for abnormal skin scars (Sullivan et al, 1990; Beausang et al, 1998).

Treating problem scars

Much of the available treatment for scars is based on the consensus of opinion among clinicians because few studies exist to objectively compare different modes of treatment (Bayat et al, 2003). The best treatment for abnormal scars is preventative, avoiding unnecessary surgery or placing the scar in an inconspicuous site. Good wound closure and healing, good placement of surgical incisions along the line of a skin crease and use

Table 3. Management of skin scars

Prevention is better than cure!
Scar < 1-year-old. Wait and see if there is spontaneous improvement or resolution
Is therapy necessary? Use the 4 S guide:
Site (anatomical location of the scar)
Symptoms (pain, itching etc)
Severity (of appearance and/or functional impairment)
Stigma (the psychosocial impact on the patient)
Which therapy should be used?
Consider type of scar, risk factors and previous response to other treatments
Treatment should include pre- and post-therapy photographs

Figure 9. The Manchester validated scar assessment-scoring sheet. From Beausang et al (1998).

Visual Analogue Scale

Excellent ——————————— Poor

	A	**Colour (cf. to surrounding skin)**	
Lighter	☐	Perfect	1
Or		Slight mismatch	2
Darker	☐	Obvious mismatch	3
		Gross mismatch	4
	B	**Matte (1)/ Shiny (2)**	
	C	**Contour**	
		Flush with surrounding skin	1
		Slightly proud/ indented	2
		Hypertrophic	3
		Keloid	4
	D	**Distortion**	
		None	1
		Mild	2
		Moderate	3
		Severe	4
	E	**Texture**	
		Normal	1
		Just palpable	2
		Firm	3
		Hard	4

of prophylactic therapy in high risk patients may help to prevent excessive scar tissue formation. Therapy may reduce the severity of the scar but will never make it disappear completely (*Table 3*).

In the first year after injury a scar may show spontaneous improvement without invasive treatment, so a wait-and-see approach with regular assessment and reassurance of the patient is the first-line management of any acute scar (Bayat et al, 2003). After a suitable period of time the clinician and the patient need to work together to decide if other treatment is appropriate and which therapy will give the best results.

Treatment may involve the combined use of invasive therapies such as intralesional steroid injection, cryotherapy, surgical excision and revision, radiation for keloid scars and laser therapy for red scars with more conservative therapies such as compression, splinting and antihistamines. There is also an important place for considering treatment of psychosocial problems, and other associated symptoms of scarring.

Widespread scars tend to improve after surgical excision and resuture. International clinical guidelines suggest the use of intradermal sutures for at least 6 weeks and up to 6 months if necessary to prevent recurrence (Mustoe et al, 2002). Splinting can also be used to reduce tension on the wound.

Laser therapy, dermabrasion or chemical peels remove outer layers of the epidermis and may reduce the depressed appearance of an atrophic scar. Fillers may also have a role in some cases. Severe acne scars have been treated using cryotherapy but this is painful and not without potential side effects such as changes in pigmentation and skin atrophy. Keloid and hypertrophic scars can be treated with a variety of techniques (*Table 4*) (Bayat et al, 2003;

Table 4. Treatment options for abnormal skin scar types

	First line*	Second line	Third line
Atrophic scars	Chemical peel Fillers Dermabrasion Surgical revision		
Widespread scars	Surgical revision Laser		
Contractures	Silicone gel and compression Steroid injection	Surgical excision Steroid injection Silicone gel and compression	
Hypertrophic scars	Silicone gel and compression	Silicone gel and compression Steroid injection	Surgical excision Silicone gel and compression Laser
Keloid scars	For first 12 months: Silicone gel and compression Steroid injection	Steroid injection Silicone gel and compression Imiquimod Bleomycin	Steroid injection Imiquimod Bleomycin Interferon Radiation Surgical excision (in selected cases in experienced hands)

* if there is no response following first-line scar therapy consider referral to specialist plastic surgeon or dermatologist with interest in management of skin scars

Bayat and McGrouther, 2005). Surgery is rarely indicated alone except for debulking and requires experience and precise informed consent.

Looking ahead

It is thought that alteration of the profile of inflammatory mediators implicated in wound healing, such as changing the ratio of cytokines such as TGFβ isoforms, can restore the endogenous embryonic regenerative response without any adverse effects. Therefore exogenous addition of specific molecules may help in scar prevention and reduction. Currently human recombinant neutralizing antibodies to TGFβ1 and β2, TGFβ3, and mannose 6 phosphate are all in various stages of human clinical trials for the prevention of skin scarring. It is possible that with the advent of novel pharmaceutical therapies, human skin scarring may be prevented and treated more effectively. In the not too distant future, scarring may no longer remain an inevitable consequence of cutaneous wound healing. BJHM

KEY POINTS

- Skin scarring covers a wide spectrum of clinical phenotypes from normal fine line scars to abnormal Stretched (wide spread), Contracture, Atrophic (depressed), and Raised (hypertrophic, intermediate, keloid) scars.
- Scarring can cause physical, cosmetic, and psychosocial consequences producing significant emotional and financial costs.
- Abnormal scars can arise following a perfect surgical procedure to the most minor injury in genetically susceptible individuals and in specific anatomical locations. Some scars such as keloids can have an age, ethnic and familial distribution.
- Clinicians should recognize skin scars and manage them appropriately. Misdiagnosis and mismanagement of scars can be costly to the patient, physician and the health-care system.

Conflict of interest: Mr A Bayat has provided consultancy advice on keloid scars to Renovo Ltd. Professor DA McGrouther is a current member of the Scientific Board of Renovo Ltd.

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