The principles of managing acute wounds

The acutely traumatic wound has a broad phenotype: from superficial abrasions to full-thickness thermal burns. It is crucial that practitioners can identify complex wounds that warrant referral to a plastic surgery unit for specialist assessment. The scar is the final sequela of dermal injury. Under optimal conditions it will mature and become barely perceptible with time; if poorly managed, or in patients at risk from abnormal scarring, it may cause significant functional and psychosocial impairment. The methods by which wound healing should be optimised to achieve a favourable outcome are explored within this paper.

In adult wounds, tissue injury initiates a complex cascade of processes which lead to the restoration of tissue integrity (Mathes and Hentz, 2006). This wound healing process involves three overlapping phases of inflammation, proliferation and remodelling, which finally result in the generation of a mature scar (Gurtner, 2007). As clinicians, it is possible to influence each component of the wound healing process and thus exert considerable control on the final aesthetic and functional result of a scar.

Generally speaking, the majority of wounds presenting to a minor injuries unit or emergency department will be acute wounds capable of primary healing if correctly managed (by direct closure). However, it is important to identify wounds where healing either by secondary intention or tertiary healing (also known as delayed primary closure) will give the most favourable outcome (Gurtner, 2007). Acute wounds are those less than a few weeks of age, while those that present for more than four to six weeks are classified as chronic wounds, and lie beyond the scope of this paper, although many useful articles attempt to address this complex subject (Mustoe et al, 2006).

Figure 1. The wound healing process.
Most surgical wounds are incisional wounds that are approximated by sutures, staples or adhesives to facilitate primary healing. Such direct closure generally results in the most optimal scarring, however, local factors appertaining to the wound and general factors related to the patient may influence the wound healing process, the rate of healing, and thus the quality of the final scar (Table 1) (Giele and Cassell, 2008). Wounds that cannot be closed directly, such as partial-thickness burns or a superficial graze, or those that are not reapproximated (for whatever reason), must heal by granulation and re-epithelialisation — so-called secondary intention (Gurtner, 2007). Such wounds require regular dressings, have a greater propensity to become chronic and may have a suboptimal final aesthetic result. In the context of burns, if healing takes longer than 21 days, 78% of burn sites will develop hypertrophic scars (Deitch et al, 1983).

**Mechanism of acute injury**

A thorough clinical history and examination is essential to determine the pattern of injury, which to a significant extent will govern the optimal means of managing the wound in question.

Potential mechanisms include:
- Laceration (either sharp or blunt) (Figure 2)
- Abrasion (Figure 3)
- Crush
- Degloving (open or closed)
- Burn (flame, scald, contact, electrical, chemical, radiation)
- High energy-blast
- Bite (human or animal) (Figure 4).

The zone of injury is an important concept to consider at the time of the initial wound assessment. Clearly, a simple finger laceration sustained while slicing vegetables with a kitchen knife causes localised (although potentially disabling) damage, the extent of which is dependent upon the mechanism of injury.
Antibiotics should never be a substitute for an inadequately debrided wound.

In the case of hand injuries, rings and bracelets must be removed as subsequent swelling could result in vascular compromise and digital gangrene.

Complex wounds (Table 2 and Figures 2–6) should be promptly referred to the appropriate surgical team. However, if the wound is amenable to primary closure and the healthcare professional is competent to undertake the procedure in the emergency department, it will be necessary to employ an appropriate local or regional anaesthetic block (a comprehensive review of their use is available in Mathes and Hentz, 2006). It is important to ensure that sensibility has been accurately documented before infiltration of local anaesthesia, particularly in digits. Adrenaline is frequently used in combination with local anaesthetics (e.g. 1% lignocaine with one in 200,000 adrenaline) to aid haemostasis during surgery and is ideal for suturing facial lacerations. Traditional teaching states that local anaesthetics containing adrenaline should be avoided in the digits (and the penis) due to the risk of distal necrosis. Although evidence supporting this view is limited, most surgeons do not use adrenaline in these anatomical situations (Denkler, 2001). The use of a tourniquet to produce a bloodless operative field is probably best limited to the controlled environment of an operating theatre and thus avoided in the emergency department.

As eluded to in Table 1, adequate wound debridement is essential and may necessitate a specialist referral in itself, as it is frequently impossible to assess adequately the full extent of an injury to the underlying structures such as nerves, arteries and tendons (Figure 6). This is particularly pertinent in children who may be too distressed to cooperate — an examination under general anaesthesia will often be necessary. Abrasions resulting from a ‘road rash’ injury should be thoroughly scrubbed to remove particulate contamination in order to minimise the risk of permanent scar tattooing (Figure 7). Significant damage to deep anatomical structures is commonly associated with extensive injuries or heavily contaminated wounds, and it is important to identify the relevant damaged structures in order that they can be adequately reconstructed.

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Penetrating wounds to the fingers...
such as animal bites or seemingly innocuous injuries arising from splinters or thorns can result in potentially severe infections if the digital flexor sheath apparatus is involved. The cardinal signs of a ‘flexor sheath infection’ were described by Kanavel in 1925 and include; flexed posture and fusiform swelling of the affected finger, pain on passive extension, and exquisite tenderness overlying the flexor sheath (Ong and Levin, 2009). If clinically suspicious, an urgent specialist referral is necessary as suppurative tenosynovitis, but may be exogenous (e.g. Pasteurella multocida following a cat bite).

Infection: this prolongs the inflammatory phase and delays healing. Bacterial infections usually arise from the host (e.g. Staphylococcus aureus), but may be exogenous (e.g. Pasteurella multocida following a cat bite)

Ischaemia: this limits collagen synthesis and may result from local oedema or haematoma formation, or from chronic disease (e.g. peripheral vascular disease)

Non-viable tissue: the presence of devitalised (necrotic) tissue delays wound healing. Thus, adequate wound debridement (by mechanical, chemical or biological means) is critical to optimal wound healing

External beam radiation: causes endothelitis, obliterans and lymphatic damage which impair tissue perfusion and cause lymphoedema respectively

Hypoxia: transient hypoxia stimulates angiogenesis, however prolonged hypoxia is detrimental to wound healing

Inherited disorders: e.g. Ehlers-Danlos syndrome, pseudoxanthoma elasticum, Werner syndrome (progeria), osteogenesis imperfecta

Acquired disorders: e.g. diabetes, obesity, chronic renal failure, jaundice, malignancy

majority of presenting wounds. If an alternative reconstructive technique is indicated, such as split skin grafting in a large pre-tibial laceration or necrotic pre-tibial haematoma, an appropriate referral should be made to the plastic surgery unit.

Suturing in the emergency department

In the first author’s experience, plastic surgeons generally favour the use of simple interrupted non-absorbable skin sutures in adults (such as Prolene or Ethilon [both manufactured by Ethicon Inc]) to directly close superficial traumatic wounds in a tension-free manner. Their subsequent removal limits the amount of foreign material in the wound, reduces the incidence of stitch marks and, of course, ensures that the wound is subsequently checked by a healthcare professional to exclude complications such as infection, necrosis or dehiscence. Typically, a 5/0 or 4/0 suture is used on the torso, a 5/0 suture for the hand and a 6/0 suture (or smaller) on the face. Successful suturing is dependent on a co-operative patient, with an appropriately selected wound (for example, it may not be appropriate to suture a full-thickness eyelid laceration under local anaesthetic — if damage to the underlying lacrimal duct is suspected, a formal exploration in theatre is warranted), a sound local anaesthetic technique, and a suitable environment (preferably a dedicated minor

Table 1

<table>
<thead>
<tr>
<th>Local factors</th>
<th>General factors</th>
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<tr>
<td>Tissue handling: poor handling of wound edges,</td>
<td>Age: wound healing is generally delayed in the</td>
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<td>excessive bipolar diathermy use or wound closure</td>
<td>elderly, whereas the potential for scarless healing</td>
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<td>under tension are all deleterious to wound healing</td>
<td>exists in the feetus (Siebert et al, 1990)</td>
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<td>Drugs: corticosteroids, immunosuppressants,</td>
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<td>chemotherapy agents, non-steroidal anti-inflamm</td>
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<td>atory drugs (NSAIDS)</td>
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<td>Infection: this prolongs the inflammatory phase</td>
<td>Smoking: causes local vasoconstriction and</td>
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<td>and delays healing. Bacterial infections usually</td>
<td>carboxyhaemoglobin reduces the oxygen-carrying</td>
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<td>but may be exogenous (e.g. Pasteurella multocida</td>
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<td>following a cat bite)</td>
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<td>Ischaemia: this limits collagen synthesis and</td>
<td>Malnutrition: vitamin A promotes epithelialisation</td>
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<td>may result from local oedema or haematoma</td>
<td>while vitamin C is essential for collagen synthesis</td>
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<td>formation, or from chronic disease (e.g.</td>
<td>by fibroblasts. Zinc is an essential cofactor in</td>
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<td>peripheral vascular disease)</td>
<td>numerous crucial enzymes (Arnold and Barbul, 2006)</td>
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operations’ theatre with adequate lighting and appropriate instruments and equipment, such as bipolar diathermy if required). Suture removal is typically undertaken at 5–7 days for the face and 10–14 days elsewhere. In situations where the wound extends deeper than skin, closure is achieved in layers in order to minimise dead-space and provide additional mechanical support: interrupted, buried ‘dermal’ sutures. Furthermore, achieving adequate wound edge eversion, which has important implications for the final aesthetic result, is extremely difficult when these techniques are used in isolation. Indeed, deleterious wound inversion and even scar tattooing is possible (Swan et al, 2006).

The first author’s unit favour simple dressings for directly closed wounds such as Micropore® tape (3M Healthcare), as it is relatively inexpensive, does not need to be sterile and is water resistant. Patients are advised that the tape should be in place for a minimum of two weeks following suture removal in order to support the wound. The tensile strength of wounds is only 20% of normal skin at three weeks post-closure, and 70% at six weeks. Thus, immature wounds are prone to inadvertent dehiscence (Mathes and Hentz, 2006). The tensile strength of the final scar is approximately 80% of that of normal skin. Following tape removal, the patient should be advised to massage the wound on a twice-daily basis using a simple moisturiser or emollient for at least three to six months (i.e. during the ‘remodelling’ phase of wound healing), or until the scar has fully matured. Patients are also advised to avoid exposing their scar to excessive sunlight (i.e. SPF 30+ is recommended if holidaying in warmer climes) until it is fully mature to avoid any abnormal pigmentary changes.

Table 2
Potentially complex wounds for which a specialist referral should be considered

- Open fractures
- Vascular compromise of limb or digit (Figure 5)
- Suspected deep structural injury (e.g. tendon or nerve, Figure 2)
- Bite injuries (animal or human) (Figure 4)
- Significant soft tissue infection (e.g. flexor sheath or joint space infection)
- Burns (see Hettiaratchy et al, 2005 for referral guidelines)
- Amputated parts (for replantation) (Figure 5)
- Significant co-existing injury (American College of Surgeons, 2004)
- Any wound that the clinician does not feel confident to manage in the emergency department

By applying basic plastic surgical principles it should be possible to triage those patients whose wounds warrant specialist referral, versus those which can be successfully managed locally (usually by direct closure).

Daycase procedure. Similarly, suture removal may prove to be a traumatic experience for child and parent alike, thus absorbable sutures (such as 7/0 Vicryl rapide for a lip laceration) may be considered. Many emergency departments advocate the use of adhesive strips (e.g. SteriStrips) or glues (e.g. Dermabond®) for paediatric wound closure. Although useful in selected cases, in the first author’s experience for cosmetically sensitive areas it is harder to achieve accurate wound approximation when compared to suturing — although they may be used in conjunction with buried dermal sutures. Furthermore, achieving adequate wound edge eversion, which has important implications for the final aesthetic result, is extremely difficult when these techniques are used in isolation. Indeed, deleterious wound inversion and even scar tattooing is possible (Swan et al, 2006).

Abnormal scarring
Normal, immature scars are characteristically red, raised and itchy or painful. They may take up to 12–18 months to completely mature, by which time they should be pale and flat (Bond et al, 2008). Abnormal scarring results from an excessive inflammatory response during healing and is classified as being either hypertrophic or keloid in nature. The latter is much commoner in darker skin types and tends to develop within a year of the injury, whereas hypertrophic scars generally occur within four weeks of injury. Keloids are commonest in the auricular, pre-sternal and deltoid areas. Whereas hypertrophic scars are confined to the margins of the original injury, a keloid scar extends beyond the site of the original injury (Broughton et al, 2006) (Figure 9).

Hypertrophic scars are characteristically self-limiting
and involute within two years. If symptomatic or aesthetically unsightly, they may respond to pressure therapy, topical silicone, intra-lesional corticosteroid injections or pulsed dye laser (for decreasing scar erythema) (O’Brien and Pandit, 2006). However, keloid scar formation is permanent and requires specialist intervention. The standard therapies used for hypertrophic scars are of variable effectiveness (Durani et al, 2008), and any form of surgical intervention is prone to a high risk of recurrence (up to 93%) (Broughton et al, 2006). Other treatment modalities for keloids include radiotherapy and intra-lesional interferon.

Conclusions

Although a scar is the inevitable outcome following an acute full-thickness wound, it is the duty of the emergency department practitioner to manage the wound in an appropriate and timely fashion to achieve an optimal aesthetic and functional result. By applying basic plastic surgical principles, it should be possible to triage those patients whose wounds warrant specialist referral, versus those which can be successfully managed locally (usually by simple dressings or direct closure). In the event of an atypical or complex wound, it is prudent to seek the advice of the local plastic surgery unit.

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References

American College of Surgeons (2004) Committee on Trauma. ATLS, advanced trauma life support program for doctors. 7th edn. American College of Surgeons, Chicago

Key points

- Acute wounds can sometimes distract from more significant systemic injuries — never forget to undertake a primary survey in trauma patients (American College of Surgeons, 2004).
- Understanding the mechanism of injury is crucial to predicting the likely severity and extent of the wound.
- A thorough clinical assessment is mandatory. This can be difficult in young children and a general anaesthetic may be necessary.
- Always check the tetanus status of the patient, remove rings and bracelets in hand injuries, and exclude a foreign body (by radiographic means if necessary) if the history is suspicious.
- If you are unsure or wish to ask for advice, do not hesitate to contact your local plastic surgery unit who will be happy to assist.