Early Wound Care in Open Fractures

Malcolm Smith, MD
Massachusetts General Hospital

INTRODUCTION

The viability and care of the soft tissues are the primary factor in the healing of any fracture. This becomes critical in open injuries where a defect in the soft tissue envelope allows bacterial contamination of the zone of injury and fracture hematoma. Although initially the open fracture is only contaminated, with time, bacterial multiplication will lead to established infection. The risk of infection will be increased by the size and virulence of the inoculum. The time since inoculation and several host factors which reduce the resistance to infection or allow a focus for infection to develop. These include the presence of shock, local hematoma, dead space, fracture instability and nonviable tissue, especially muscle. Interestingly, in current day practice the importance of the initial inoculum has become much reduced. Today if infection develops, it is usually due to hospital acquired organisms.

The principles of management involve the application of basic surgical and fracture management principles to reduce the chance of infection. These are: wound debridement to remove any dead or doubtful tissue, profuse lavage of the wound to reduce the size of the inoculum, fracture stabilisation to allow good soft tissue healing and reconstruction of the soft tissue envelope to protect the zone of injury from infection.

Principles of open fracture management

Debridement and lavage

Fracture stabilisation

Healthy soft tissue closure

Dr. Smith is an Associate Chief of Orthopaedic Trauma Service and an Associate Professor of Orthopaedic Surgery, Harvard Medical School

Address correspondence to:

Massachusetts General Hospital
55 Fruit Street
Boston, MA 02114

WOUND DEBRIDEMENT AND LAVAGE

Adequate wound assessment, debridement and lavage is probably the most underrated element of open fracture care. Logically, this should be done as soon as possible after injury, traditionally within 6 hours. The earlier the bacterial contamination is reduced the less likely it is that infection will supervene. However, recent publications ([1]) have questioned the need to rush all open injuries to the operating room within 6 hours, and particularly not at night when the quality of care is questionable. Evidence suggests that skilled initial management from an experienced team has many advantages and that while this should be performed as early if the patient presents late in the day, the primary surgery may be better carried out as first case the next morning. Our own policy is to treat all severe limb threatening injuries immediately but to treat moderate or minor grade open injuries during normal hours with an experienced surgical team, if the patient presents late at night the surgery will be performed as first case the next morning.

After anesthesia an initial wound cleaning should be performed, this involves the removal of gross contamination and is the first real opportunity to assess the injury. A formal surgical debridement should then be performed. It is essential to explore the zone of injury and remove all non-viable tissue. As the injury becomes more severe this can involve removal of significant areas of skin, subcutaneous tissue and muscle. All free bony fragments or those attached by insignificant threads of soft tissue should be removed. Only the neurovascular bundles are critical although if a very extensive debridement is required and several compartments are lost, reconstruction may be futile. In parallel with debridement, a profuse wound lavage should be performed, some surgeons favor the use of pulsatile lavage but a simple large volume washout is generally very effective and probably safer. It is essential that warm, isotonic fluid is used to avoid additional tissue damage.

It is important that reconstructive options are considered as the debridement is performed as poorly planned incisions can change the nature of the defect and require a more complicated reconstruction. In general, wound extensions should be longitudinal and be sited to maximise skin viability and avoid large undermined flaps. Any flaps should be short and broad based and skin bridges kept as wide as possible. In more severe injuries the debridement should be discussed and if possible performed with the plastic surgeon who will performed the definitive reconstruction. In many cases, adequate debridement is only possible when you have the confidence that you or a colleague can reliably deal with the resulting defect.

"There are many injuries in which the combination of bone and soft tissue injuries requires collaboration between Orthopaedic and Plastic surgeons from the beginning" *British Orthopaedic Association & British Association of Plastic Surgeons 1997 ([2])*

Complex fracture triage - "to orthopaedic traumatologist with plastic surgical support," - care is - "highly demanding, very technical and team orientated". *S Hansen 1991 ([3])*

FRACTURE STABILISATION

A detailed discussion of appropriate fracture stabilisation is outside the sphere of this article. However, without underlying mechanical stability, shearing forces will prevent wound healing and experimental evidence confirms that in the presence of bacterial contamination bony stability provides the best environment for healthy healing without infection ([4]). Modern soft tissue reconstruction after an open fracture should facilitate the use of any implant suitable for the fracture pattern. However, external fixation devices provide the majority of the problems associated with fixation devices and should be avoided when ever possible ([5]).

WOUND CLOSURE, TIMING AND TECHNIQUES

Definitive wound must lead to healthy healing, seal the fracture and protect against infection. The surgical judgement to decide how and when to close is critical. All injured tissues swell, and if closed too tightly additional tissue will become necrotic and make the reconstruction more complex and infection likely. Traditionally, debridement is staged and wound closure delayed to allow doubtful tissue to define itself. However, given the risk of hospital acquired infection the modern tendency is to earlier wound closure. This more radical approach is attributed to Godina ([6]) Many surgeons now follow this approach, believing that debridement is best completed at the primary procedure and that each delay incorporates of additional dead tissue as superficial layers desiccate and are damaged by exposure. Earlier wound closure prevents additional tissue damage and hospital acquired infection.

"Wide, early, experienced debridement to clearly healthy tissue and early rotational or free muscle flap cover may be better in experienced hands than sequential debridement and delayed closure" *Marco Godina 1986([6])*

SPECIFIC SOFT TISSUE INJURY PATTERNS

Low energy, grade I wounds are tiny puncture wounds with a minimal zone of injury. After wound extension, debridement is minimal and after fracture stabilisation the surgical extensions can be directly closed with little risk of swelling and wound necrosis, with a tiny wound this essentially implies primary wound closure.

Low energy, grade II wounds are lacerations over healthy deep tissues, the lacerations should be extended, the zone of injury displayed and the bone and soft tissues debrided and lavaged as required. It is unlikely that significant amounts of tissue will be required to be removed. After fracture stabilisation the surgical extensions can usually be closed although the primary open wound should be left open. A second assessment, debridement and lavage and delayed primary closure is usually performed. Some surgeons will close some grade II wounds primarily but cannot be widely recommended, it needs experience and careful postoperative monitoring.

High energy wounds are considered as grade IIIa when after debridement there is adequate tissue for soft tissue closure, and grade IIIb when the tissue cover is inadequate.

All high energy injuries are difficult to assess and should be treated by an experienced ortho-plastic reconstructive team from the outset ([2,3,5]).

Grade IIIa injures are quite rare particularly over the tibia where soft tissue are commonly deficient. They should be debrided and left open for a second look and delayed primary closure at 48 hours.

Grade IIIb injuries are rare; by definition, after debridement there is a soft tissue defect that will not close but can be of varying size and nature. The reconstruction required should be tailored to the wound and is of increasing complexity depending on the site and severity of the wound.

THE RECONSTRUCTIVE LADDER FOR SOFT TISSUE DEFECTS IN OPEN FRACTURES

Split skin graft (SSG)

Fascio-cutaneous flap

Rotational muscle flap (with SSG)

Free muscle flap (with SSG)

High energy wounds with inadequate soft tissue cover (grade IIIb) include a wide spectrum of injury from small awkward wounds in places where there is just not enough local cover, (typically the distal medial tibia), to devastating injuries where all the compartments are widely open with significant soft tissue loss and possibly an associated bony defect. The soft tissue reconstruction should be considered with a plastic surgeon from the outset. The techniques available for soft tissue reconstruction involve a progressive increase in complexity as the needs of the wound increases. Each surgeon will favour certain reconstructive techniques but the following options are a reasonable selection for the common scenarios that present.

Incomplete skin closure over a healthy muscle bed can be treated by simple spilt skin grafting (SSG) with reliable results.

A small defect of skin and subcutaneous tissue over bone or implant, without a significant underlying zone of injury (commonly over the mid-anterior tibia), can be covered with a rotational fasciocutaneous flap either with a proximal or distal base. The distally based flap is easiest to turn into an anterior defect and leaves a donor area over healthy calf muscle that takes SSG well. This technique is reliable only if the soft tissue defect and zone of injury is localised to the defect. It is not advisable to rotate flaps within a significant zone of injury as

this then carries a significant risk of flap necrosis and failure.

Larger defects and injuries with a wide zone of injury require cover with healthy tissue with a reliable blood supply. The best cover is a muscle flap covered with SSG. In injuries around the proximal tibia and knee a rotational gastrocenemius flap may be adequate, the gastrocenemius (especially medial head) is useful as it has a pedicled blood supply from the superior popliteal artery and is consistently undamaged in fractures of the tibia, indeed in devastating tibila fractures with complete compartmental muscle loss below the knee the gastrocenemius is often all that is alive below the knee and may be all that is available to cover an amputation stump. Loss of a Gastrocenemius flap is uncommon unless there is injury to the politeal vessels.

If a pedicle flap is not suitable then free transfer of a distant muscle flap is required. This imports healthy muscle but requires specialist skills in microvascular reconstruction and should only be done by surgeons experienced in the technique. The workhorse flap is the free Lattimus dorsi, although Rectus and Gracilis among others can be used depending on the specifics of the defect and situation. Over the last few years evidence has gathered supporting Godina's philosophy ([5,7]) that earlier cover leads to better results and that a primary debridement, fixation and primary flap cover ("Fix and flap technique") gives the best results. Indeed a very high (93%) limb salvage rate with minimal infection and a >60% primary bony healing rate has been reported ([5]). While this appears to be the gold standard, few hospitals have the experience or staff availability to provide such high quality ortho-plastic care with access to an immediate free flap service. The practical option is to complete the debridement, bony stablization and wound assessment at presentation and then perform the definitive soft tissue reconstruction at the second visit to the operating room at 48hours.

Over the last few years the Vaccum Assisted Closure (VAC) has become a popular method of wound dressing for severe wounds. While certainly very useful in chronic wounds, the place of the VAC system in acute wound care is yet to be determined. However, small acute wounds that would otherwise required a flap can often be closed by granulation using a VAC before a simple SSG or even gradual wound epithelisation. VAC therapy can gradually but fairly consistently even cover visible hardwear as long as the implant is stable and the tissues healthy ([8,9]). In large major wounds the VAC provides a better seal to the wound than traditional dressings and although data is still lacking it may lengthen the window before definitive closure and in some cases make the closure simpler. At present, the results of VAC therapy need to be more defined, some wounds just don't close and SSG on granulation tissue may not be durable cover for bone in the long term; the definitive success of muscle flaps should not be dismissed.

Figure 1. A distally based flap turned over an anterior defect and SSG over the donor area.

Figure 2 a

Figure 2 b

Figure 2 a,b A complex grade IIIb wound (a), debrided, and treated with a "Fix and Flap" procedure with a latissimus dorsi free flap (b).

References

1. **Skaggs DL et al.** The effect of surgical delay on acute infection following 554 open fractures in children. J Bone Joint Surg. Am. 2005; 87: 8-12.
2. **British Orthopaedic Association and British Association of Plastic Surgeons- a working party report.** The management of open tibial fractures. September 1997.
3. **Hansen ST Jr.** Open fractures. In Orthopaedic trauma protocols. Eds. Hansen & Swinotowski. Raven press New York 1993.
4. **Worlock P, Slack R, Harvey L, Mawhinney R.** The prevention of infection in open fractures: an experimental study of the effect of fracture stability. Injury 1994; 25(1): 31-8.
5. **Gopal S, Majumder S, Batchelor AG, Knight SL, de Boer P, Smith RM.** Fix and Flap, the radical treatment of open tibial fractures. Journal Bone Joint Surgery (Br) 2000; 82-B, 959-966.
6. **Godina M.** Early microsurgical reconstruction of complex trauma of the extremities. Plast Reconstr Surg 1986; 76: 719-728.
7. **Hertel R, Lambert SM, Muller S, Ganz R.** Rebuliding severe open fractures of the leg: immediate is better than early soft tissue reconstruction for open fractures of the leg. Injury 1998; 29 (2): 154-55.
8. **Steiert AE et al.** The VAC system as a bridging between primary Osteosynthesis in conjunction with functional reconstruction of soft tissue in open fractures type 2 and type 3. Zentralbl Chir, 2004 129 supp 1: S98-100
9. **DeFranzo, AJ et al.** The use of vacuum assisted closure therapy for the treatment of lower extremity wounds with exposed bone. Plast Reconstr Surg. 2001, 108:1184-91.