

# Changing paradigms in the management of Open Injuries

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## Abstract

Open injuries still pose a major problem as they are prone to higher rates of infection and non-union and are usually associated with life threatening polytrauma. Nowadays, specialized trauma centres and a multimodal team approach have shown to give superior results in the outcome following open injuries. Early aggressive wound debridement followed by early fracture stabilization with early wound closure to achieve bone and soft tissue healing are important components as nowadays we focus on the 'Era of functional restoration'. Serum Lactate is a widely used biochemical marker to assess the adequacy of tissue resuscitation and the Ganga Hospital Open Injury score (GHOIS) has a higher specificity towards limb salvage and also gives guidelines regarding timing and type of soft tissue reconstruction. A combined 'Orthoplastic' approach in the management of open injuries and adherence to the 'revised reconstruction ladder' with regarding to wound coverage has shown to a favourable outcome.

**Key words :** Open fractures, Debridement, Serum lactate, Ganga Hospital Open Injury score

## Background

The definition of an open fracture where the fracture and the hematoma communicate with the external environment is well known. But the treating surgeon should also be aware that the skin defect may not lie directly under the fracture site and may communicate with the fracture under degloved skin. Hence any fracture with a wound in the same region should be considered an open injury until proven otherwise by exploration. Open injuries – often high-velocity injuries- are frequently associated with higher risk of complications including amputation [1,2,3,4]. The present challenge to the trauma surgeon is not simply to salvage

the injured limb but also provide a good functional outcome. The principles of management of open injuries have evolved with time and today with advances in both orthopaedic and plastic surgery, the management is now in the 'Era of functional restoration'. Surgeons have now realised that success of open injury management is not merely salvage and one should not succumb to the 'triumph of technique over reason'. The paradigm has now shifted to restoring a good functional outcome to the injured patient and also focusing on developing safe protocols of bone and soft tissue reconstruction<sup>5</sup>. In this article, we discuss the important recommended practices which are determinant of a good outcome in open injury management.

## Initial assessment of Open Injury :

Any open injury is an orthopaedic emergency. Thorough evaluation as per ATLS protocols is necessary to avoid missing any other injury and the initial

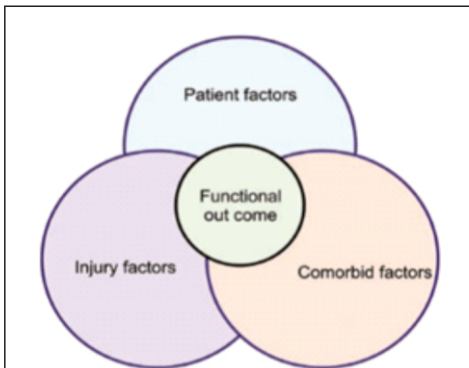
evaluating clinician should decide if there is a role for whole body CT-scan which helps identify injuries to the neck, spine, pelvis, chest and abdomen which may be missed [5]. In the casualty, after the ATLS survey, the limbs are checked for vascularity and neurovascular status. Wounds are to be photographed before being covered by a sterile dressing. Wound photographs would prevent repeated opening of the dressing to view the wound. The injuries and the wounds are then assessed in the operation theatre [6]. Special attention and emphasis has to be given for details of the patient's history with regard to systemic illnesses like diabetes, rheumatoid arthritis and the medication history and smoking history as they significantly determine the outcome [8].

## Role of cultures in the emergency room:

Studies have clearly shown disparity and poor correlation between the presence

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**Figure 1:** The triad comprising of the injury severity, co-morbid factors and factors related to the patient determine the functional outcome of the patient.

of positive cultures and subsequent rate of clinical infection [7,8]. There is disparity between organism grown on wound swab, development of infection of the wound and the organism grown subsequently. The practice of obtaining routine cultures from the wound either pre or post debridement is no longer advocated [5,8,9]. It is now known that apart from contamination, infection is influenced by various local wound, agent, host and environment factors.

**Antibiotics:**

The antibiotic therapy for open injuries is considered therapeutic and not prophylactic and must be instituted at the earliest possible [10,11] as all open fractures are always contaminated to degrees of varying extent. Various guidelines have been formulated regarding antibiotic usage. Many recommend only gram positive cover for grade I and II Gustilo grades and additional gram negative cover for grade III fractures. They recommended maximum duration of antibiotics for 72 hours in grade III fractures [10]. Aminoglycosides are to be added at time of debridement or fixation surgery. They recommend a maximum duration of three days for antibiotics. The authors recommend an early administration (within 3 hours) of antibiotics. A combination of a second generation cephalosporin and an

<b>Covering structures: Skin and Fascia</b>	
Wound with no skin loss and not over the fracture site	1
Wound with no skin loss and over the fracture site	2
Wound with skin loss and Not over the fracture site	3
Wound with skin loss and over the fracture site	4
<b>Functional Tissues: Musculotendinous and Nerve Units</b>	
Partial injury to musculotendinous unit	1
Complete but repairable injury to musculotendinous units	2
Irreparable injury to musculotendinous units, partial loss of a compartment, or complete injury to posterior tibial nerve	3
Loss of one compartment of musculotendinous units	4
Loss of two or more compartments of subtotal amputation	5
<b>Skeletal Structures: Bone and Joints</b>	
Transverse of oblique fracture or butterfly fragment <50% circumference	1
Larg butterfly fragment >50% circumference	2
Comminution or segmental fractures without bone loss	3
Bone loss <4 cm	4
Bone loss >4 cm	5
<b>Comorbid Conditions: Add Two Points for Each Condition Present</b>	
Injury leading to debridement interval >12 hours	
Sewage or organic contamination or farmyard injuries	
Age >65 years	
Drug-dependent diabetes mellitus or cardiorespiratory diseases leading to increased anesthetic risk	
Polytrauma involving chest or abdomen with injury severity score >25 or fat embolism	
Hypotension with systolic blood pressure <90 mm Hg at presentation	
Another major injury to the same limb or compartment syndrome	
Injuries with a score equal to 14 or below are advised salvage	
Injuries with score 17 and above usually end up in amputation	
Injuries with score 15 and 16 fall into gray zone where decision is made on patient to patent basis	

**Figure 2:** Figure to show the Ganga Hospital Open Injury Score (GHOIS).

aminoglycoside are given for 3 days. In wounds with organic contamination, penicillin with metronidazole should be given.

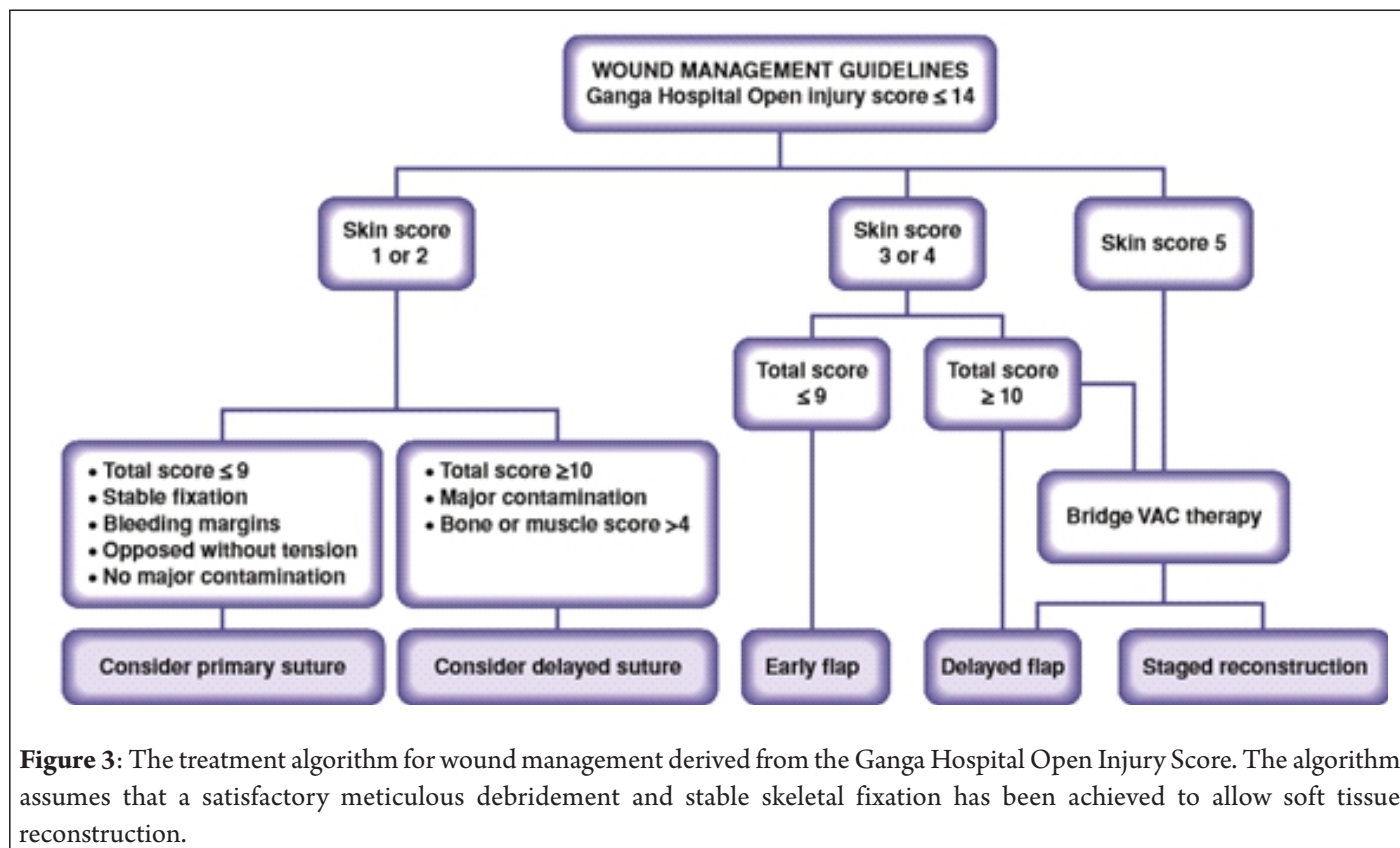
**Role of biochemical markers:**

CRP(C-reactive protein), Interleukins(IL-6,IL-10) and Serum Lactate are the commonly used biochemical markers. Of the above, Serum lactate is a good screening method for occult hypo perfusion and both a high and persistent lactate level is predictive of organ failure and increasing mortality5,13,14. In a study

involving 285 Gustilo type IIIb injuries in our unit, it was found that there is a proportionate increase in both serum lactate and IL-6 even in isolated injuries of limbs when the severity was measured by Ganga Hospital Score.

**Classification and Scores for Open Injuries:**

Gustilo proposed a classification for open injuries in 1976 which still is the most commonly followed classification worldwide. MESS(Mangled extremity severity score) is another most commonly used score which decides



between amputation and salvage of injured limbs.

However, many disadvantages have been exposed in the routine use of Gustilo and Anderson's classification and MESS score like loss of uniformity in usage, no uniform guidelines in management, no consideration of severity of the injury, no account of co-morbid factors and low inter-observer rate(60%) [5].

It is now accepted that a more accurate and objective method for the assessment of these challenging injuries is needed. For this Ganga Hospital Score gives a better clinical picture of the severity of injury.

### Ganga Hospital Open Injury Score (GHOIS)

The Ganga Hospital Open Injury Score (GHOIS) was described in 2005 by Rajasekaran et al to specifically address the issue of salvage and reconstruction pathways in Type IIIB injuries [15] (Fig 2). The three components of a limb - covering tissues (skin), structural tissues

(bone) and functional tissues (muscles, tendons and nerves) form the basis of this scoring system. Seven co-morbidities that are known to influence the outcomes are given two points each. The total score is used to assess the need for amputation and the individual scores provides guidelines in management such as the need for a flap or the need for bone transport. The scoring involves detailed assessment of the injury of different components of the limb and hence must be done at the end of debridement.

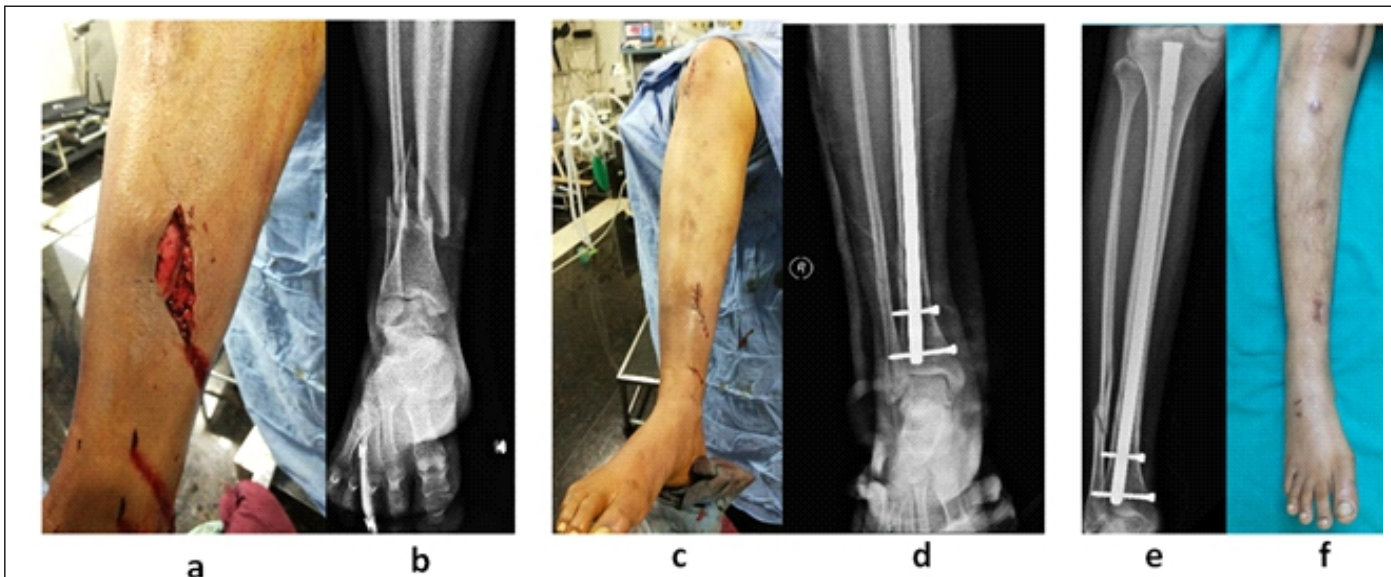
In an initial study of 109 consecutive Type IIIB injuries, all limbs with a score of 14 and below were found to be salvaged successfully. All limbs with a score of 17 and above were found to require amputation. The injuries with a score of 15 and 16 were categorized to be in a grey zone. The unique feature of GHOIS was to recognize that there could not be a single cut off score in a complex clinical situation such as an open injury. The authors while recommending salvage in all injuries

below 14 and consideration for amputation in injuries above 17 emphasised on a grey zone of score 15 and 16 where the decision to salvage or amputate must be based on factors such as associated injuries, the expertise of the team, the social background of the patient, the personality of the patient and considerations of the cost when applicable.

### The advantages of GHOIS are :

- 1) Evaluates the severity of the three components of the limb – Covering tissues, Functional tissues and Skeleton separately on a scale of 1 to 5.
- 2) Gives weightage to co-morbid factors.
- 3) High inter-observer reliability.
- 4) Total score provides guidelines for salvage and amputation of limb.
- 5) Individual scores provide guidelines for timing and type of reconstruction.

### The art and science of Debridement:



**Figure 4:** An Open tibia fracture(a,b) with a GHIOS score of 3 (Skin 1, Bone 1 and MTS 1) treated with debridement, interlocking nailing and primary closure(c,d) at the index procedure showing good union and healing(e,f) without any complications at 6 months.

Good debridement is one of the keys to success in open injuries. The concept followed nowadays is to debride and remove all tissues which will not survive. However, this decision making requires a lot of experience and clinical acumen. A good lavage for open injuries and the use of a tourniquet is recommended. Tourniquet reduces the blood loss and improves the thoroughness of debridement. The authors recommend the use of loupes which facilitate the identification of dirt and contamination matter during debridement and also the use of a tourniquet to perform a better debridement.

#### Principles of Debridement [5]:

- 1) Debridement must be performed by an experienced team as early as possible.
- 2) 'Orthoplastic' approach involving plastic surgeons even at the time of the index surgery is recommended.
- 3) Pre-debridement photographs of the wound and use of tourniquet to allow a bloodless field is essential.
- 4) Wound must be longitudinally excised to provide adequate visualization of deeper structures.

Gentle handling of tissues is essential. All avascular fascia are removed.

- 5) All muscles in the compartment must be evaluated for viability ( 4 C's : Colour, Contractility, Consistency and Capacity to bleed ) and then debrided.
- 6) All bony fragments without soft tissue attachments must be excised. Bone ends and medullary cavity must be carefully examined for impregnated paint, mud and soft tissue material.
- 7) Adequate quantity of fluid with low-pressure pulsatile lavage is preferable.
- 8) Deflate tourniquet and assess viability of all retained structures. Assess loss of tissues and document it with a photograph to decide on the timing and method of wound closure. Document your sequence of reconstruction.

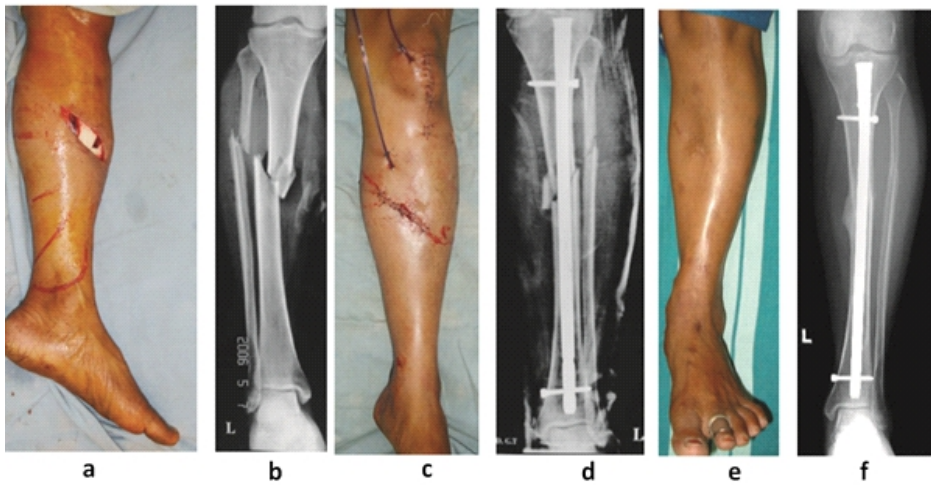
#### Treatment algorithm for Wound management :

Our unit treats more than 350 type IIIB injuries every year and our choice of reconstruction pathway is guided by the GHOS. On an analysis of the last 965 injuries in a three year period, we found

that the limb reconstruction pathway followed fits into one of the following options(Fig 3) . A Common requirement for success is a thorough debridement by an experienced 'Orthoplastic' team. Bone stabilization is tailored to the fracture needs and the cover is provided at the earliest. The individual skin score is used to choose the method of wound cover and the total score guides the time of treatment [5,15,16].

#### Fix and Primary Closure:

Injuries with a Skin Score of 1 or 2 have no skin loss at injury or during debridement. When contamination is low with satisfactory debridement, these patients are suitable for direct suturing during the initial procedure. The total score must be less than 9 as this indicates low energy violence and the chances for postoperative swelling or compartment syndrome is low. Stable skeletal fixation and bleeding skin margins which are opposed without tension are the prerequisites for primary closure. It should be noted that the length of the wound is not a criteria for suitability for suture.



**Figure 5:** An Open tibia fracture (a,b) with a GHIOS score of 6 (Skin 2, Bone 2 and MTS 2) treated with debridement, interlocking nailing and primary closure (c,d) at the index procedure showing good union.

protocol.

**Fix and Skin Grafting:**

A Skin score of 3 indicates skin loss either at injury or during initial debridement. In a Score of 3, the wound does not expose the fracture site or there is an adequate cover of soft tissue. A classic example is open fractures of femur where a good soft tissue cover is usually available after skeletal stabilization. Here a simple wound management by split skin graft (SSG) is also possible.

A Skin score of 3 or 4 indicates skin loss either at injury or during initial debridement. If the wound exposes bone, articular cartilage, tendons or a vascular anastomosis site, a flap is needed. The nature and the type of the flap will be determined by the location and size of the defect and the structures exposed. Again the timing is guided by

the total score of GHOS. An early flap can be done if the total score is less than [9]. This indicates a more definable zone of injury:

We do not favour the traditional reconstructive ladder philosophy but rather would choose the most appropriate procedure that would best suit the injury and the needs as per the bone and soft tissue defect. Often a well performed free tissue transfer or flap transfer would bring better functional results and can even make the difference between salvage and amputation.

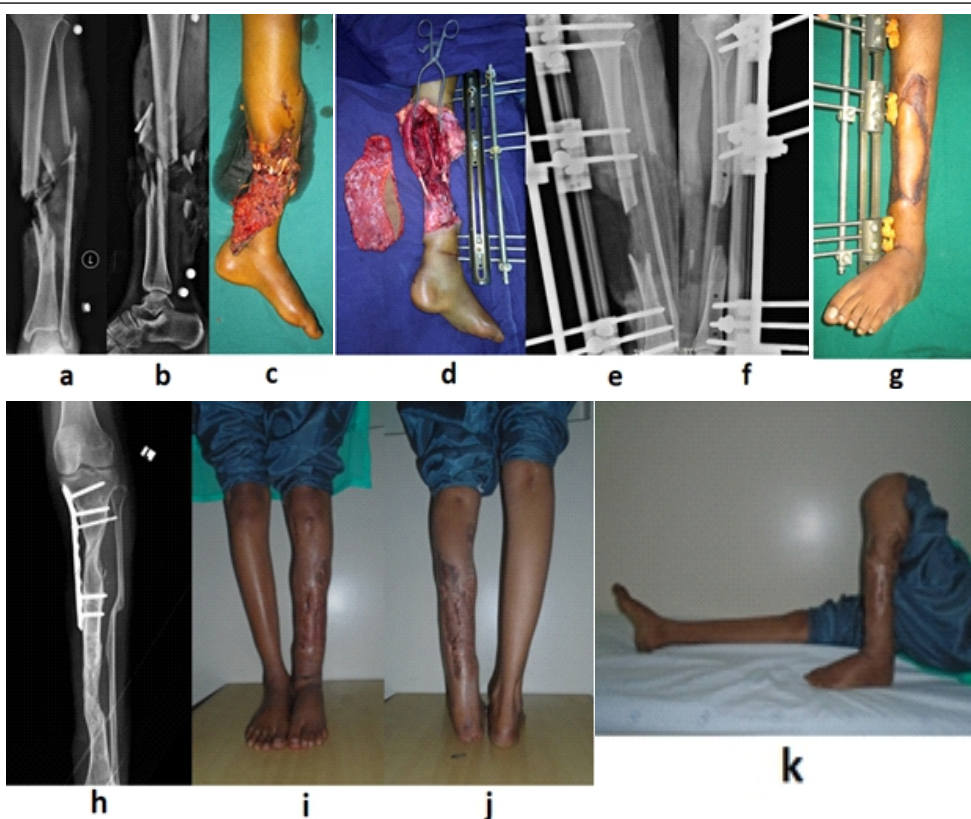
**Fix and delayed flap:**

A fix and delayed flap protocol is performed whenever there is severe contamination or the total score is more than 10. The duration of delay will depend on the condition of the wound, the swelling of soft tissues and any evidence of infection. If during the relook procedure, the wound is not suitable for flap, usage

**Fix and Delayed Closure:**

Injuries with Skin score of 1 or 2, but with either a total score of >9 or with moderate or severe contamination are not be primarily closed. A higher score of >9 indicates a high energy violence and a reassessment at 48 or 72 hours is

necessary. A delayed closure is performed if the wound Characteristics at second look debridement allow closure. If additional debridement is required at the second look surgery leading to skin and soft tissue loss, the patient is managed by staged flap



**Figure 6:** An open tibia fracture with marked soft tissue loss and bone loss (a,b,c) with a GHIOS score of 13 (Skin 5, Bone 4 and MTS 4) treated in various stages. Initial debridement and LRS application (d,e,f) followed by covering the defect with a free flap (g). Secondary procedure of plating and bone grafting (h) resulted in union and a good functional outcome (i,j,k).

of VAC (Vaccum Assisted Closure) device following another debridement is a suitable option.

### Staged Reconstructions:

A score of 5 or more in any of the tissue scores and a total score of >9 indicates a limb that is not suitable for immediate reconstruction. These limbs have considerable associated bony and soft tissue injury or loss. Often the wound may not be ready for reconstruction even for a few weeks. The option of immediate or early application of VAC at the index procedure must be considered seriously. The expertise of a skilled plastic surgical team with the capability of microsurgical reconstruction and an orthopaedic team capable of bone reconstruction and bone transport experience is essential. If not available, patients must

be shifted to a higher centre where such facilities are available at the earliest. The choice of reconstruction and timing must be made on an individual patient basis depending on their pattern of injury.

### Recommended Practice by the

#### Authors :

The following are the recommended practices today in the management of open injuries which are also followed in our institute. In the casualty, after the ATLS survey, the limbs are checked for vascularity and neurovascular status. Wounds are photographed before being covered by a sterile dressing. Wound photographs would prevent repeated opening of the dressing to view the wound. The injuries and the wounds are then assessed in the operation theatre. Antibiotics—a combination

of a second generation cephalosporin and an aminoglycoside—are given as early as possible. Early debridement of the wounds is followed. An 'orthoplastic' approach—involvement of the orthopaedic surgeon and the plastic surgeon—is recommended in the initial debridement and the management of these injuries. Following debridement, the wounds are assessed using the Ganga Hospital open injury severity score and in our experience we have found that it provides excellent guidelines regarding wound coverage and further management. Unilateral external fixator forms the workhorse of open injuries of the lower limb but nevertheless primary internal fixation is done when indicated.

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