
بسم الله الرحمن الرحيم

دانشگاه علوم پزشکی
و خدمات بهداشتی درمانی بابل

Wound Cover

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TABLE 10-10 Ganga Hospital Open Injury Score (GHOIS)[154]

Covering Structures: Skin and Fascia	
• 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
• Wound with circumferential skin loss	5
Functional Tissues: Musculotendinous and Nerve Units	
• 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 or subtotal amputation	5
Skeletal Structures: Bone and Joints	
• Transverse or oblique fracture or butterfly fragment <50% circumference	1
• Large butterfly fragment >50% circumference	2
• Comminution or segmental fractures without bone loss	3
• Bone loss <4 cm	4
• Bone loss >4 cm	5

Comorbid Conditions: Add Two Points for Each Condition Present

- 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

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- 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 patient basis.

Primary Closure of Wounds

- Hope and Cole in a series of tibial fractures in children reported an infection rate of 7.8% with primary closure compared with 14.6% with secondary closure.
- Cullen et al. reviewed the records of 83 children with open fractures of the tibial metaphysis and diaphysis in which wounds were closed primarily.
- Only 2 children developed superficial infection.
- Rajasekaran et al. have reported excellent results with only 3% deep infection rate.

Primary Closure of Open Wounds

- **Indications**

- Type I and II open injuries and III A and B injuries of limbs without vascular deficit

- Wounds without primary skin loss or secondary skin loss after debridement

- Ganga Hospital Skin Score of 1 or 2 and a total score of 10 or less

- Injury to debridement interval less than 12 hours
- Presence of bleeding wound margins that can be apposed without tension
- Stable fixation achieved either by internal or external fixation

➢ Contraindications

- Type IIIC injuries
- Ganga Hospital Skin Score of 3 or more and a total score of >10
- Wounds in patients with severe polytrauma involving chest or abdomen with injury severity score >25

❖Figure

- An open tibial fracture with a GHOIS score of 6 (skin 2, bone 2, and MTS 2) (*A*, *B*), which has been treated by primary closure and interlocking nail at the index procedure (*C*, *D*) and good functional outcome was achieved without any complications.

A, B

C, D

- If primary closure is to be successful, the following points have to be kept in mind.

1. When the patient initially presents in the emergency room, almost all open injuries appear to have skin loss.

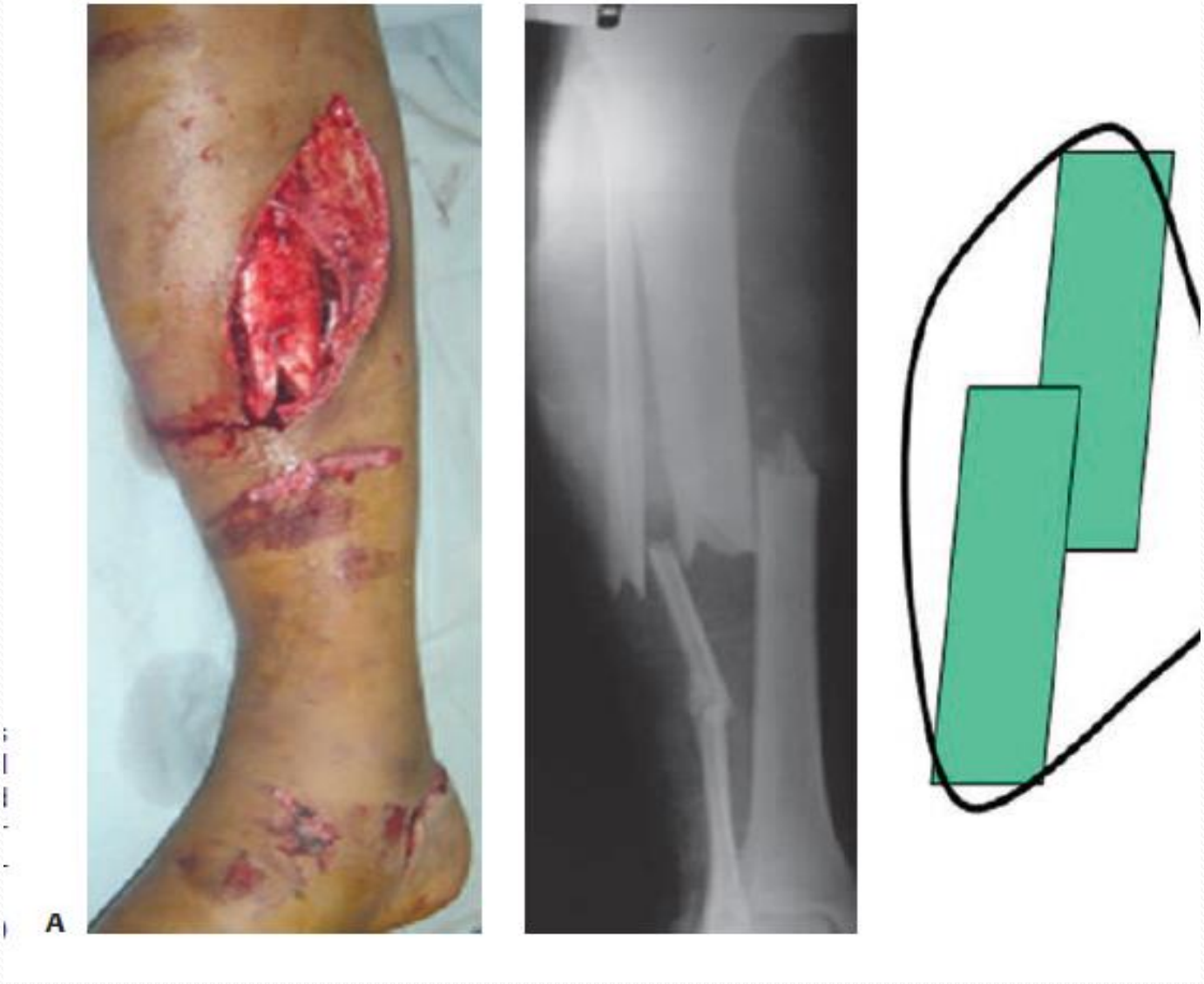
- Because of shortening or angulation at the fracture site.

- In many cases, the margins will oppose easily when the fracture is reduced and limb length restored (Fig. 15-26).
- Hence the assessment of skin loss and the ability to oppose the skin without tension should be done only after fracture reduction.

❖Figure

- Assessment of skin loss requires experience and must be done after the skeletal length is restored.

➢ **A:** In the emergency room and during debridement, all lacerated wounds appear to have skin loss as they gape due to bone shortening and angulation.


A

- **B:** Once fracture reduction is achieved, the wound margins usually come together and primary closure is possible in nearly a third of injuries.

2. The length of the wound does not correlate with the ease with which the wound can be closed by primary closure.(Fig. 15-27).

❖Figure

- **An open fracture with tibial comminution and exposure of the articular surfaces (*A, B*).**

- Although the wound measured 31 cm, there was no loss of skin and bleeding viable skin margins could be opposed without tension (C).

- Good articular reconstruction (D) and primary wound healing was achieved (E).

3) A GHOIS of 10 or higher denotes a high-energy injury possibly with a crushing component.

- The zone of injury may not be obvious on day 1 or during the index procedure.
- These limbs have a tendency to swell up in the next few days and therefore are not suitable for primary closure.

4) Careful judgment is required in the presence of skin flaps.

- Flaps are common especially in wounds around the joints where there is loose skin on the extensor aspect.

- When the joint is flexed, these flaps retract making the wound appear very large.
- Many of these flaps, if viable, can be managed by primary closure when the joint is extended.

5) Lacerations adjacent to closed degloving or associated with extensive bruising of the skin are not suitable for primary closure.

6) Wounds treated with primary closure should have a deep drain inserted so that an underlying hematoma is avoided.

7) A useful policy is “whenever in doubt, do not close.”

- Whenever in doubt, the decision to second-look surgery 48 to 72 hours later is preferable.

Need for Second-Look Debridement

- High-energy blast injuries
- Severe contamination, farmyard, and sewage contamination
- Delayed presentation >12 hours

- Evidence of infection during debridement
- Initial debridement considered unsatisfactory

Timing of Wound Closure

- Primary closure: Wound closed by direct skin suturing during the index procedure

- Immediate cover: Soft tissue cover performed within 48 hours

- Early cover: Soft tissue cover performed within 1 week
- Delayed cover: Soft tissue cover performed within 3 weeks
- Staged reconstruction: Soft tissue reconstruction done after 3 weeks

Zone of Injury

- Blunt and open injuries with a crushing element have a larger area of impact and tissue destruction than penetrating injuries.
- The extent of damage, especially to the deeper tissues, may be much wider than it initially appears.

- Figure
- This case demonstrates the concept of “zone of injury.”
- The injury resulted in a comminuted fracture of the femur and tibia.
- **A–C:** On presentation, the wound was deceptively small

A, B

- **D:** There was extensive skin and tissue loss over the next 3 days as the zone of injury slowly revealed itself.

C, D

- This required secondary debridement (E), and the defect required a latissimus dorsi free flap (F).

- **G, H:** The fractures were treated by primary plate fixation.

❖Three typical zones of injury are described.

- The direct trauma contact area is the central zone or "zone of necrosis" and is directly beneath the wound.

- Surrounding this zone is the "zone of injury" that extends into the peripheral uninjured viable zone.

- The extent of these zones depends on the amount of energy imparted to the tissues at the time of impact and also on the anatomy of the area of impact.

- This zone of injury is characterized by inflammatory edematous soft tissue with disturbed microcirculation.

- It is often difficult to clearly distinguish the zone from adjacent healthy tissues immediately after trauma and during the initial debridement.

- This has considerable clinical importance because the vascular pedicles of flaps that are based in this zone of injury or microvascular anastomoses performed in this area are associated with an increased rate of failure.

- In our experience, whenever GHOIS is above 9, it is preferable to stage the soft tissue reconstruction.

Source of Infection in Open Injuries

- Although infection does result from wound contamination especially if the debridement has been poor, there is now firm evidence that most acute infections after open injuries are the result of pathogens acquired in the hospital rather than from the site of injury.

- In a prospective study, Patzakis et al. found that only 18% of infections were caused by the organism that was initially isolated in the perioperative period.

The Timing of Soft Tissue Cover

- The optimal timing of soft tissue reconstruction in open injuries still remains imprecise, and to date, there are no level 1 studies that have looked into the timing of soft tissue cover.

- Traditionally, the protocol in a majority of units is to limit the initial surgical procedure to debridement and skeletal stabilization.

- The definitive soft tissue and bony reconstruction is postponed to a later date.

- Godina initiated the trend toward early soft tissue cover and reported a significant difference between wounds reconstructed within **72 hours** of injury and those reconstructed later.

- The rates of infection and free-flap failure in wounds in which microvascular reconstruction was performed within 72 hours of injury were significantly **lower** than the rates for wounds reconstructed between 72 hours and 3 months after injury.

- In the “fix and flap” protocol, wounds are reconstructed with muscle flaps as early as within 72 hours of injury.

- In a review of early debridement and muscle flap cover, patients undergoing soft cover within 72 hours had a deep infection rate of only 6%(29% deep infection rate in patients undergoing soft tissue cover after 72 hours).

- Hertel et al. reported in the delayed reconstruction group the
  - time to full unprotected weight bearing ,
  - the time to definitive union,
  - the number of reoperations,
  - and the infection rate were significantly higher.
  -

- They advocated that whenever possible and where the condition of the patient allowed, a “zero-delay protocol” might be useful to maximize results.

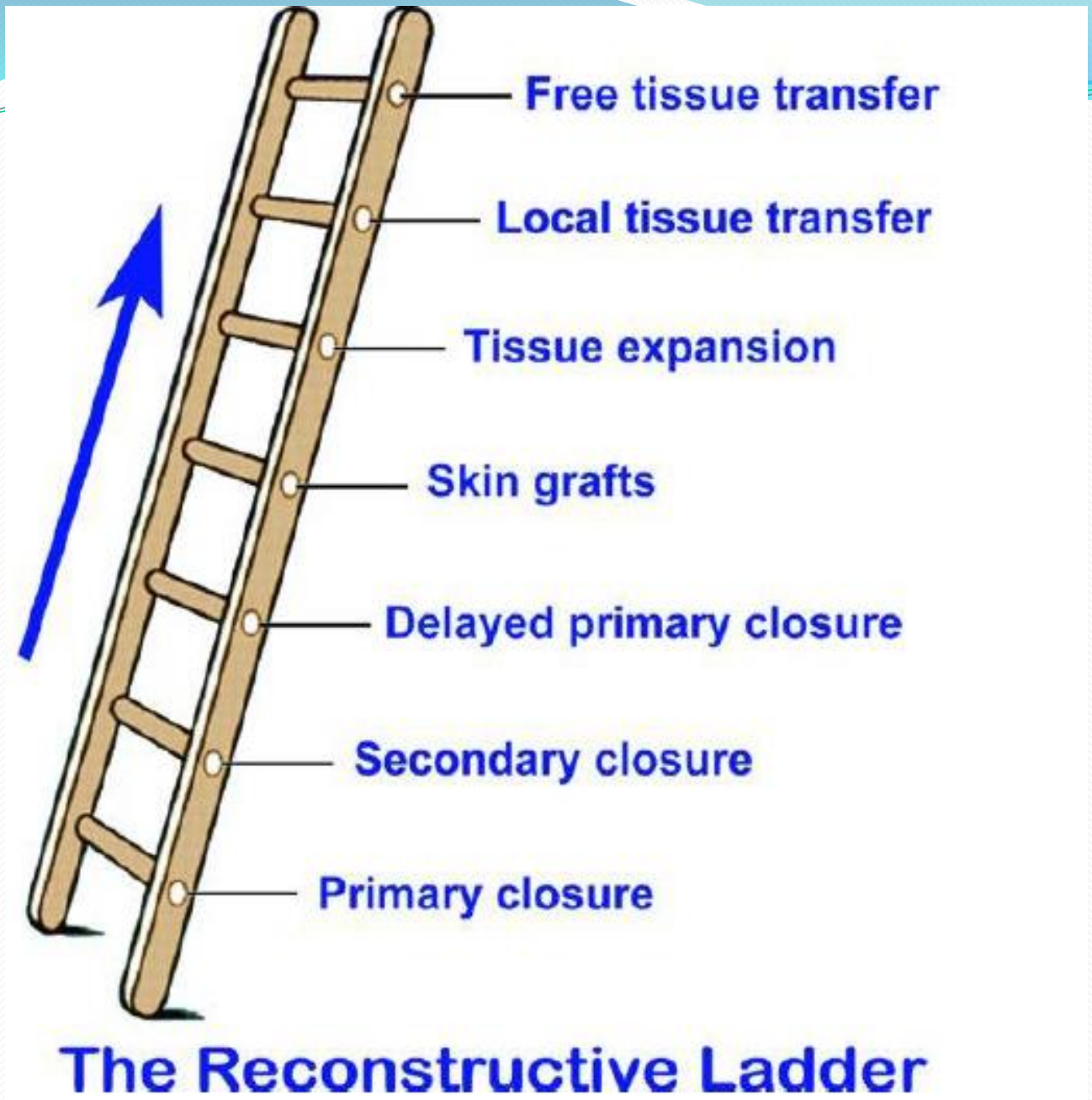
Type of Cover

- In patients with established skin loss, there are many options for providing skin cover over the fracture site from releasing incisions to microvascular free tissue transfer.

- Traditionally, choices were viewed as a reconstructive ladder starting from simple split skin grafts and progressing to fasciocutaneous flaps, rotational muscle flaps, and free muscle flaps (Fig. 15-29).

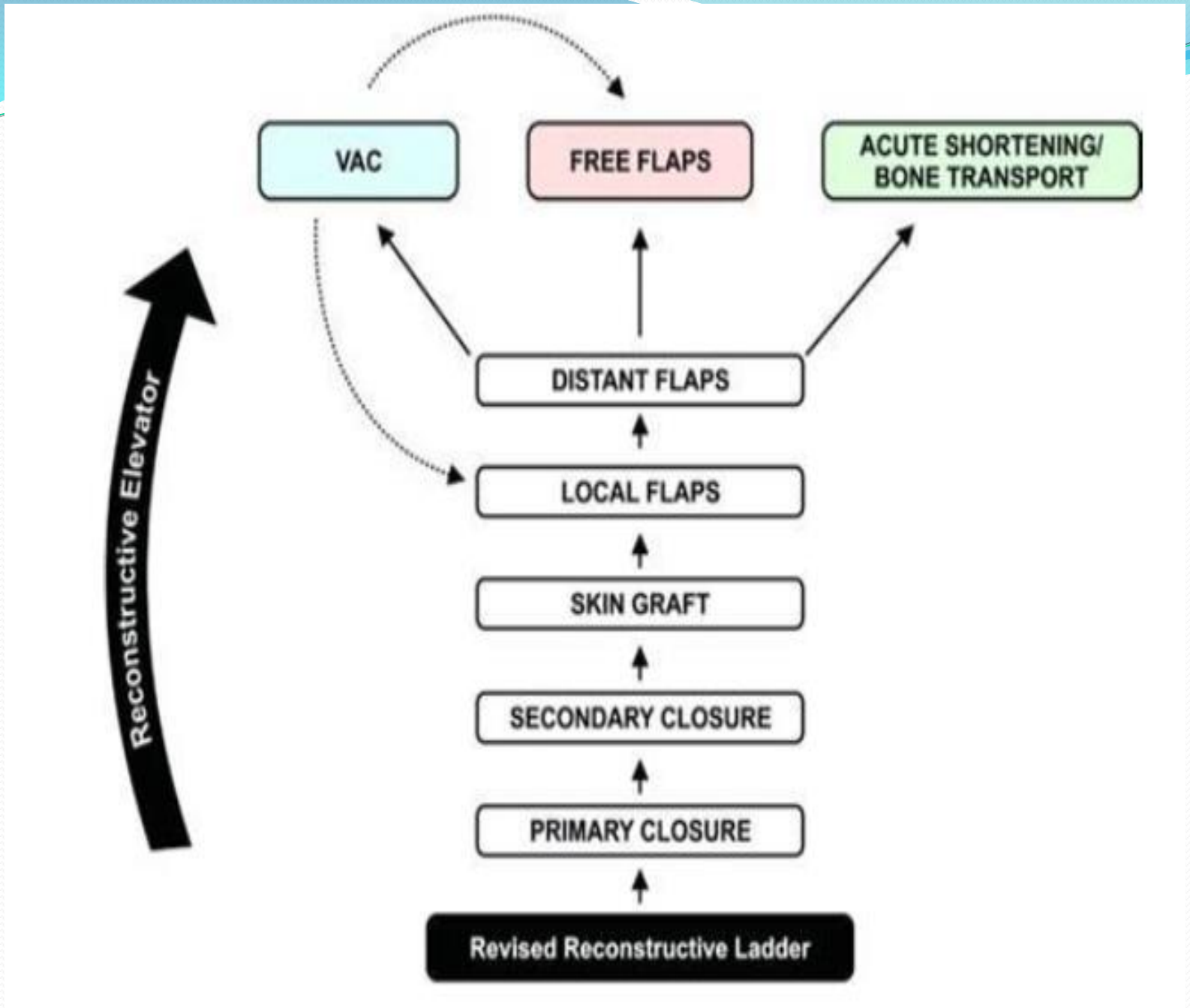
- Figure

- The traditional reconstructive ladder proposes a plan for reconstruction where each step of the ladder denotes a reconstruction of increasing complexity starting from primary closure.
- It was originally suggested that the surgeon must choose the lowest possible step that will suit the defect.
- However, this concept is not followed now.



The Reconstructive Ladder

- Figure
- The “reconstructive elevator” concept is more popular now where the most appropriate and effective method of cover is chosen as the primary choice, however complex it may be.


VAC
FREE FLAPS
ACUTE SHORTENING/
BONE TRANSPORT
Reconstructive Elevator
DISTANT FLAPS
LOCAL FLAPS
SKIN GRAFT
SECONDARY CLOSURE
PRIMARY CLOSURE
Revised Reconstructive Ladder

- Following guidelines generally hold true:

- Lacerated wounds without skin loss, which can be opposed without tension, can be primarily sutured.

- In small linear vertical wounds lying over bone, with minimal soft tissue loss, cover can be achieved using a parallel releasing skin incision that will allow direct closure of the laceration.

- The releasing skin incision should be over a good muscle bed or fascia so that it will allow skin grafting of the defect.

- Wounds that are not directly over the bone and that have a healthy muscle bed can usually be treated by split skin grafting with good results.

- Small defects in the skin that are directly over bone and are exposing implants can be successfully covered with rotational fasciocutaneous flaps that may have either a proximal or a distal base (Fig. 15-31).

- Figure
- **A–C:** An open tibial fracture with soft tissue loss and exposure of the fracture site, and a GHOIS score of 8.

- **D, E:** This was nailed and an early fasciocutaneous flap was undertaken. A low total score allowed successful early flap cover.

- Larger defects and injuries exposing the bone and tendons require to be covered with vascularized tissue and the best option is a muscle flap covered with split skin graft.

- A good example of this is the rotational gastrocnemius flap that is used for injuries around the proximal tibia.

- The medial gastrocnemius is especially useful as it has a good blood supply from the superior branch of the popliteal artery that is usually uninjured in fractures of the tibia.

- Even in patients who require an amputation due to severe crushing of the soft tissues in the calf the gastrocnemius is usually viable and can be utilized effectively to cover the amputation stump.

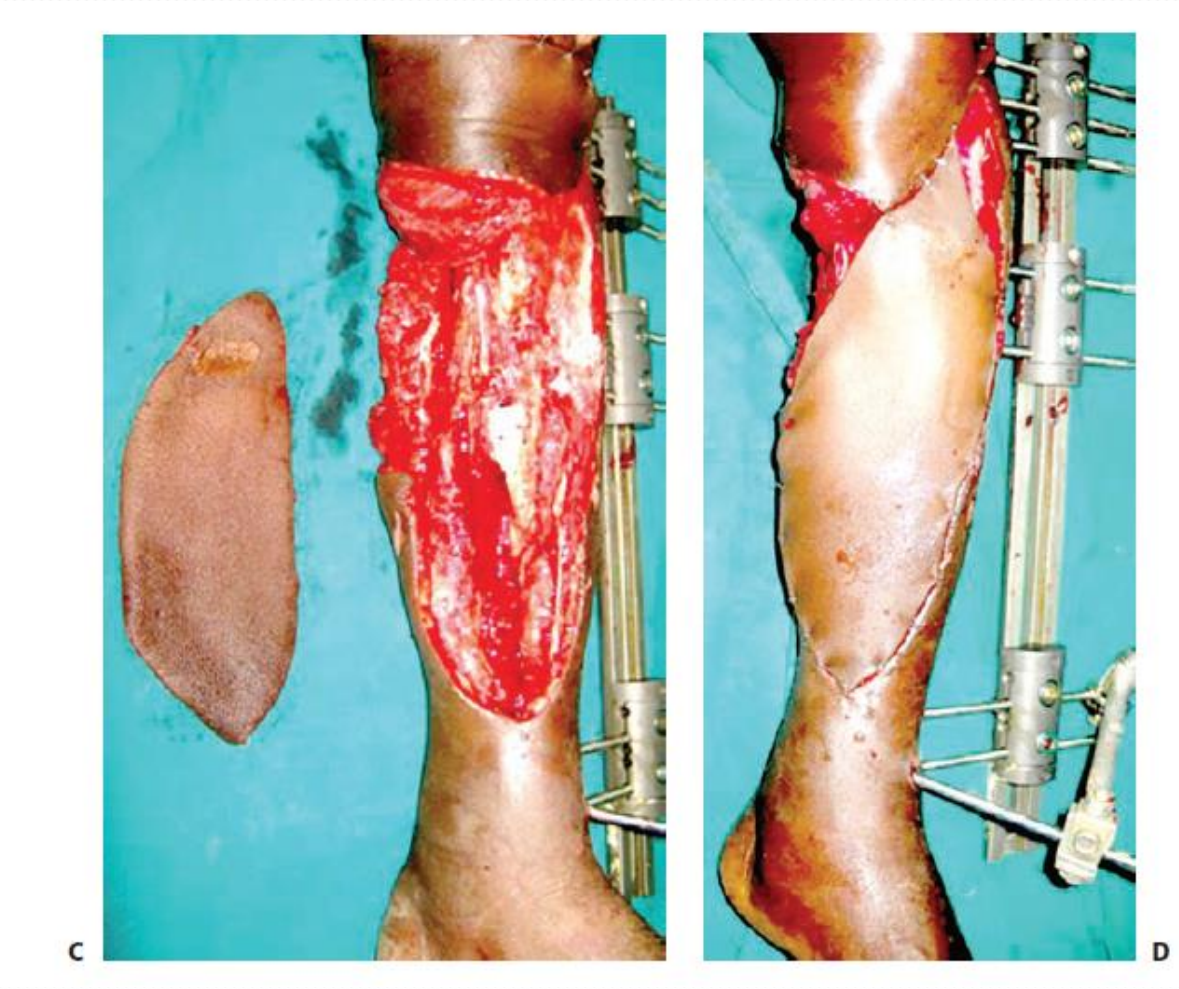
- Failure of a gastrocnemius flap is very uncommon unless there is an injury to the popliteal vessels or the pedicle blood supply is damaged during dissection.

- Wounds in which a pedicle flap is not suitable or which are too large to be treated with a pedicle flap require free microvascular tissue transfer (Fig. 15-32).

- Figure
- A severe open injury of leg with a GHOIS score of 13.
- There was significant soft tissue loss during debridement (**A**, **B**).


A
B

This was managed by secondary debridement and a delayed free flap performed at 1 week (**C, D**) and a good result was obtained. A score of 10 or more indicates a very severe injury to all compartments of the limb and immediate soft tissue reconstruction is contraindicated.



Negative-Pressure Wound Therapy

- NPWT has largely replaced wet dressing therapy in most centers that treat a large number of open injuries.
- Wet dressings have to be changed frequently, these being labor-intensive and costly.
- Repeated dressings lead to increased exposure and susceptibility to the risk of nosocomial infection.

- These drapes also stop protein loss,
- minimize wound desiccation,
- and prevent additional contamination from the hospital environment.

- In animal models, it has been shown that a pressure of –125 mm Hg,
- applied for 5 minutes at
- intervals of 7 minutes, has the most beneficial effect on the formation of granulation tissue and it increases the blood flow in the surrounding tissues by almost fourfold.

- **Continuous** negative pressure increases granulation tissue by only 63% compared to 103% with **intermittent** negative pressure.

Beneficial Effects of VAC Therapy

- Promotes wound contraction and increases the chance of delayed primary closure
- Continuously removes excess edematous fluid
- Causes reactive increase in blood flow and promotes healing

- Removes proteins and electrolytes that are harmful for wound healing
- Decreases bacterial burden
- Causes cellular microdeformation and favorable electrical fields that stimulate cell response and growth factors

Application of NPWT Device

- It should be **emphasized** that VAC is not a replacement for good surgical principles.
- The wound must be thoroughly debrided of all debris and infected tissues and bleeding should be well controlled before the application of negative pressure.

VAC Therapy

❖**Indications**

- Severely crushed injuries not amenable for immediate soft tissue cover
- Wounds that require dead space management
- Exposed bone with degloved skin
- Exposed tendons and ligaments
- Open joint injuries with soft tissue loss

❖Contraindications

- Presence of necrotic skin with eschar
- Untreated osteomyelitis
- Exposed neurovascular bundle
- Exposed vascular anastomosis

- Figure An extensive degloving injury of the buttocks (A) with a pelvic fracture (B) had a large defect following debridement (C).

- **D:** Such large defects are amenable to immediate VAC therapy, which facilitated early granulation and treatment by skin grafting.


A
B
C
D

- Keeping the skin dry helps the adhesive drapes to get a firm hold.

- Circumferential application of the adhesive drapes must be avoided to prevent a tourniquet effect.

- If patients complain of pain with the intermittent suction protocol continuous suction can be used.

- The VAC device is left in place for 2 or 3 days after which the wound can be inspected and suction continued.

Clinical Effects

- In a study by Dedmond et al.reporting the prevalence of infection in type IIIA, IIIB, and IIIC injuries was 8.3%, 45.8%, and 50%, respectively, which is similar to studies that did not use NPWT.

- A few studies have shown a decrease in the bacterial load but others have found no difference or an overall increase in the bacterial load.

- In a retrospective study of open tibia fractures, Blum et al. have reported an infection rate with NPWT less than conventional dressings.

- The incidence of polymicrobial infection was less with NPWT.

- However, it is not completely clear in clinical practice that whether NPWT decreases the level of contamination of gram-negative organisms in open fracture wound or serves as a barrier to colonization with nosocomial gram-negative organisms.

Complications

- Twelve deaths have been reported related to the use of NPWT due to bleeding when used

- in wounds near the groin
- or presternal region
- or when used over vascular grafts.

- NPWT is also contraindicated in patients :

- taking anticoagulants and

- in those who have significant adhesions between the wound bed and dressings when dressings are removed.

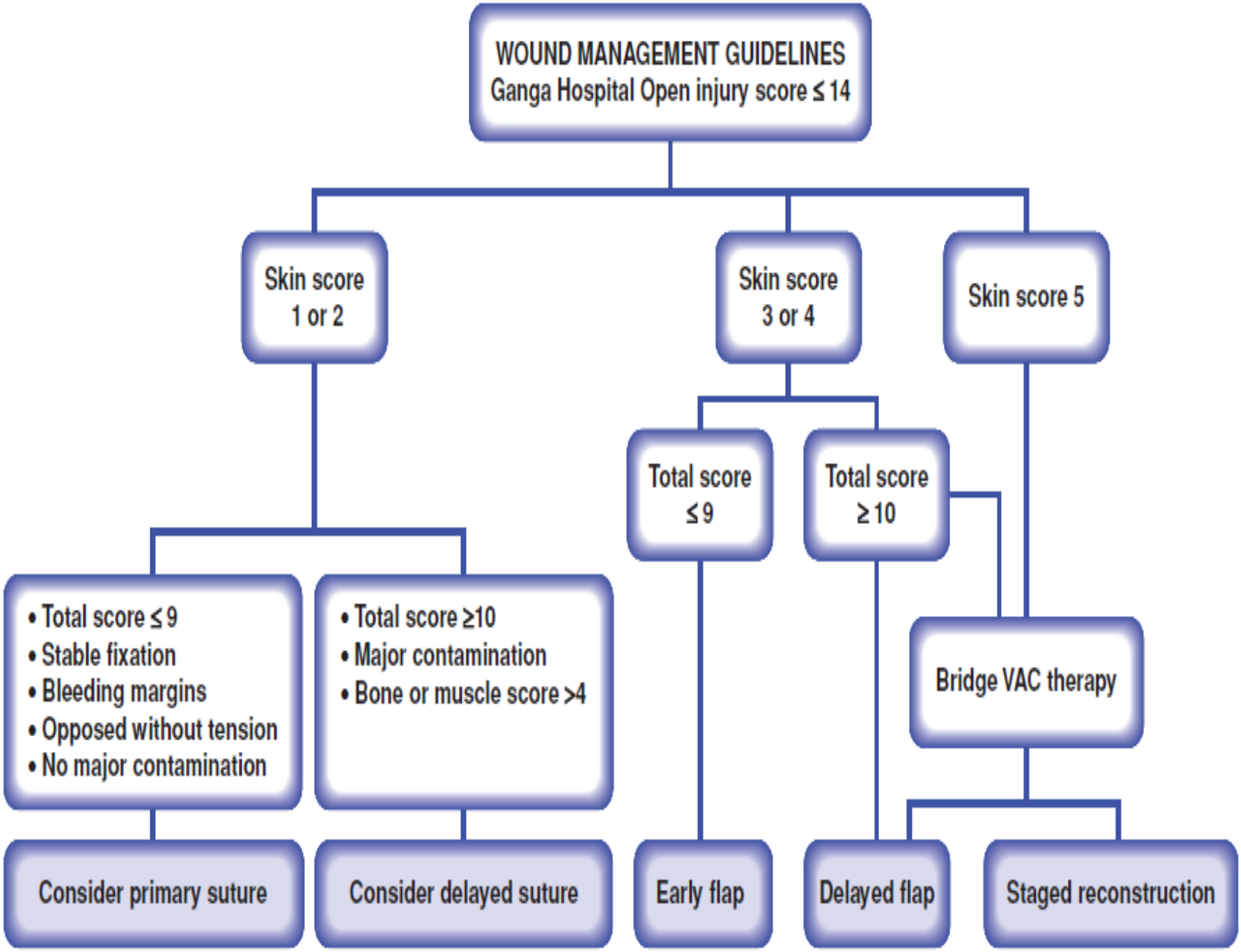
- Loss of suction and failure of the VAC system to maintain a vacuum will increase the risk of wound infection.

Author's Preferred Treatment

- Our unit treats more than 300 type IIIB injuries every year, and our choice of reconstruction pathway is guided by the GHOIS.
- In an analysis of 965 injuries treated in a 3-year period, we found that the limb reconstruction pathway that was selected followed one of a number of options:

- "Fix and close" protocol
- "Fix, bone graft, and close" protocol
- "Fix and flap" protocol
- "Fix and delayed flap" protocol
- "Stabilize, observe, assess, and reconstruct" protocol

- The individual skin score is used to choose the method of wound cover and the total score guides the time of treatment (Algorithm 15-1).


WOUND MANAGEMENT GUIDELINES
Ganga Hospital Open injury score ≤ 14
Skin score 1 or 2
Skin score 3 or 4
Skin score 5
Total score ≤9
Total score ≥10
• Total score ≤9
• Stable fixation
• Bleeding margins
• Opposed without tension
• No major contamination
• Total score ≥10
• Major contamination
• Bone or muscle score >4
Bridge VAC therapy
Consider primary suture
Consider delayed suture
Early flap
Delayed flap
Staged reconstruction