Initial management of war wounds with fractures

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BONE FRACTURES CANNOT BE CONSIDERED AS AN ISOLATED LESION

SURROUNDING SOFT TISSUES STATUS IS OF THE UTMOST IMPORTANCE
INITIALLY

FORGET THE BONE

FOCUS ON THE SOFT TISSUES
ALL WAR WOUNDS ARE HIGHLY CONTAMINATED
AVOID INFECTION
The goal of war surgery is to avoid infection.
The treatment of war wounds is based on well established principles.

Although new technologies have been brought to war theater medical facilities the basic surgical principles discovered during the wars of the last century are still valid today.

Indeed, they remain the most important steps in the proper care of war wounds:

- Initial debridement
- Irrigation
RIGHT LEG OPEN FRACTURE FROM SHELLS

- WATER & SOAP
- INITIAL CARE OF CONTAMINATION
- DBR & IRRIGATION
- WOUNDS LEFT OPEN
- SHORT TERM ANTIBIOTIC
- TEMPORARY STABILIZATION EXFIX
- SOFT TISSUE COVERAGE SSG
- CONVERSION TO BK WALKING CAST
OPEN FRACTURE
FROM INSIDE-OUT

- THE BONE BREACHES THE SKIN

RISK OF CONTAMINATION

OPEN FRACTURE
FROM OUTSIDE-IN

- AN EXTERNAL OBJECT PENETRATES THROUGH THE SKIN AND BREAKS THE BONE
<table>
<thead>
<tr>
<th>Year</th>
<th>Author</th>
<th>Description</th>
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</thead>
<tbody>
<tr>
<td>1957</td>
<td>CAUCHOIS</td>
<td>The pioneer, still used by French authors, similar to Gustilo</td>
</tr>
<tr>
<td>1976</td>
<td>GUSTILO</td>
<td>Most widely used, standard in international literature</td>
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<tr>
<td>1984</td>
<td>TSCHERNE</td>
<td>Emphasis on potential complications, e.g. CS</td>
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<tr>
<td>1985</td>
<td>BYRD</td>
<td>Combines mechanism of injury with bone and ST damage</td>
</tr>
<tr>
<td>1990</td>
<td>AO</td>
<td>Very detailed, 125 possible combinations</td>
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</table>
# The Gustilo Classification for Open Fractures

**Original version 1976**

<table>
<thead>
<tr>
<th>Type</th>
<th>Description</th>
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<tbody>
<tr>
<td>Type I</td>
<td>An open fracture with a wound &lt; 1cm long and clean</td>
</tr>
<tr>
<td>Type II</td>
<td>An open fracture with a laceration more than 1 cm long without extensive soft tissue damage, flaps or avulsions</td>
</tr>
<tr>
<td>Type III</td>
<td>Either an open segmental fracture, an open fracture with extensive soft tissue damage or a traumatic amputation. Gunshot injuries, farm injuries, any open fracture with accompanying vascular injury requiring repair</td>
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</tbody>
</table>
### THE GUSTILO CLASSIFICATION FOR OPEN FRACTURES

Revised edition 1984  
CURRENTLY IN USE (no changes for type I and II)

<table>
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<th>TYPE</th>
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<tr>
<td>TYPE IIIA</td>
<td>Adequate soft tissue coverage of a fractured bone despite extensive soft tissue laceration or flaps, or high energy trauma irrespective of the side of the wound</td>
</tr>
<tr>
<td>TYPE IIIB</td>
<td>Extensive soft tissue injury with periosteal stripping and bony exposure. This is usually associated with massive contamination</td>
</tr>
<tr>
<td>TYPE IIIC</td>
<td>Open fracture associated with an arterial injury that requires repair, regardless of wound siege or soft tissue injury</td>
</tr>
</tbody>
</table>
INITIAL EVALUATION OF A FRACTURED LIMB

N/V status of the limb

- Distal pulses
- Capillary refill
- Skin temperature
- Edema
- Sensitivity
- Motricity
- Pain
FOOT SENSITIVITY EVALUATION

LOWER LIMB
4 NERVES
4 COMPARTMENTS

DEEP PERONEAL: 1° WEB SPACE
(anterior compartment)

SUPERFICIAL PERONEAL: DORSAL PART OF FOOT
(lateral compartment)

TIBIAL NERVE: PLANTAR ASPECT OF THE FOOT
(deep posterior compartment)

SURAL NERVE: LATERAL ASPECT OF FOOT
(superficial posterior compartment)
FOOT MOTRICITY EVALUATION

Plantar flexion ➔ tibial nerve (posterior compartments)

Dorsiflexion ➔ deep peroneal nerve (anterior compartment)
HAND MOTRICITY EVALUATION

RADIAL N. → WRIST, THUMB EXTENSION

ULNAR N. → LITTLE FINGER ABDUCTION

MEDIAN N. → THUMB OPPOSITION
HAND SENSITIVITY EVALUATION

RADIAL N. → DORSORADIAL HAND, THUMB

ULNAR N. → VOLAR AND DORSUM LITTLE FINGER; ULNAR HALF OR RING FINGER; DORSAL ULNAR ASPECT OF HAND

MEDIAN N. → VOLAR THUMB, INDEX, LONG FINGERS; RADIAL HALF OF RING FINGER; DORSUM INDEX, LONG; RADIAL HALF OF RING FINGER
HAND SENSITIVITY EVALUATION

BLANK: MEDIAN N.  
BLUE : ULNAR N.  
MAROON: RADIAL N.

RIGHT HAND

VOLAR ASPECT

DORSAL ASPECT

M

U

R
X-rays are obtained after patient has been stabilized and all (or potential) life threatening situations have been addressed.

The only views required in major trauma are a lateral of cervical spine, an AP of pelvis and chest.

Limb segments images should be obtained in two orthogonal planes and should include both adjacent joints (to be obtained after secondary survey)
BONE HEALING

Described by swiss authors of AO; requires absolute rigidity with interfragmentary compression, obtainable only with compression plate osteosynthesis; doesn’t occur in nature

Most common mechanism of fracture repair; several stages including the formation of a fibrocartilaginous callus that is later substituted by lamellar bone
TWO ESSENTIAL CONDITIONS FOR BONE HEALING

BLOOD SUPPLY

STABILITY

STABILITY ≠ RIGIDITY
STABILITY + BLOOD SUPPLY = FRACTURE HEALING

EX-FIX

TRACTION

SPLINT/CAST

INTACT PERIOSTIUM

COVERAGE WITH VASCULARIZED ST

ANY COMBINATION IS POSSIBLE BUT YOU NEED AT LEAST ONE FACTOR FROM EACH GROUP
EXTERNAL FIXATION
DON’T LET THE SPARKLING FRAME TURN INTO AN UGLY MONSTER!

KEEP IT SIMPLE!
PRIMARY INDICATION:
MANAGEMENT OF SOFT TISSUE LESIONS associated to a fracture
LIMBS WAR TRAUMA

DCO: damage control orthopedics

EXTERNAL FIXATION

temporary

CASTING

Im nailing

SOFT TISSUE COVERAGE

+++++

Bone grafting

+B/-

Bone union

G IIIb/c

Vascular repair

Growth

Infection

Tactical

Imposed

Definitive

Safe and effective

Used by military at out of theater level of care

Modif. from Mathieu et al.
The three components of a standard monolateral exfix:

- Tube or bar
- Clamp or connector
- Schantz screw or half-pin
EXTERNAL FIXATION

Mechanical axis of bone

Body weight $W$

Bone-pin junction

Bone

Bone pin junction

Pin

Clamp-bar junction

Bar

RIGIDITY OF THE SYSTEM

Rigidity increases if:

- $d$ decreases ($\text{var } d^2$)
- $W$ decreases
- Configuration
- Type of material
SAFE SECTORS OF PIN INSERTION IN LEG

- THE MAIN SECTOR IS ANTERO-MEDIAL
- BEWARE OF INTRACAPSULAR INSERTION
- BEWARE OF POSTERIOR NEURO-VASCULAR BUNDLE
- DON’T GO THROUGH MUSCLE MASSES
- PUT YOU PINS IN HEALTHY SKIN ONLY
EXTERNAL FIXATION

IDEAL ORDER OF PIN PLACEMENT

1
5
3
4
6
2

> 2 CM

> 2 CM
• DOUBLE BAR
• THREE PINS ON EACH SIDE OF THE FRACTURE
• MAXIMUM RIGIDITY
• WEIGHT BEARING IS POSSIBLE
• SOFT TISSUE TREATED WITH SSG
• PINS ANTERO-MEDIAL, HEALTHY SKIN
RIGHT HUMERUS OPEN FRACT.

RESULT AT ONE YEAR
12 YRS OLD GIRL AFTER HIGH ENERGY RTA

Primary survey performed on arrival revealed clear airways and breathing, pelvic hematoma was immediately suspected and fluid resuscitation started.

X-ray taken on OT table, with ongoing resuscitation and preparation of surgical team.
12 YRS OLD GIRL AFTER HIGH ENERGY ROAD TRAFFIC ACCIDENT

PATIENT BROUGHT TO OT WITH A TOWEL WRAPPED AROUND HER HIPS TO AVOID FURTHER “OPENING” AND TO CONTROL INTRA PELVIC HEMATOMA

PELVIC OPEN-BOOK FRACTURE
Rapid positioning of ex-fix allowed reduction and stabilization of pelvic ring

Diastasis <1.5cm
TRACTION AS

A TOOL FOR REDUCTION

TEMPORARY STABILIZATION
(Damage Control Orthopedics)

FULL TREATMENT
(Gallows, Perkins)
TEMPORARY TRACTION AS DAMAGE CONTROL

- INITIAL DBR&IRRIGATION

- TRANS OLECRANON TRACTION IS USED FOR TWO TO THREE WEEKS TO ALLOW COMPLETE SAFE HEALING OF SOFT TISSUES

AVOID INFECTION !!!!
TEMPORARY TRACTION AS DAMAGE CONTROL

- CAST IS APPLIED WITH TRACTION IN SITU
- TRACTION IS REMOVED AFTER CAST COMPLETION
CASTS 
AND 
SPLINTS
INITIALLY, NEVER DO A CIRCULAR CAST!

ALWAYS START WITH A SPLITTED OR BIVALVED CAST

IF IN DOUBT USE SPLINTS OR BACKSLABS
SPLITTED LEG CAST

ALL LAYERS: POP, PADDING AND STOCKINETTE ARE CUT

THE SKIN MUST BE VISIBLE!

THE BIVALVED AND SPLITTED CASTS ARE “CLOSED” AFTER SEVERAL DAYS ACCORDING TO THE SWELLING STATUS OF THE LIMB
BLADE TANGENT TO LIMB SURFACE !!

90° POSITION

SPLITTED CAST:
SKIN IS VISIBLE ON ENTIRE LENGTH
SPECIAL ASPECTS

- COMPARTMENT SYNDROME AND FASCIOCTOMY
- VASCULAR REPAIR
- BONE GRAFT
- FLAPS AND SKIN GRAFTS
- AMPUTATIONS
1: make a short vertical incision to positively identify the intermuscular septum.

2 and 3: make two full length parallel incisions at the anterior and posterior extremities of the vertical incision.
Soleus must be divided from posterior edge of tibia (yellow dotted line) to open the fascia of deep posterior compartment.
Graft harvesting is done after exact amount or length needed has been established at fracture site.

Incision of all planes is done in line, midway between the two fingers grasping the iliac crest, down to periostium and bone.
The iliac crest is freed on both sides with periosteal elevators: always maintain bone contact.

Two transverse bone cuts are made with straight osteotomes (yellow dotted line).
Longitudinal bone cuts are made with a curved osteotome and the cortical frag is removed.

SPONGIOSA IS HARVESTED WITH A CURETTE OR A GOUGE. HARVESTING CAN BE DONE ANTERIORLY AND POSTERIORLY TO THE TRANSVERSE BONE CUTS.
THE CROSS-LEG TECHNIQUE

Distal ⅓ open fracture of right leg stabilized with exfix. Bone graft from iliac crest before coverage with saphenous art. fascio-cutaneous flap from contra-lateral leg (cross-leg flap)

Important soft tissue loss with exposure of fracture site
THE CROSS-LEG TECHNIQUE

Aspect of cross-leg flap coverage at weaning time, three weeks after inset. The crossover bars ensures the pedicle stays slightly distended and avoids kinking.
Clinical example of the use of gastrocnemius and soleus rotation flaps

Shell injury in young boy with comminuted open fracture of left tibia with vast exposure of proximal medial half of leg. Situation 5 days after initial debridement with no clinical signs of infection (note that wound has been left open)
At 5 days post trauma, an hemi-gastrocnemius and hemi-soleus rotation flaps are raised and used to cover the exposed bone. The proximal and distal skin edges are approximated with a “roman lace” technique with a vessel loop, to avoid “dead spaces” and the formation of hematoma or seroma.
Granulation at 12 days
SSG at 21 days
At 31 days
At 43 days post-trauma

Granulation at 12 days
SSG at 21 days
At 31 days

Full ROM and painless weight-bearing
Will need rehabilitation for proprioception
THE RATIO OF FLAP LENGTH (BLUE) RESPECT TO FLAP BASE (GREEN) SHOULD NOT EXCEED 2:1
At weaning time the donor site is covered with an SSG.
SPLIT THICKNESS SKIN GRAFT
THANK YOU