Limb Salvage in War Injury

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War is a surgeon's best training ground
Hippocrates (460-377 BC)

History

- Roman Empire
  - Military Hospitals at proximity
- Ambroise Parre 1510-1590:
  - Techniques for fracture reduction
- Spanish army of Flanders (Late 1500s)
  - First permanent military medical hospital
- John Hunter (Scottish surgeon Mid-1700s)
  - the benefits of delayed closure of war wounds

Ambroise Paré

History

- Dominic Jean Larrey (French surgeon)
  - transport of war wounded to a nearby facility via a vehicle (flying ambulances)
  - Early amputation to reduce morbidity and mortality as well as the suffering
  - 200 amputations in one day in 1812 (Borodino battle).

History

- Crimean War (1854-1856): chloroform as anesthetic
- In 1867: Joseph Lister reported a significant improvement in wound care for compound fractures with the use of carbolic acid
- Serbian-Turkish War : Carl Reyher (a Russian surgeon)
  - promoted a more aggressive wound exploration, with an extensive mechanical cleansing, which he termed "debridement"
  - This technique eventually replaced amputation for the prevention of infection, gangrene, and death in World War I

Carl Reyher (1846-1890), great Russian military surgeon: His demonstration of the role of debridement in gunshot wounds and fractures. Surgery. 1973 Nov;74(5):641-9.

History

- World War I
  - Debridement and delayed wound closure replaced early amputation in nearly all compound fractures

Miller MG; The Early Treatment of Projectile Wounds by Excision of Damaged Tissues"; BMJ., 26th June 1915.

History

- World War II
  - Alexander Fleming: Discovery of penicillin
  - Pedicle flaps
  - Osteomyelitis treatment

History

- Korean War:
  - Michael DeBakey improved vascular injuries repair techniques
  - Helicopters transfer

- Aminoglycosides

History

- Vietnam War:
  - The concept of "damage control surgery" was popularized
  - External fixator was widely used
  - Significant improvements in rapid evacuation of casualties were achieved
- Amputation rates have remained stable around 14% since

Epidemiology

- Musculoskeletal injuries represent approximately 70% of all war wounds
- Very low mortality rate when isolated but significant morbidity
- The ratio lower limb/upper limb is approximately 3/2 and more than 50% of extremity fractures are open

Epidemiology

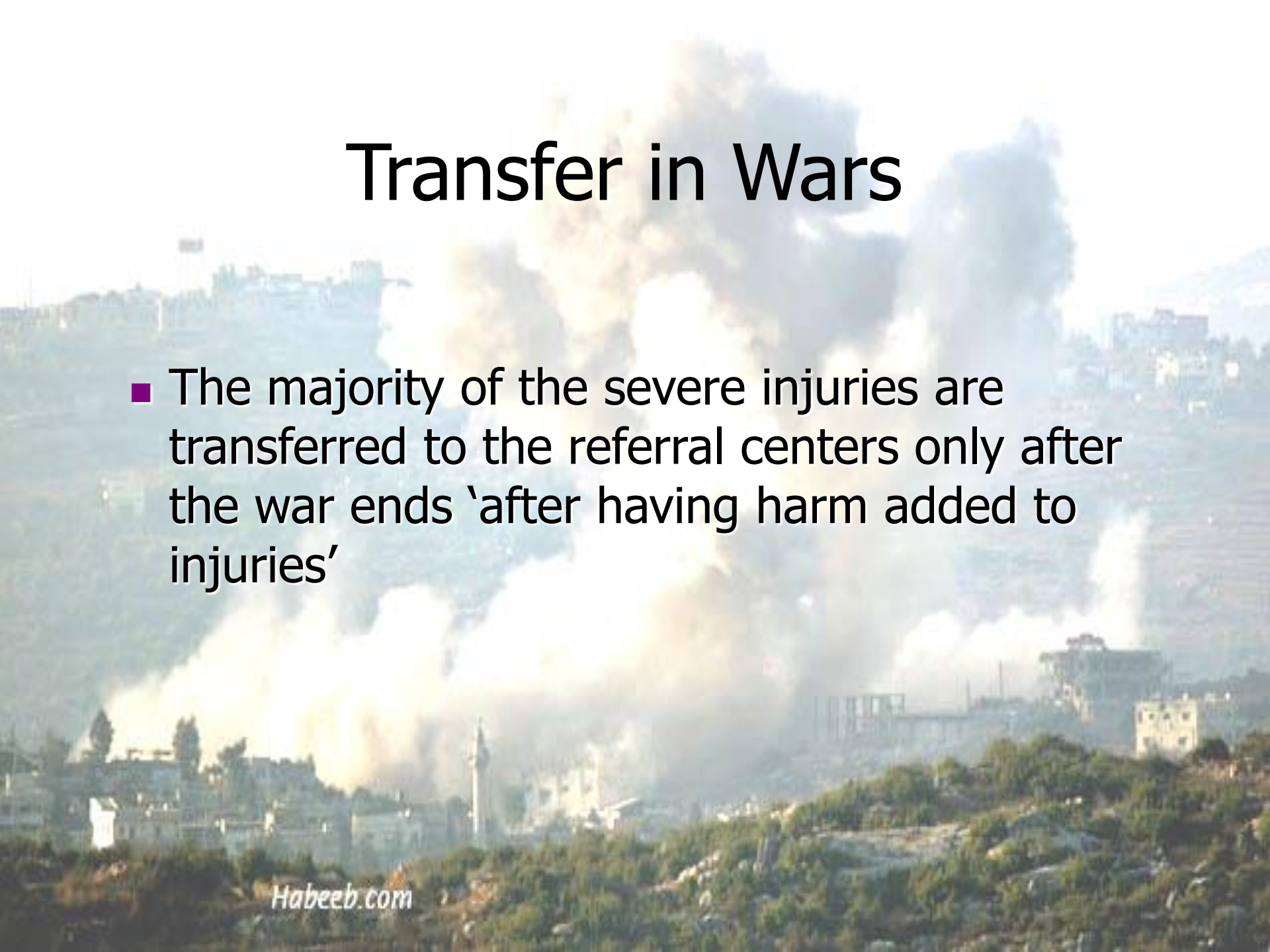
- Bullets have been the main cause of penetrating injury to the limbs
- In recent conflicts, this has been replaced by fragmenting weapons
- Blast injuries are in general dirtier than gunshot wounds
- Landmines present a particular problem
  - a threat to civilian populations for years after.

Transfer in Wars

- Local Hospitals / Field Hospitals
- Central Hospitals
- Referral Centers

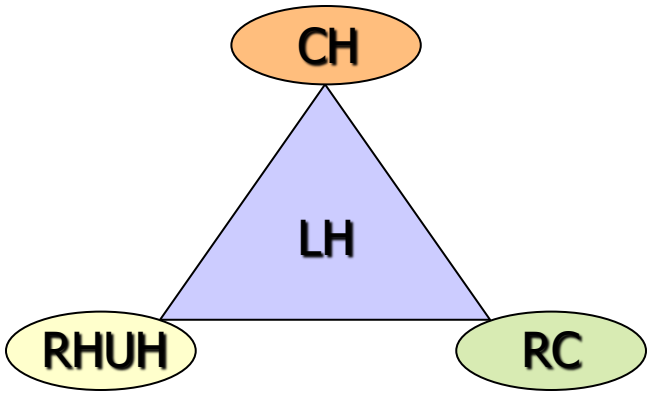
Transfer in Wars

- The majority of the severe injuries are transferred to the referral centers only after the war ends ‘after having harm added to injuries’



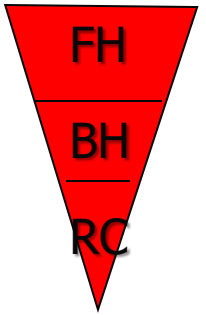
July 06 War

- Transfer was independent from patients conditions
- Transfer was related to the transient cease fires and temporary safe corridors



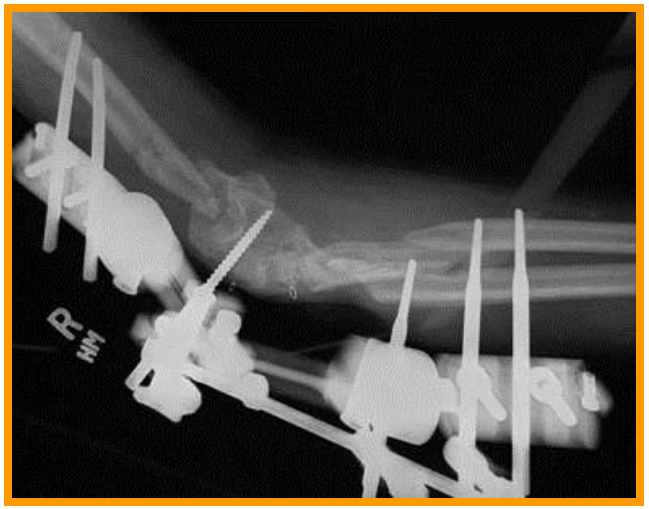
Syrian War

- Transfer is usually late
- Transfer is related to the border situation
- Transfer usually follows the scheme
  - Financial limitations
  - Logistic / Political limitations
- Most patients presented with postop complications

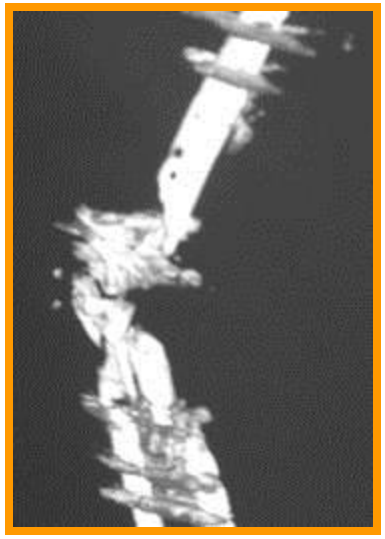


The Morbid Chain

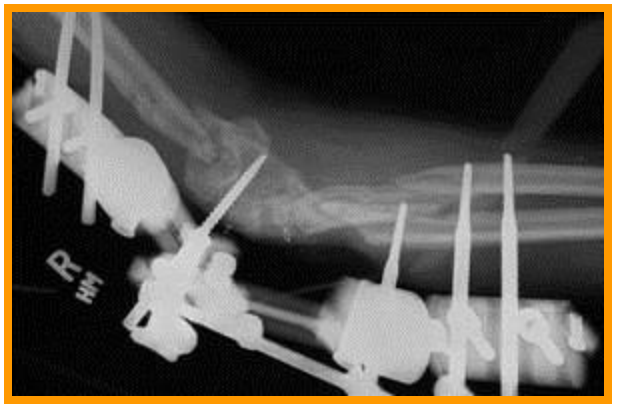
- Shattered Elbow
- Multiple Surgeries (10x)
- Infection
- Inadequate Coverage
- Inadequate Fixation



The Morbid Chain



Fused Elbow
Mobile Fixation



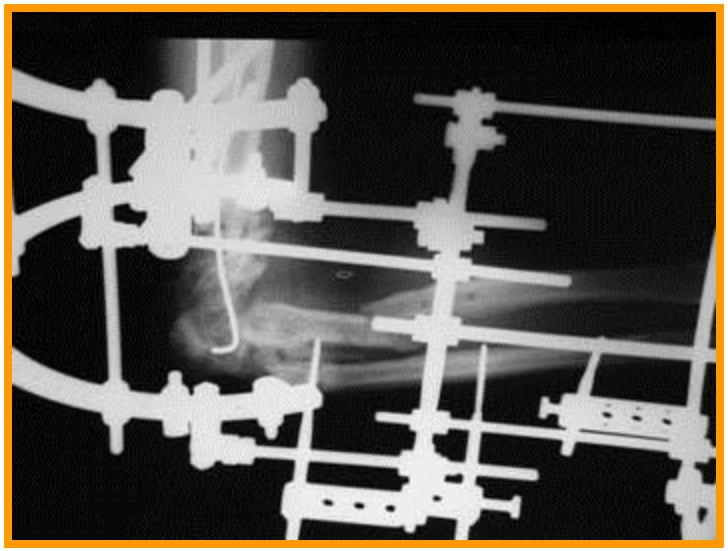
9000$ EF

Flaps

Osteomyelitis

The Morbid Chain

- 4 surgeries
- 14 months of treatment
- Healing
- No infection



Mangled Extremity

- What to do?

Open fracture

- Stabilization of the patient
- One look in ER
- Debridement, irrigation > 10 l
- Culture
- Coverage
- IV antibiotics
- Splinting

War Open Fracture

- War wounds are different
- Often worse than they appear
- Bad Additions:
  - High-energy projectiles
  - Deep penetration of foreign material
  - Dirty field conditions
  - Delayed evacuation
  - Ill-advised initial treatment such as prolonged use of tourniquet or primary wound closure

Mass Injury

- Selection :
  - Time should not be wasted on those who have a very poor survival prognosis
  - Priorities need to be established rapidly and decisively, and surgery performed quickly and efficiently
  - Low threshold for primary amputation

Indications for Primary Amputation

- 1. When the limb is nonviable
- 2. When, even after revascularization, the limb is so severely damaged in whole or in part that function is less satisfactory than that afforded by a prosthesis
- 3. In severely injured limbs in the presence of severe, debilitating, chronic disease where preservation of the limb is a threat to the patient's life

Indications for Primary Amputation

- 4. In a patient with severe, multisystem injuries, in whom salvage of a marginal extremity may induce pulmonary or multiple organ failure and lead to death

- 5. A MESS score > 7

Mangled Extremity Severity Score (MESS)

A.	**Skeletal/soft-tissue injury**	
	Low energy (stab, simple fracture, low velocity gunshot wound)	1
	Medium energy (open or multiple fractures, dislocation)	2
	High energy (close range shotgun, high velocity gunshot, crush)	3
	Very high energy (above + gross contamination, soft-tissue avulsion)	4
B.	**Limb ischemia**	
	Pulse reduced or absent but perfusion normal	1*
	Pulseless, paresthesias, diminished capillary refill	2*
	Cool, paralyzed, insensate, numb	3*
C.	**Shock**	
	Systolic blood pressure always >90 mm Hg	0
	Hypotensive transiently	1
	Persistent hypotension	2
D.	**Age (Years)**	
	<30	0
	30-50	1
	>50	2

* Score doubles for ischemia >6 hours.

The Delusion

Below Knee Amputee do well

Not so well

- Multicenter, prospective study
- 569 patients with severe leg injuries resulting in reconstruction or amputation
- Sickness Impact Profile, a multidimensional measure of self-reported health status

- BOSSE et al, N Engl J Med, 347,2002; *AN ANALYSIS OF OUTCOMES OF RECONSTRUCTION OR AMPUTATION OF LEG-THREATENING INJURIES*

As bad as in reconstruction

- At two years, there was no significant difference in scores
  - Similar functional outcomes
  - Similar proportions of patients who had returned to work by two years
  - Patients who underwent reconstruction were more likely to be rehospitalized than those who underwent amputation (47.6 percent vs. 33.9 percent, P=0.002).

And….

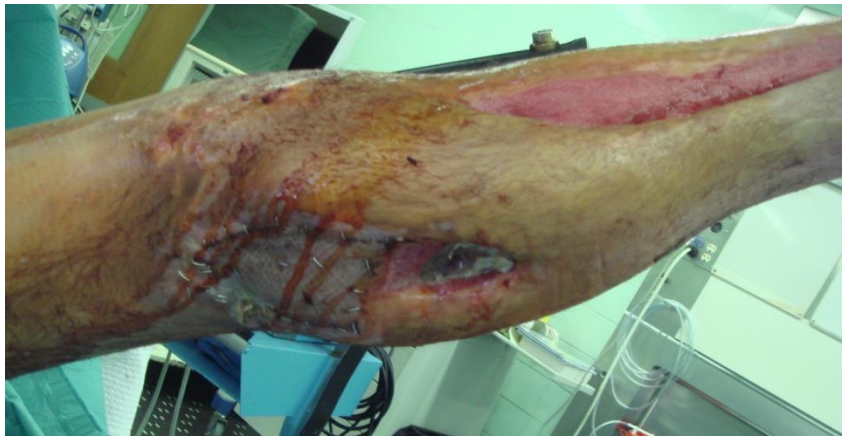
- Lower-extremity injury-severity scores at or above the amputation threshold should be cautiously used by a surgeon who must decide the fate of a lower extremity with a high-energy injury.

Bosse et al, JBJS VOLUME 83-A, 2001; A Prospective Evaluation of the Clinical Utility of the Lower-Extremity Injury-Severity Scores

And do not forget

- Patients overwhelmingly prefer their salvaged leg to an amputation

Salvage after Severe Lower-Extremity Trauma: Are the Outcomes Worth the Means?
Dagum et al, Plast Reconstr Surg. 1999 Apr;103(4):1212-20 .



Reperfusion injury
No function
2 months in hospital
100000$ bill
Equinus distraction

Management Principles

- Most limbs can be salvaged
- The orthopaedic management of fractures is second in importance only to sound wound management

Mangled Extremity

- What to do?

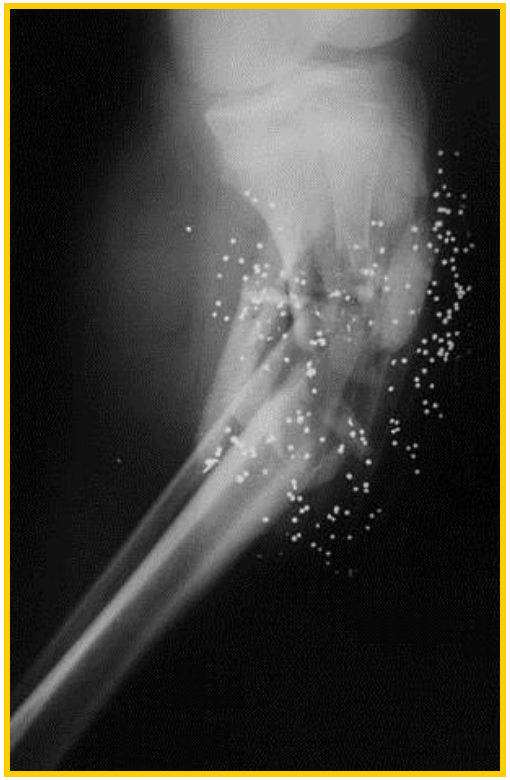
DON'Ts

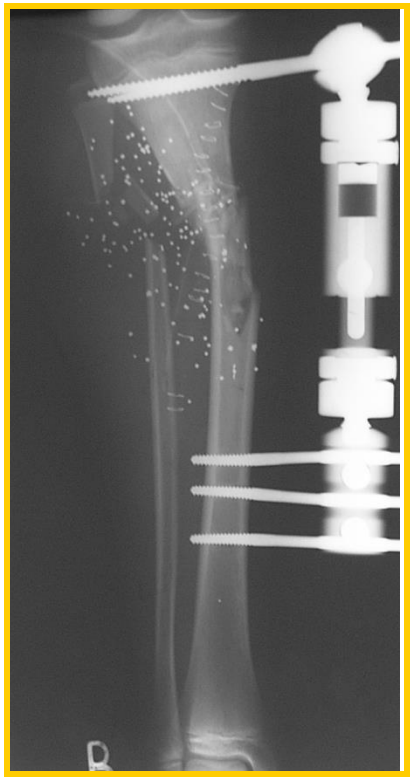
- Exploration of arterial injury in ER
- Circular cast
- Wound closure
- Internal fixation in OR

Primary Wound Closure

Secondary infection

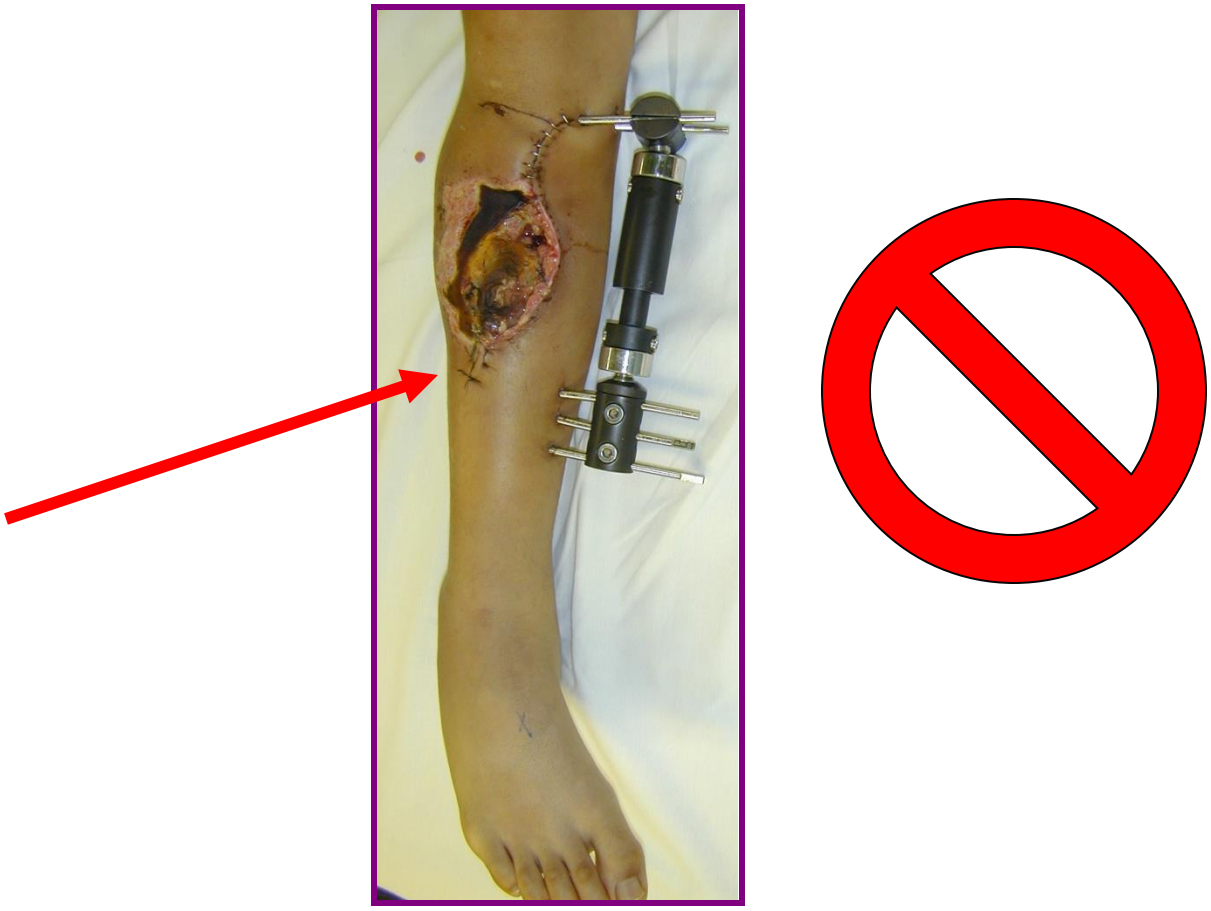
Gunshot Injury





Compound Comminuted Fracture

Gunshot Injury



Deep Infection

Gunshot Injury

Primary Closure

- 1. The original wound must have been fairly clean and not have occurred in a highly contaminated environment.
- 2. All necrotic tissue and foreign material have been removed.
- 3. Circulation to the limb is essentially normal.
- 4. Nerve supply to the limb is intact.
- 5. Closure will not create a dead space.
- 6. The wound can be closed without tension.

Primary Closure

Gaz gangrene

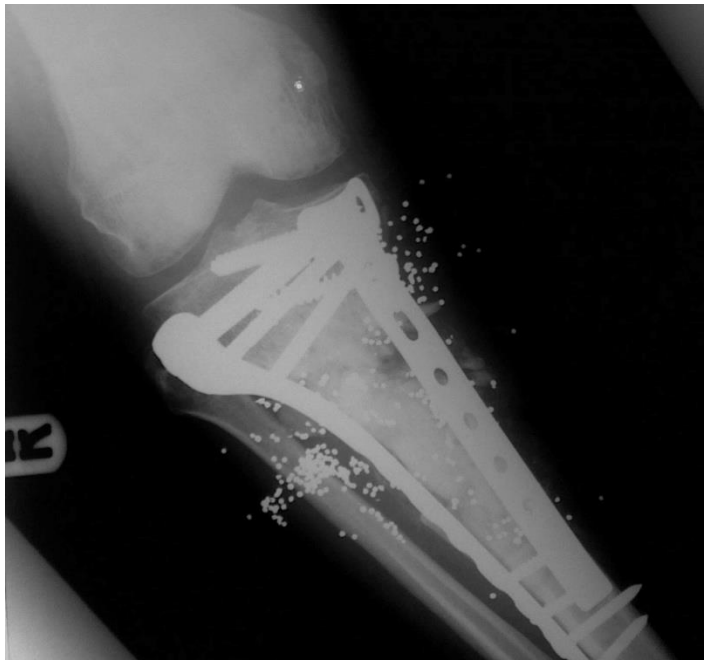
- Type I
- Type II +/-
- Never type III
- "When in doubt, leave it open,"
- “In war injury, leave all open fractures open."

Secondary Closure

- A. Delayed primary closure by suture
- B. Delayed autogenous skin graft or local or microvascularized flap
- C. Healing by secondary intention

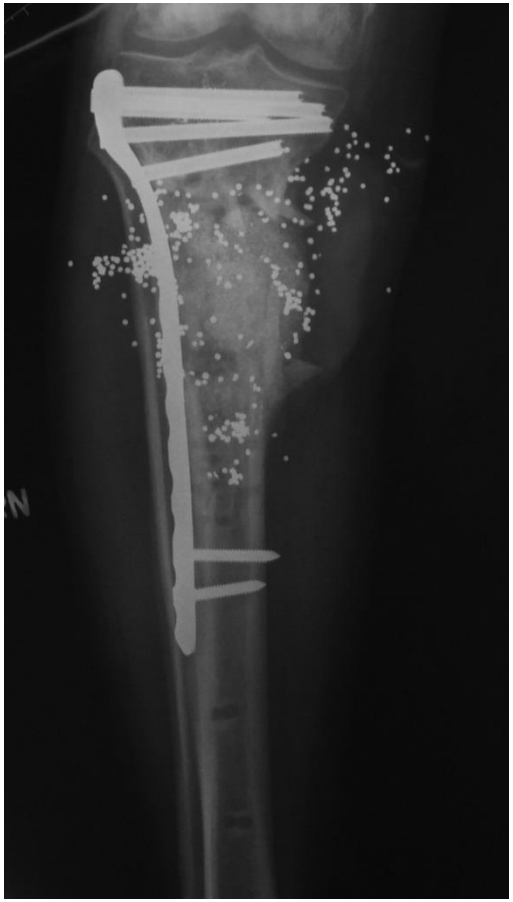
Internal fixation

- Gunshot injury
- Type 2
- ORIF
- Infection

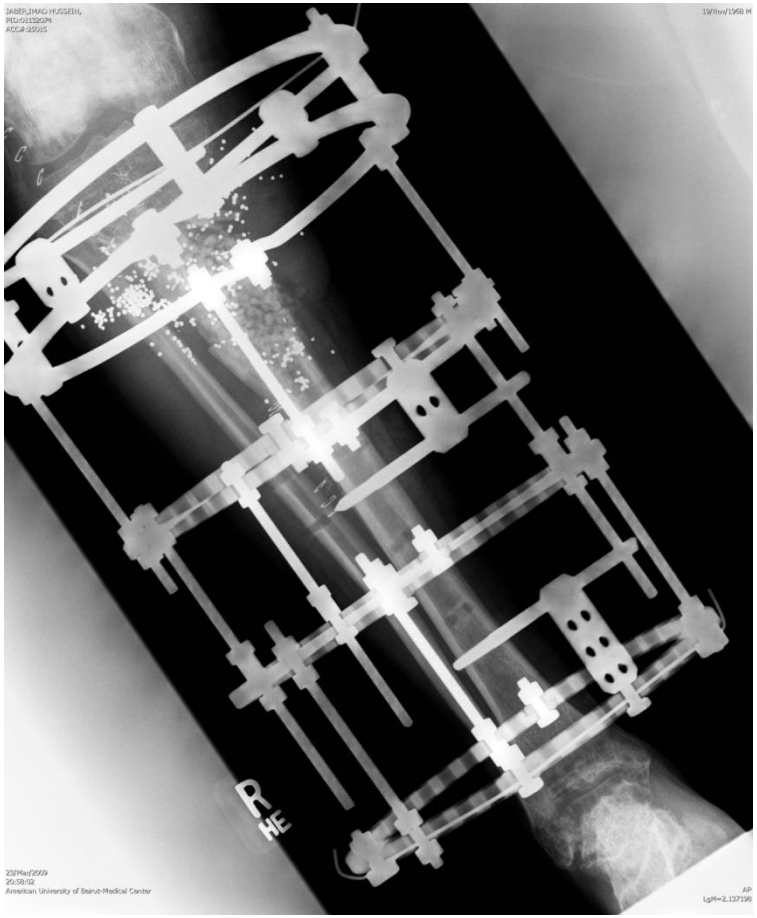


Internal fixation

- Removal medial plate
- Debridement
- Cement
- Antibiotics



Internal fixation



Healed. Knee motion 0-115’

What to Do?

- Guidelines?
- Protocol?

University of Southern California Protocol for the Management of Type III Fractures

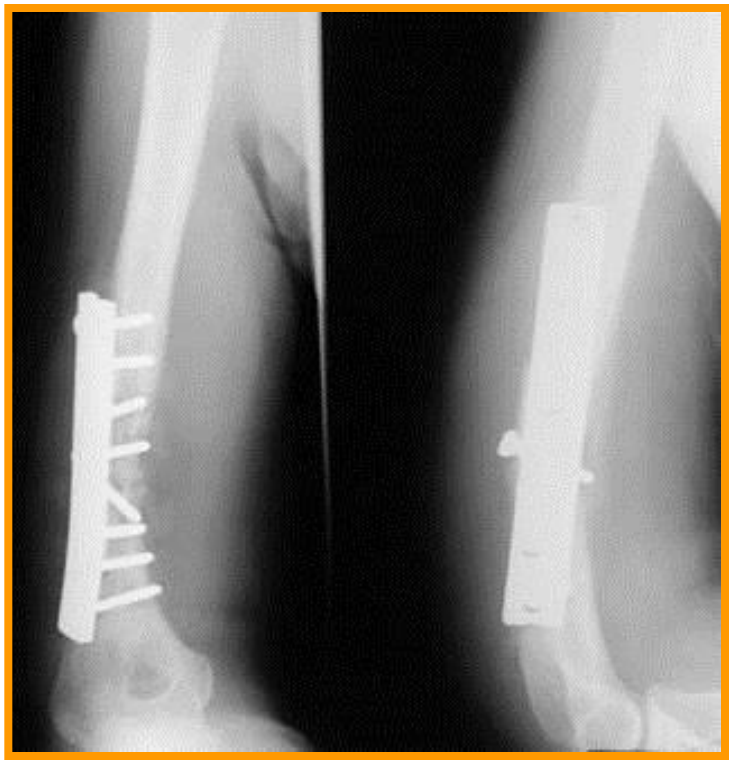
- Stabilization of patient
- Tetanus prophylaxis
- Broad-spectrum antibiotics
- Fracture reduction with external fixation
- Radical débridement of all injured tissues
- Redébridement at 24–48–72 hours, if necessary
- Early muscle flap wound coverage before 5 days, if possible
- Bone grafting at 6 weeks

Literature

- Mostly about the US wars
- Third world countries?

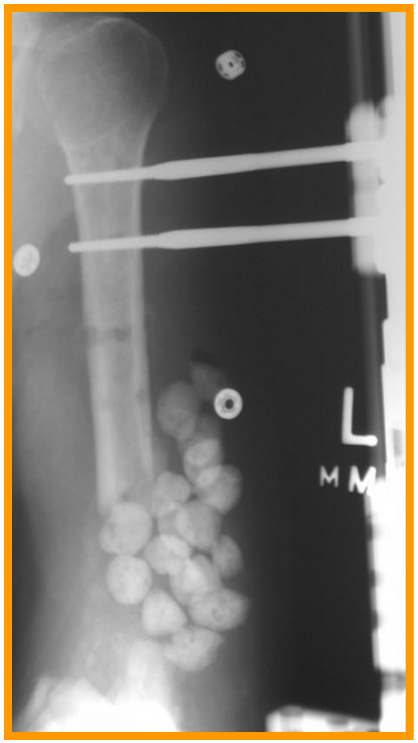
Complications

Infected Non Union



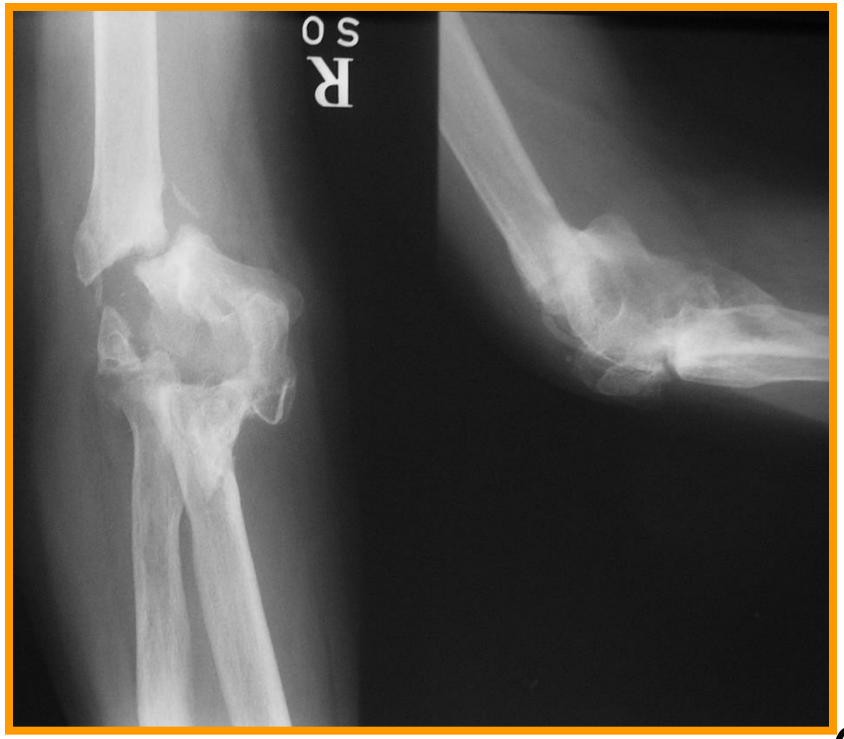
Osteomyelitis

Infected Non Union



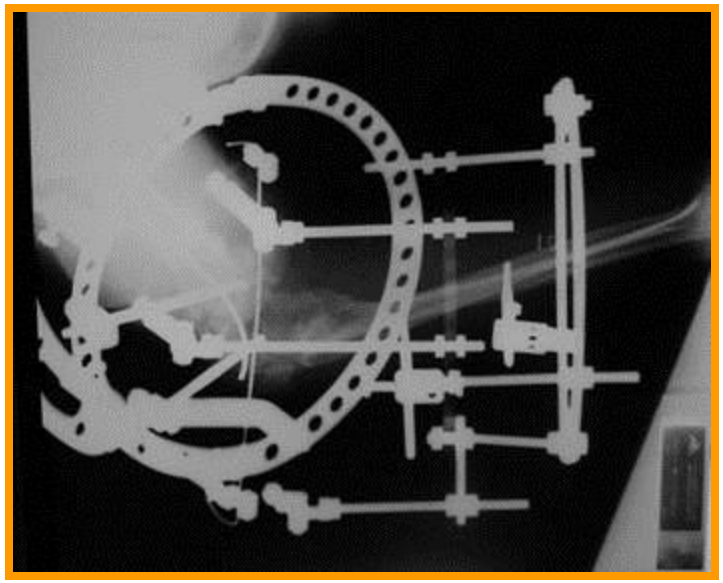
Infected Non Union

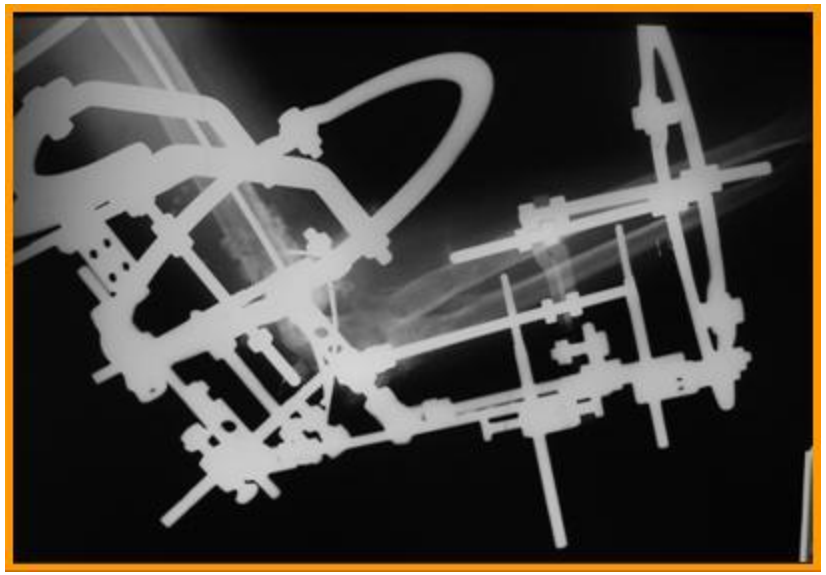
Loss of Joint Motion



Open Fx
Infection

Loss of Joint Motion





Debridement
Fusion
Rotational Flap

Inadequate ST Coverage

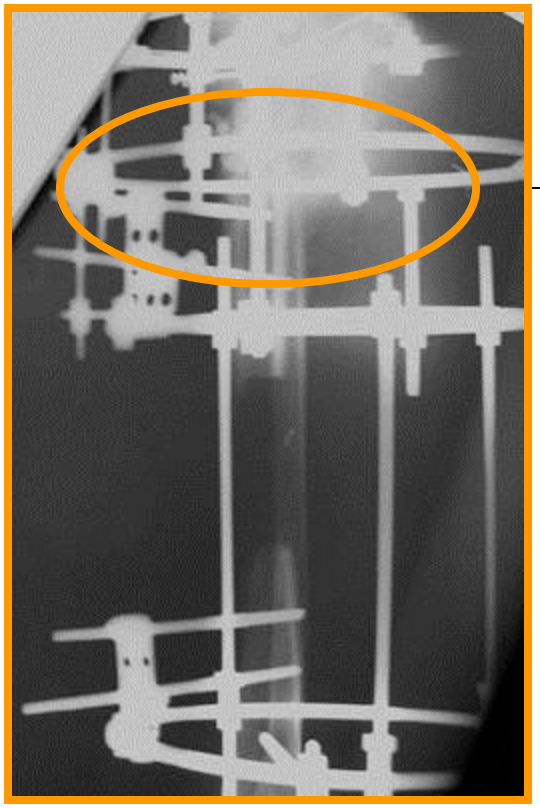
Landmine injury
Bone, ST, neurovascular

Shattered proximal tibia

Inadequate ST Coverage

Acute Shortening

Lengthening



Bone reconstruction

Cement pellets^ ABx
Scaffold for skin to grow

Soft tissue coverage:
Soleus, STSG

Inadequate ST Coverage

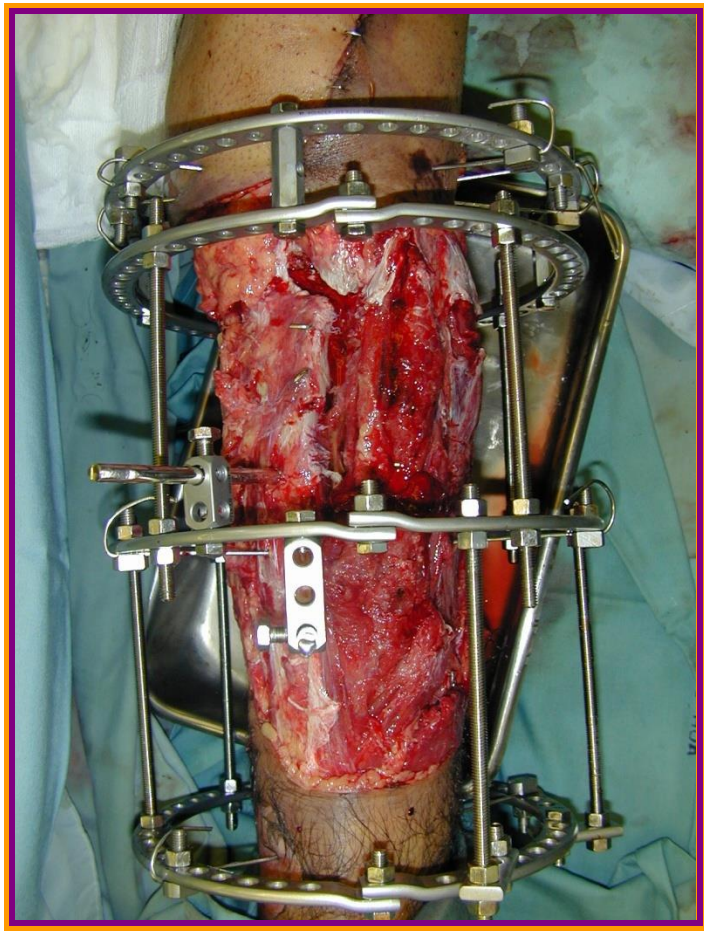
- Cement removed
- Bone graft
- Healing of bone & ST

Inadequate ST Coverage

Healing in 1 year

Loss of ST Coverage

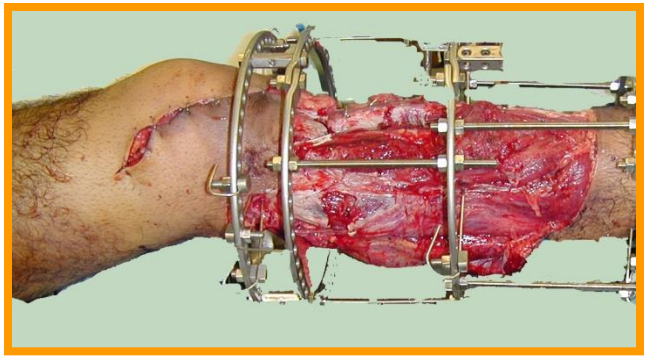
Loss of ST Coverage



Skin Necrosis and Osteomyelitis

Loss of ST Coverage

- Failed Free Flap
- Rotational Flap / STSG: Partial coverage



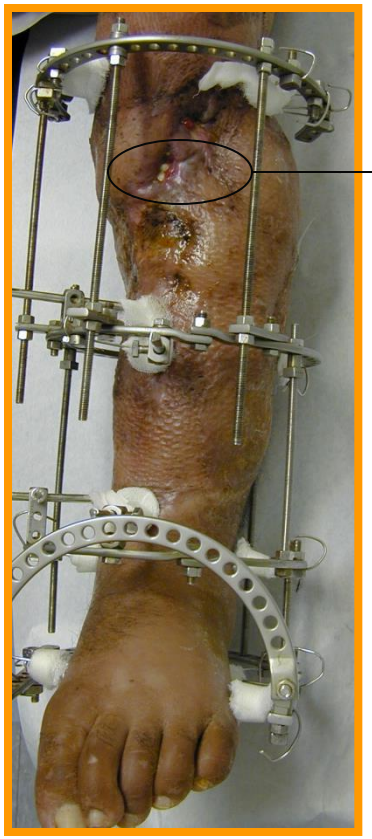
Loss of ST Coverage

Acute Shortening

Cement mantle

Loss of ST Coverage

Gradual Lengthening



Remove cement
Bone graft

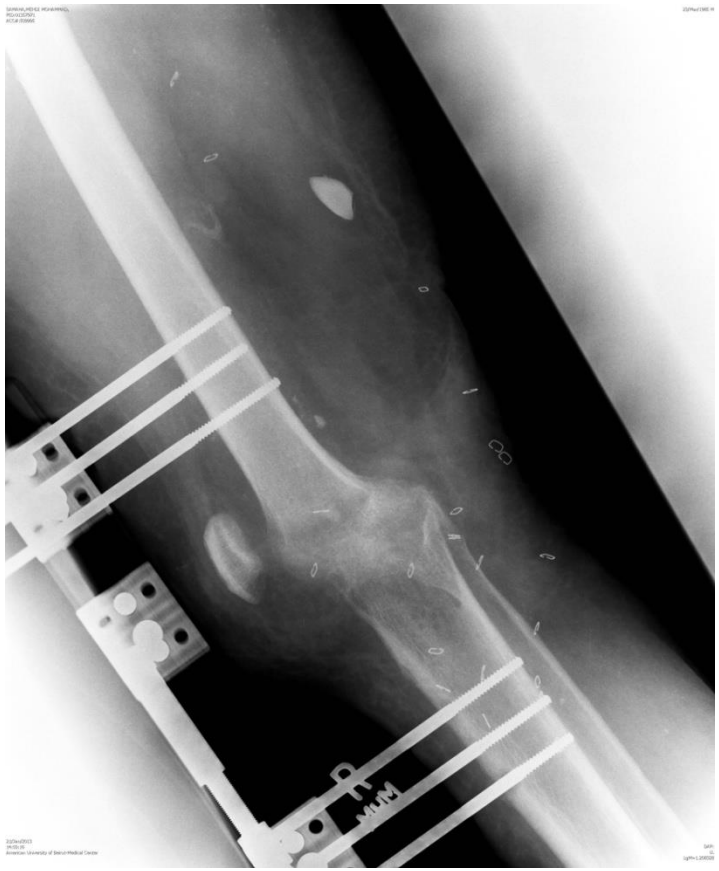
Healing of ST

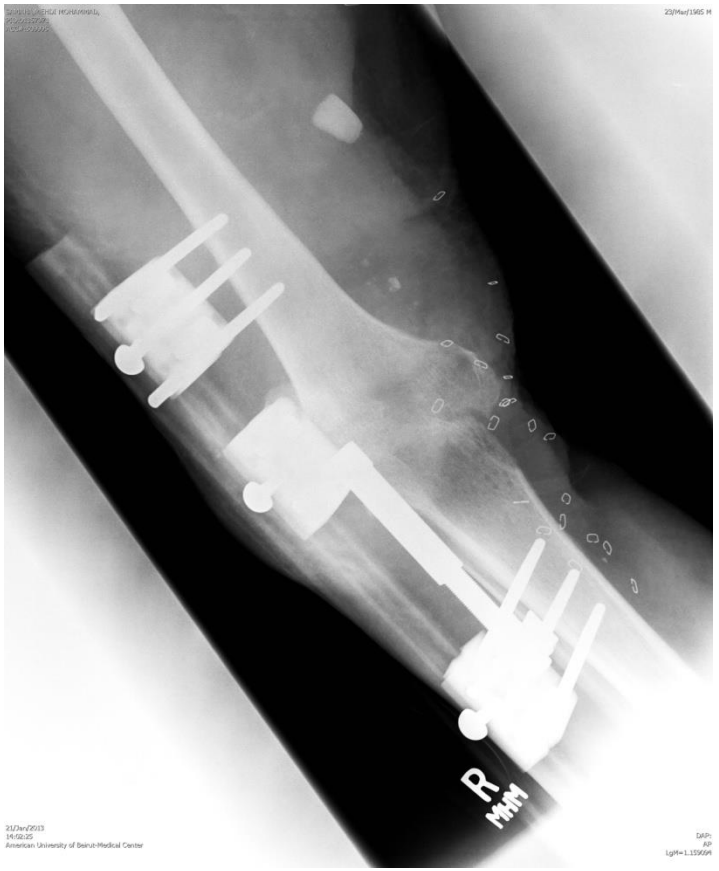
Loss of ST Coverage

Healed

Loss of ST Coverage / joint

Loss of ST Coverage / joint





Open Wound

One Vessel

7 cm bone loss

Open Wound

- Free Flap

- Alternatives??????????
  - Local flap X
  - Acute Shortening X
  - Bone Graft X

Open Wound

Debridement

Lengthening

Shortening

Bifocal Treatment

Open Wound

Delayed Closure / Bone Graft

Open Wound

12 cm of new bone formation
Soft tissue closure
Only STSG

Beyond Salvage

- AKA Rt
- Femur fracture Lt
- Infected BK stump / ST loss

Beyond Salvage

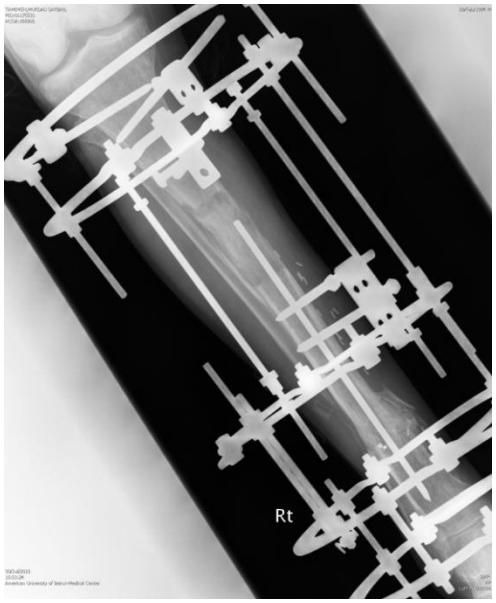
- ORIF femur
- Free Flap
- = BKA

Beyond Salvage

Lengthening of the stump in the future

Patient Outcome

- I'm so grateful and so happy.
  You did a great job and thanks for your kindness and i will never forget you.
  I'm unable to express my feelings to you.
  I will pray for you what you have done to me.



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