

Initial managements In Open Fx



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Cultures in the Emergency Room

-Studies:

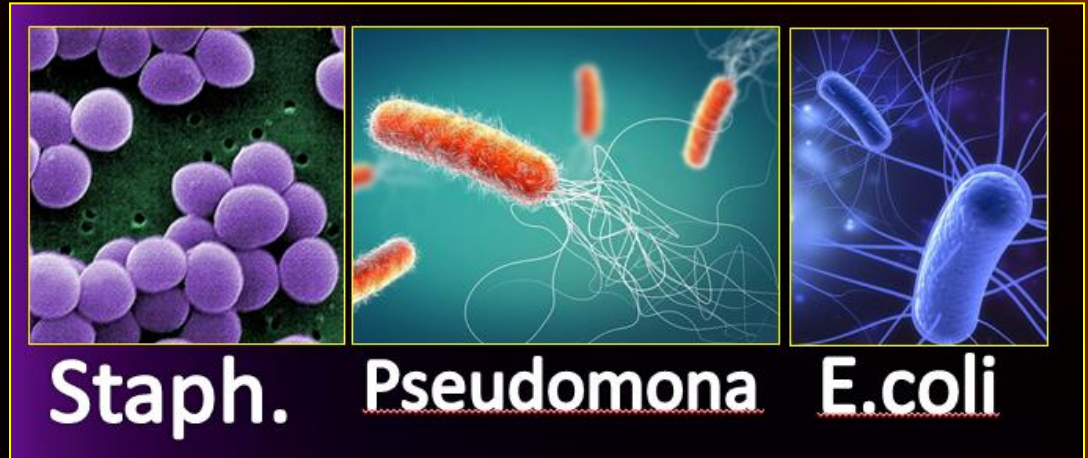
poor correlation between **positive cultures** and subsequent rate of **infection**.



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-The commonly isolated organisms are

Staph. aureus,
Pseudomonas,
E.coli.



- frequently due to **hospital contamination**
and are never isolated from the environment
where the accidents occur!!!



- AB should be **therapeutic and not prophylactic!**
- and as early as possible!
- In the absence of organic/sewage contamination
- IV 1st / 2nd-G cephalosporins.

- Gustilo 3 ---→ **Aminoglycoside** is added

- Gross organic contamination ---→

Penicillin+/- metronidazole.



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- most of the infections are **hospital acquired** → choose antibiotics based on the background of the common bacterial flora of the institution.
- main organisms → ***S. aureus* & MRSA**
- **developing countries** → ↑↑ **gram-negative**
(regular addition of **aminoglycosides**)

Tetanus status?

	Clean or minor wound	Dirty or large wound
fully immunized (≥ 3 tetanus toxoid doses)	<ul style="list-style-type: none">• Tetanus toxoid containing vaccine if last dose ≥ 10 years ago• No Tetanus Immunoglobulin	<ul style="list-style-type: none">• Tetanus toxoid containing vaccine if last dose ≥ 5 years ago• No Tetanus Immunoglobulin
Not immunized, unknown vaccination status or ≤ 3 tetanus toxoid doses	<ul style="list-style-type: none">• Tetanus toxoid containing vaccine• No Tetanus Immunoglobulin	<ul style="list-style-type: none">• Tetanus toxoid containing vaccine + • Tetanus Immunoglobulin

- ↑↑ **kidney injury**: aminoglycoside usage in pts with **diabetes**, increased use of **iodine contrast**, prolonged hypotension and other nephrotoxins.
- In such situations, a **high mortality rate of up to 44%** is reported.



Avoid the overuse of antibiotics !

- 1- Prolonged and continuous AB
- 2- as long as the drains are in
- 3- until wound drainage is present
- 4- to prevent pin-tract infections
- 5- as a substitute for debridement!

Comparison of EAST and SIS Recommendations for Antibiotic Prophylaxis According to the Gustilo-Anderson Open Fracture Type*

Gustilo-Anderson Type	Infection Rate	EAST ⁸ (2011)	SIS ¹⁰ (2006)
I	0%-9%	Gram-positive coverage (e.g., cefazolin)	Gram-positive coverage (e.g., cefazolin)
II	1%-12%	Gram-positive coverage (e.g., cefazolin)	Gram-positive coverage (e.g., cefazolin)
III	9%-55%	Gram-positive coverage (e.g., cefazolin) + gram-negative coverage	Gram-positive coverage (e.g., cefazolin)

*EAST = Eastern Association for the Surgery of Trauma, and SIS = Surgical Infection Society.

JBJS 2020

IV Antibiotic Therapy Recommendations 2017 Open Fx

Type

Gustilo 1

- 1stG cephalosporin (**cefazolin**)

Gustilo 2

- **clindamycin** (β -lactam allergy)

Gustilo 3

Cefazolin/clinda. + AG (**genta.**)
-Alternatives: **3rdG** cephalosp.
(**ceftriaxone/piperacillin/tazobactam**)

**Fecal or potential
clostridial contamination**

Consider addition of **penicillin**
(cefazolin/gentamicin)

Orthop Clin North Am. **2017**

Role of systemic and local antibiotics in the treatment of open fxs.

Carver DC, Kuehn SB, Weinlein JC.

- ⇒ A case control study (Dunkel et al.):
- compared 1 day of AB Rx with 2-3 days, 4-5 days, and >5 days
 - did not show ↑↑ infection
 - infection in open fxs is related to the **extent of tissue damage** but not to the duration of prophylactic therapy.

- ⇒ A RCT by (Dellinger et al.):
- compared a 1day Vs 5day course of postop. ABs in 248 pts with **open injuries**
 - no reduction in infection rates related to the longer (5day) course of ABs.

CURRENT CONCEPTS REVIEW

Gram-Negative Antibiotic Coverage in Gustilo-Anderson Type-III Open Fractures

JBJS 2020

Grades of Recommendation	Grade*
Cefazolin monotherapy for open fracture prophylaxis (types I, II, and III)	B
24-hr duration of antibiotic prophylaxis (types I, II, and III)	B
24 to 72-hr duration of antibiotic prophylaxis (type III)	C

CURRENT CONCEPTS REVIEW

Gram-Negative Antibiotic Coverage in Gustilo-Anderson Type-III Open Fractures

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Grades of Recommendation	Grade*
Routine use of EGN antibiotic <small>extended gram-negative</small> coverage for type-III open fractures	?
Routine use of ceftriaxone for type-III open fractures	?
Routine use of piperacillin-tazobactam for type-III open fractures	?

Local ABs

- Delivery of **high concentrations** of ABs without significant risk of systemic toxicity.
- High concentrations of (local) ABs is **effective against biofilms!**



- ⇒ Retrospective study (Ostermann et al.):
- adjuvant use of local **AB-laden PMMA beads** may ↓ **infection** in severe open fxs.
 - local + systemic ABs: infection rate (**3.7%**)
Vs (only systemic AB: **12%**)

RESEARCH ARTICLE

Open Access

Low post-arthroplasty infection rate is possible in developing countries: long-term experience of local vancomycin use in Iran



Mohammad Naghi Tahmasebi¹, Arash Sharafat Vaziri² , Fardis Vosoughi² , Mohamad Tahami^{3,4} ,
Majid Khalilizad^{2,5*}  and Hamid Rabie⁶ 



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Lavage

- ⇒ **solution for pollution is dilution.**
- Typically **> 9 L** of fluid is required in type **IIIB**.
- Current evidence → **normal saline**
(routinely)

~~hydrogen peroxide,
alcohol solution,
povidone iodine,
Liquid(Castile) soap
may impair osteoblast function,
inhibit wound healing,
cartilage damage.~~

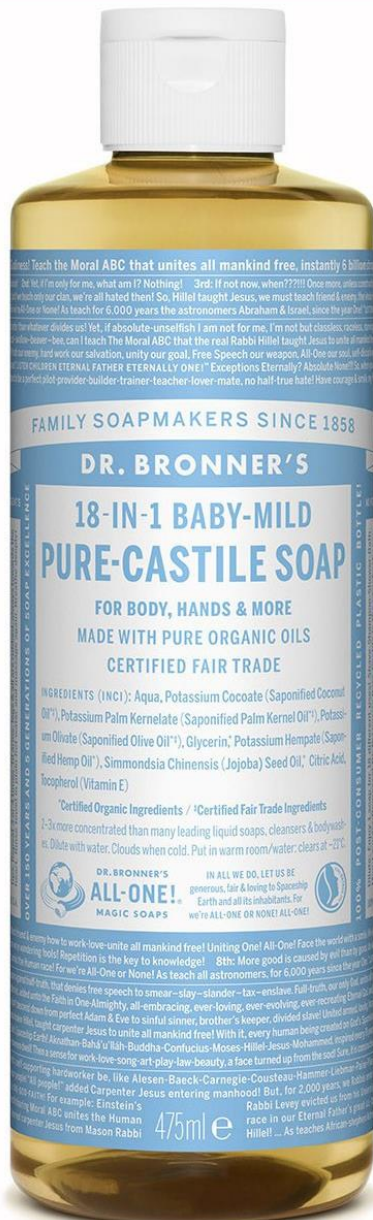
major benefit of irrigation with a castile soap solution?

Decreased rate of primary
wound healing problems !



nonsterile liquid
soap additive
(castile soap)

is at least as effective
as the use of **bacitracin**
, regards to the rate of
postop. infection
and fx healing, and
shows a significant
decrease in problems
with **soft-tissue healing**



Irrigation solutions

- 1- surfactants
- 2- Antibiotics
- 3- Antiseptics



Surfactants:

- 1- Castile soap
- 2- Benzalkonium

Surfactants: facilitate the removal of bacteria from wounds by chemically disrupting bacterial adherence

- Bhandari et al: osteoblast and osteoclast activity, that **soap** was the only nondetrimental surfactant to bone-producing cell lines compared with ethanol, povidoneiodine, chlorhexidine gluconate, and bacitracin

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~~- High-pressure lavage has no advantage!~~



-Disadvantage: **damaging tissues such as periosteum and tendon sheaths** and it may also **push dirt and debris deeper** into the tissues.

- **low-pressure lavage** with normal saline is preferred!

Fixation

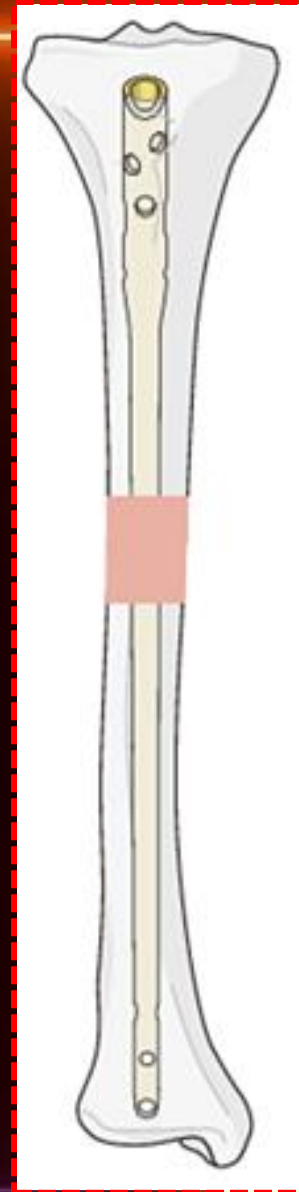
- In high-energy injuries with contamination, our preference: temporary external fixator followed by later secondary ORIF.
- where there is a good soft tissue envelope as in upper limb and femoral fxs or soft tissue cover could be achieved within 48-72 hours, primary internal fixation can be considered.

plate or nailing?

-As a **general rule**: plate is preferable for **all UL open Fxs** and **periarticular injuries** \pm articular surface involvement.



-Lower limb diaphyseal fxs are usually treated by IM nailing .



External Fixation

- Unilateral frames: is the **workhorse** for stabilization in open fxs.
- Ring fixators: mainly in **juxta-articular** fxs with soft tissue injury and in **bone loss**.

⇒ When ext. fix. for a long period:
predrilling → ↓ thermal necrosis (↓ pin
loosening and infection.)

-Pins should be placed through intact
soft tissues!

- In fxs with **articular surface involvement** (especially around the knee & elbow): joint congruity must be achieved on **day 1** with internal fixation as late reconstruction of the joint surface is often not possible.

conversion of Ext.Fix. to Int.Fix.

-If **flap** is performed:
conversion has to be postponed to
accommodate the flap settling time
(between 3-4 weeks)

- Meta-analysis: conversion to IMN in tibial & femoral open fx's within 28 days (4w) → ↓infection (3.7% Vs 22%).

-In late conversions: interval of **10-14 days** between removal and internal fixation.

Plate fixation

⇒ The method of choice in:

- 1- most open upper limb fxs,
- 2- all intra-articular and juxta-articular fxs,
- 3- open injuries with vascular involvement.

- Critical factor in plating ---> **wound cover within 3 days.**

-Locking plates provide greater stability but there are **no large series** for **superiority of locking plates.**

IM Nails

- the first choice for **LL diaphyseal** fxs (superior biomechanical conditions.)
- ideally for **Gustilo 1 & 2** and even in type **3** where contamination is minimal.

The decision to use **reamed or unreamed** nails was debated but now there are **many studies** that show the **superiority** of the **reamed nail**.

Reamed Vs Unreamed Nailing

Reamed Nailing

Reaming function as **autologous bone graft**
Induces a **6fold** increase in **periosteal blood flow**
Shorter union time with fewer nonunions
Allows insertion of **larger nails (increased stability)**

Unreamed Nailing

Higher rate of secondary interventions
Patellofemoral complications are more common
Smaller diameter nails with decreased stability
Shorter operating time

Management of Bone Loss



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⇒ The decision to retain or discard damaged bone:

1- **vascularity**

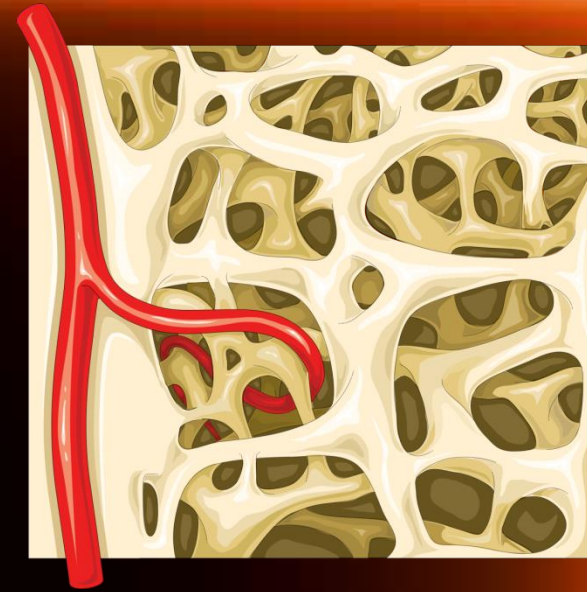
2- **Location (diaphysis, metaphysis, or the articular margins.)**

-It is not clear how much soft tissue attachment is required for viability but **< 50% soft tissue attachment** should be considered to have **poor viability**.



-Comminuted cortical fragments without soft tissue attachments are avascular, and must be removed!

-In contrast, **metaphyseal bones** (cancellous) have a **higher capacity for revascularization** and can be preserved if not grossly contaminated.



- **Cancellous bone involving the articular surface is usually retained.**

- Metaphyseal fragments, with attached articular surfaces, can be retained even if they are devoid of soft tissue.

- The lower end of femur was reconstructed and primary skin closure.

- Both bone and soft tissue healing were achieved.



Bone gaps in the Upper limb

- can generally be managed by **bone shortening** followed by **bone grafting**.
- In the **humerus**, pts cope with **shortening** of **even 4 cm** very easily.

- In the **forearm**, bone shortening must be **very carefully** done because of the presence of **two bones**.
- A bone loss of up to **2 cm** in one bone ---> **bone grafting**.
- A very severe loss (radius / ulna) ---> **single bone reconstruction** .



-severe mangled injury of the forearm and major bone.

-one-bone forearm reconstruction.

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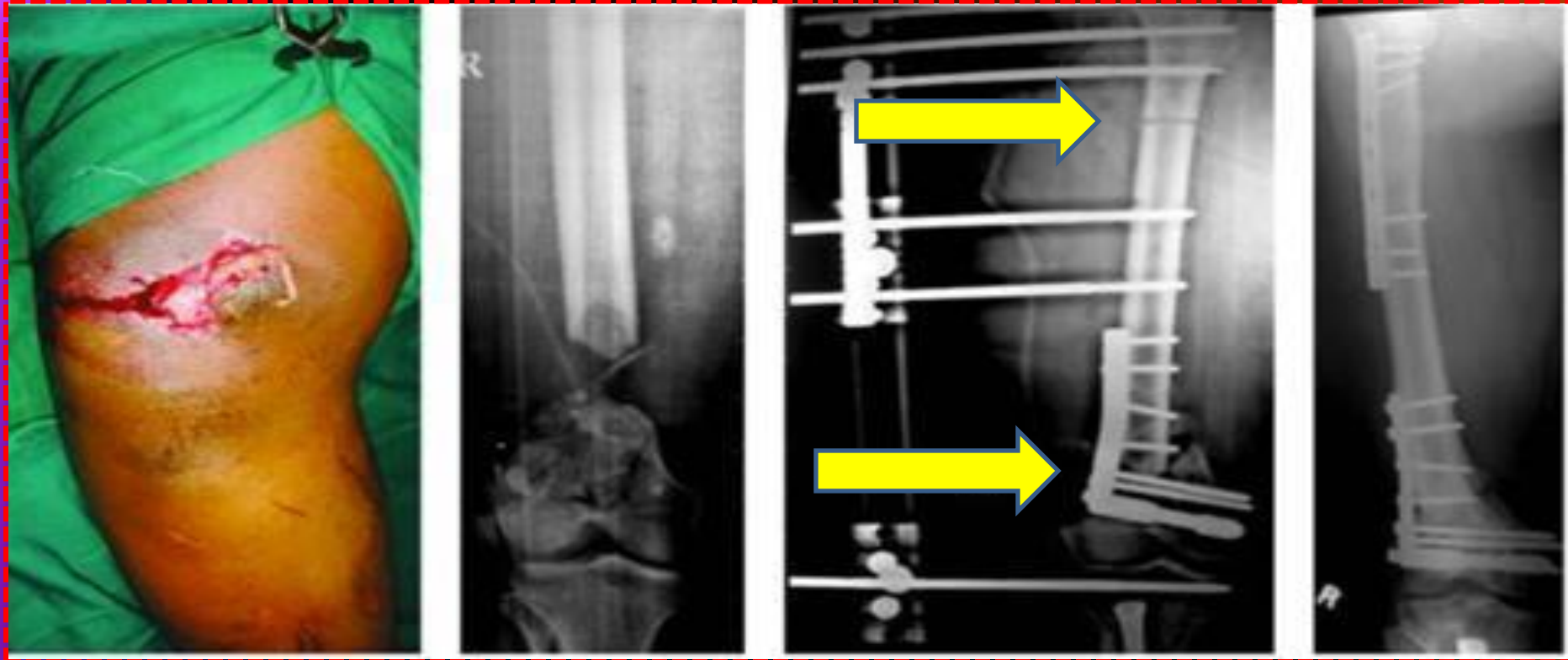
Bone gaps in the Lower limb

- the extent of bone loss determines reconstruction options.
- A loss of < 2 cm is well tolerated and primary shortening can be safely done.

-When the loss is due to the removal of a **large comminuted fragment**, or when the **circumferential loss is < 3 cm**, iliac
--> **crest bone grafting.**

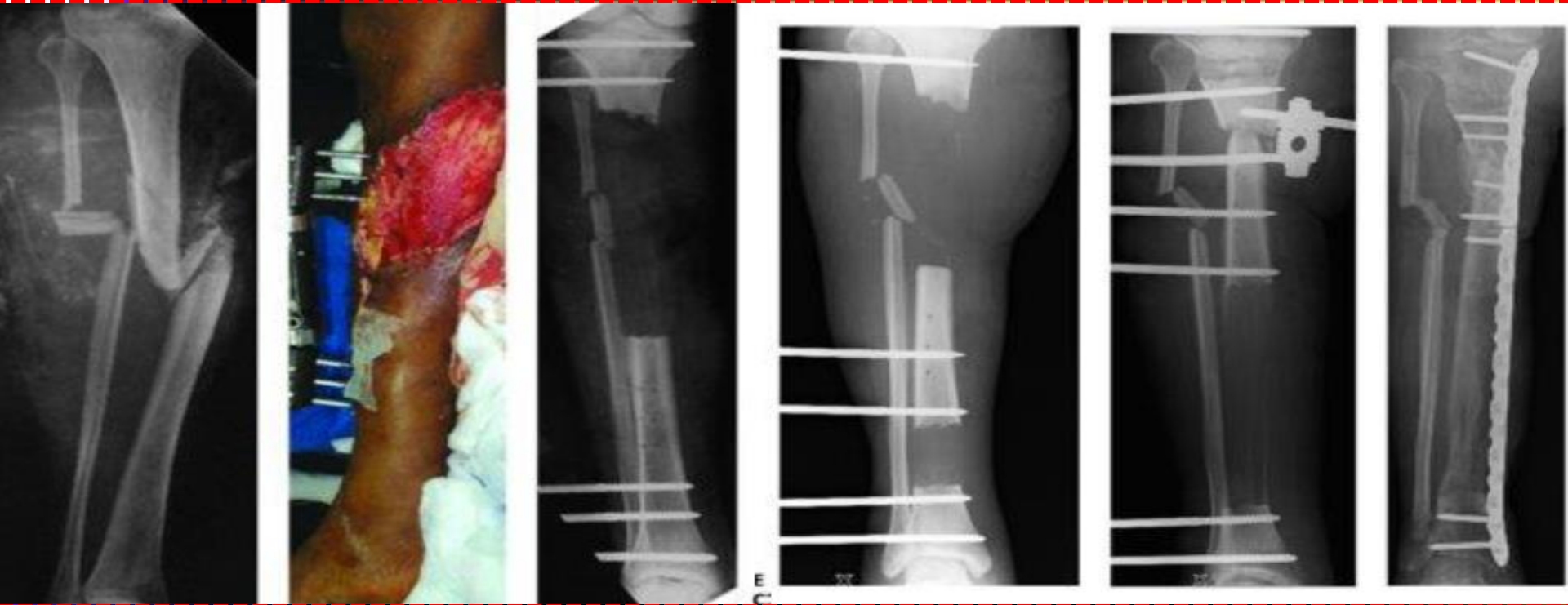
- The **timing of bone grafting** is determined by the **status of the soft tissue bed/cover**.
- When the **loss exceeds 4 cm**, a decision is made between **primary bone shortening and subsequent lengthening** or **bridging the gap by bone transport**.

Acute bone shortening and lengthening.



supracondylar femoral (open Fx 3b) with primary bone loss.

Bone transport



- type **3B open fx** with extensive soft tissue loss.
- bone transport and subsequent plating.

Extruded bones

-In the ankle, foot, and carpal regions, entire tarsal and carpal bones may sometimes be extruded!

Sterilization methods

- 1- boiling
- 2- autoclaving
- 3- washing
(chlorhexidine /povidone-iodine)
- 4- Gamma irradiation

Disinfection

- autoclaving / antiseptic / antibiotic solution.
- Autoclaving leads to complete loss of viable cells
- antiseptic / antibiotic solutions do not disinfect completely.



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journal homepage: www.elsevier.com/locate/tcr

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Case Report

A novel technique for reimplanting extruded bone fragments in open fractures

2016

Sameer Rathore^{*}, Indukuri Viswanatha Reddy¹, A.H. Ashwin Kumar²

Department of Orthopaedics, Block 3, 3rd Floor, Krishna Institute of Medical Sciences, Secunderabad 500003, India

Distal Femur Fx



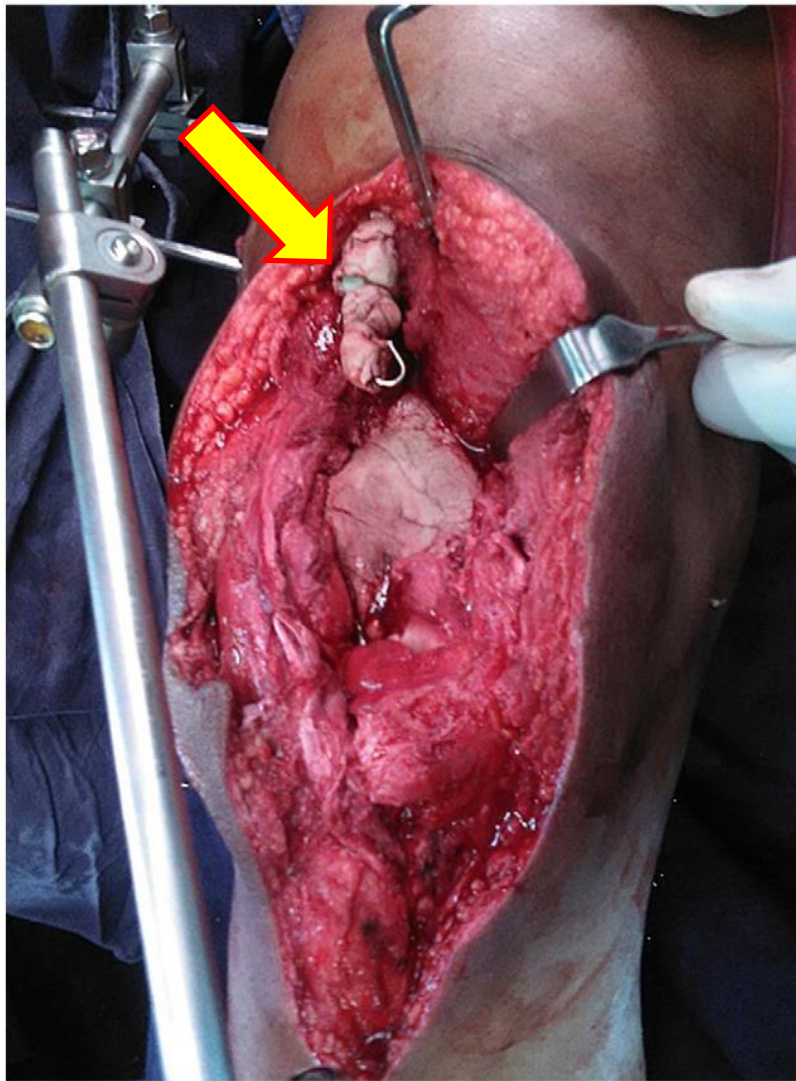
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Severe Fx comminution



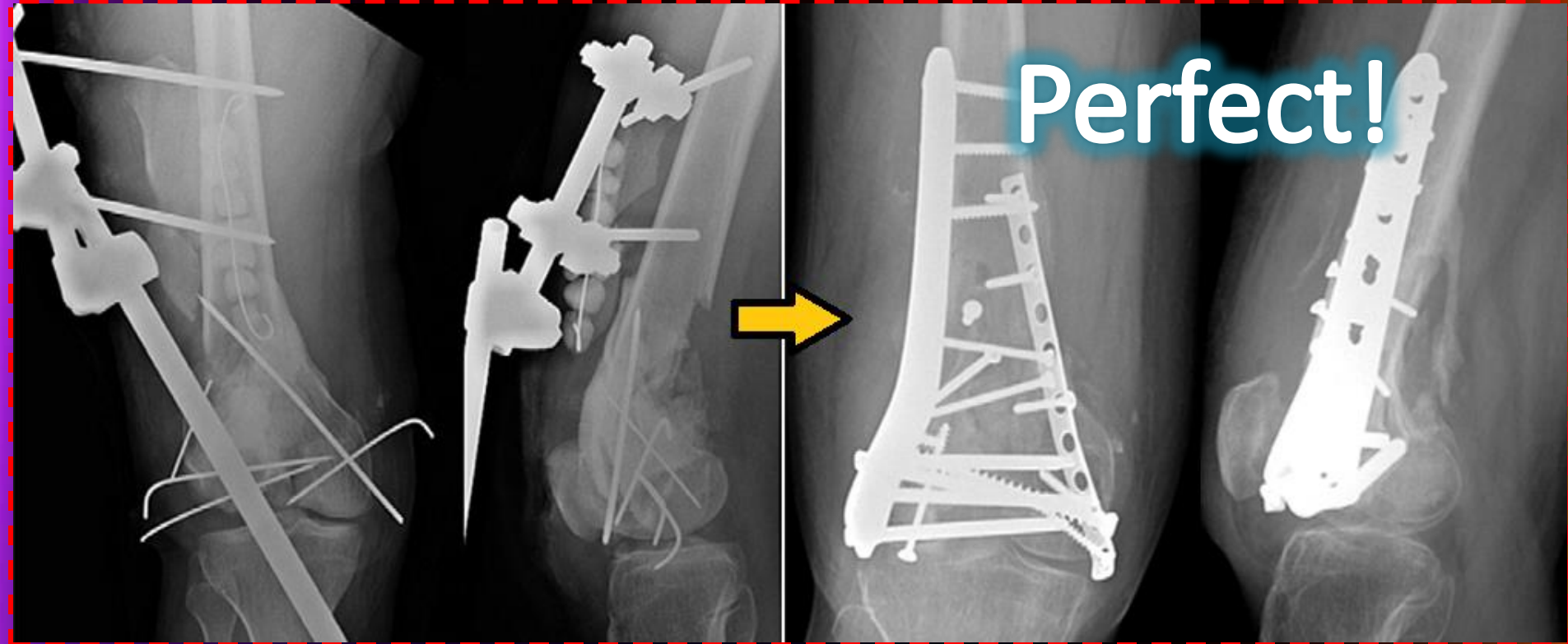
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two pieces of extruded femur were preserved in the subfascial plane in the healthy soft tissues of the thigh and reimplanted after **one week**



Intra-operative image after debridement and placement of antibiotic cement spacer.

The **free bone fragments** were inserted at the proximal end of the incision along with a few antibiotic cement beads

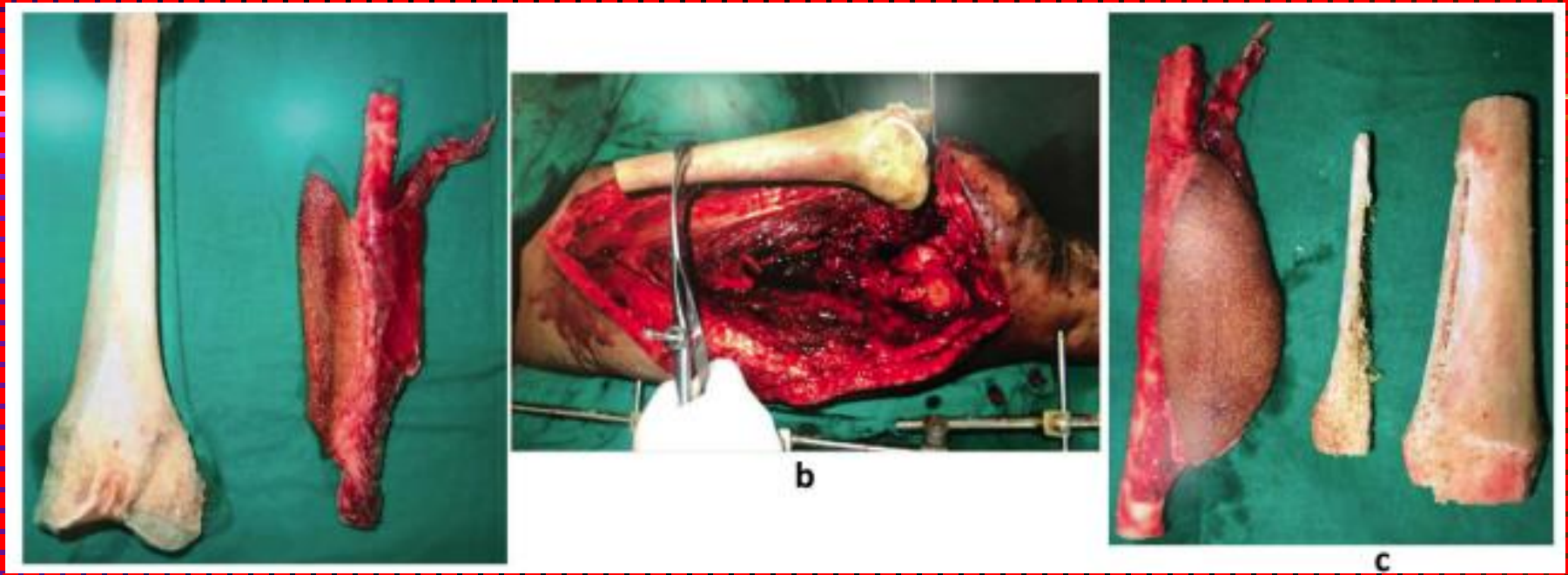


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- A 24 y/o, supracondylar open fx with a **large extruded segment of 13 cm**.
- that reimplanted immediately after I&D, and the extruded bone washed with **povidone-iodine** .
- A **locking plate** fixation and primary closure.

- Massive open injuries around the knee with extensive dist. femoral bone loss are difficult to treat.
- A modified Capanna technique in which a long free vascularized fibular graft is incorporated into a large femoral allograft to bridge the gap was recently successfully used.



- vascularized fibula provided the biologic bridge and the femoral allograft provided a structural support and aided in early mobilization and weight bearing.



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