Segmental, proximal and distal tibial shaft fractures

Andreas Panagopoulos, MD, PhD
Assistant Professor, Patras University Hospital

Objectives

General principles

Epidemiology & anatomy

Classifications

Pearls of reduction and fixation

Best implant choice

Results and evidence based outcome

Introduction

Tibial shaft fractures:

commonest long bone fractures

often open, RTA

slow to heal

frequently cause sequelae

related to both injury and treatment

Wide spectrum of injury patterns

Epidemiology

are **declining** in incidence

Sweden: $18.7/10^5$ (1998)
$16.1/10^5$ (2004)
48% fall, 21% RTA

Edinburgh: $26/10^5$ (1988)
$21.5/10^5$ (2003)
$14.3/10^5$ (2008)

Mechanism of injury

1988-1990: **37.5% RTA**, 30.9% sports, 17.8% fall
2007-2008: 20.5% RTA, 27.4% sports, **32.8% fall**

Epidemiology

↓ young males, ↑ old females

$7.9/10^5/$ (2000) → $10.2/10^5/$(2008)
av. age 37.1→ 44.6

$13.3/10^5/$ (2000) → $15.6/10^5/$ (2008)
av. age 48.9→ 56.0

Important factors in overall management

Injury characteristics

Soft tissue injury: open/closed
type: transverse, spiral, oblique
Degree of comminution
Mechanical stability

Surgeon factors

Skills and training
Familiarity with implants

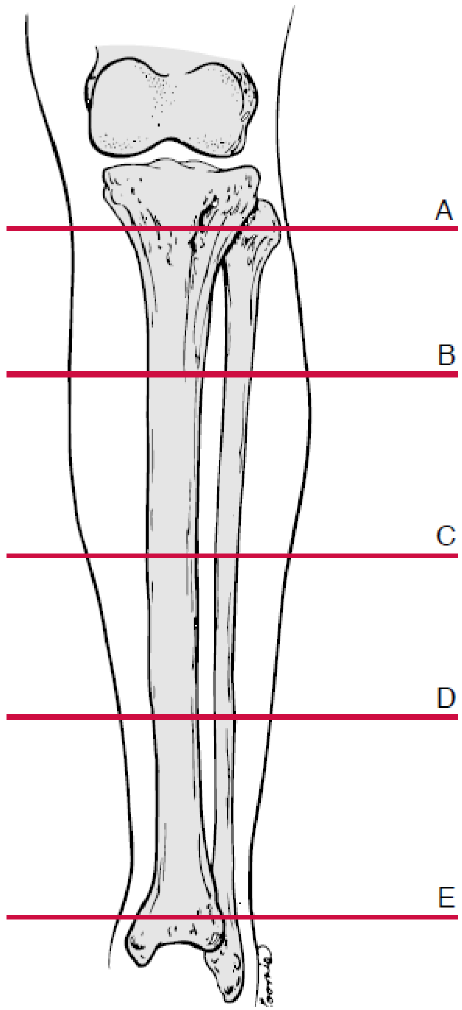
Patient factors

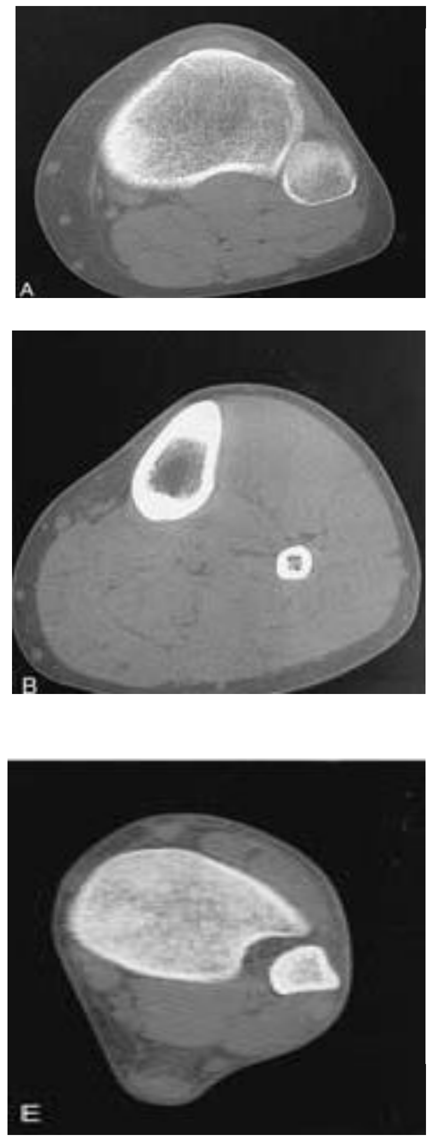
Comorbidity
Associated injuries
Functional requirements
Likely compliance

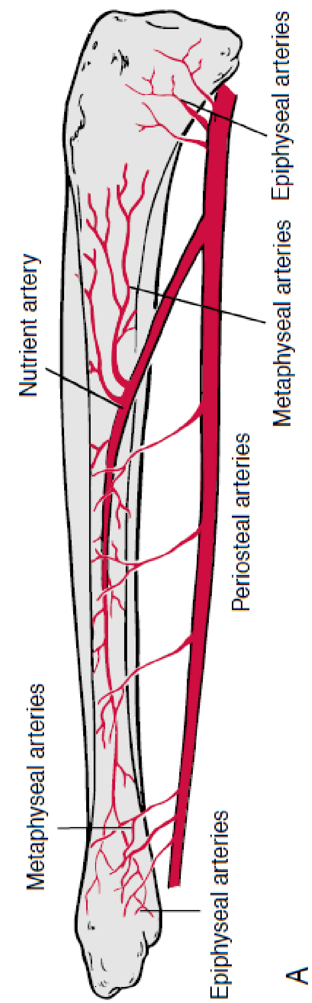
Other factors

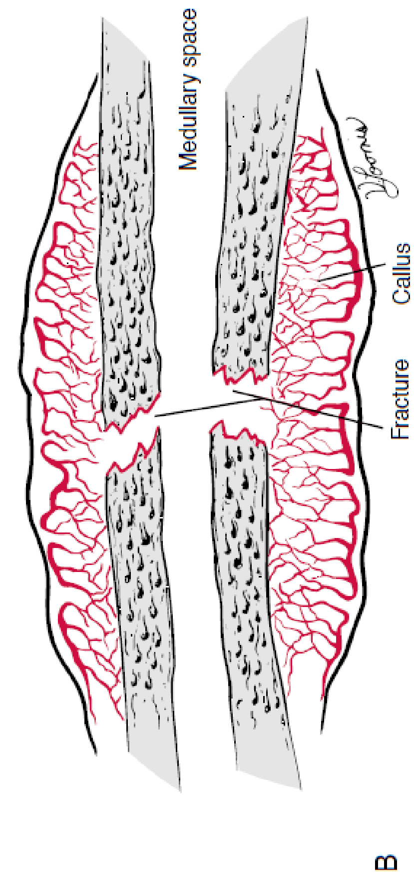
full range of implants
Anaesthetist and theatre staff
Radiograph facilities
Follow-up facilities

Relevant anatomy









Acta Orthopaedica 2008; 79 (5): 689–694

Current management of tibial shaft fractures

A survey of 450 Canadian orthopedic trauma surgeons

Jason W Busse[1], Emily Morton[2], Christina Lacchetti[1], Gordon H Guyatt[1], and Mohit Bhandari[1]

closed fractures

87% IM, 8% plates and 2% non-op

open fractures

83% IM, 7% plates and 7% Ex-Fix

Choice of implant	Closed [a] n (%)	Open [b] n (%)
Nailing with reaming	120 (47)	152 (59)
Nailing without reaming	104 (40)	62 (24)
Plate	21 (8)	18 (7)
External fixator	1 (<1)	19 (7)

[a] 2% (n = 6) stated that they used "another" type of implant, and 2% (n = 6) stated that they do not usually manage closed tibial shaft fractures operatively.
[b] 3% (n = 7) stated that they used "another" type of implant.

17 y old, RTA
6 m pop
Full WB
Full ankle & knee motion

The SPRINT Study

Prognostic Factors for Predicting Outcomes After Intramedullary Nailing of the Tibia

Study to Prospectively Evaluate Reamed Intramedullary Nails in Patients with Tibial Fractures (SPRINT) Investigators*

Investigation performed at McMaster University, Hamilton, Ontario, Canada

Large (1226 pt), multicenter trial of reamed & unreamed IM

Higher risk of a **poor** outcome
- high-energy injuries,
- need for soft-tissue reconstruction,
- fracture gap (< 1 cm)
- open fractures with reamed nails
- full weight bearing postop

Severity of injury plays the most important role

Segmental tibial fractures

Incidence between 3% and 12%

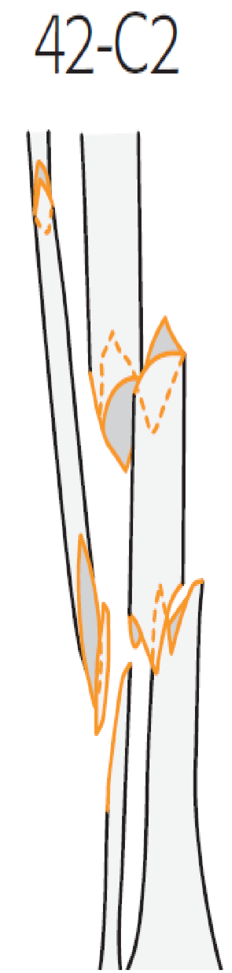
Usually severe soft tissue injuries

- impaired fracture healing (up to 50%),
- compartment syndrome (up to 50%), and
- septic complications (up to 35%)

↓ blood supply of intermediate fragment

Difficulties in reduction and alignment

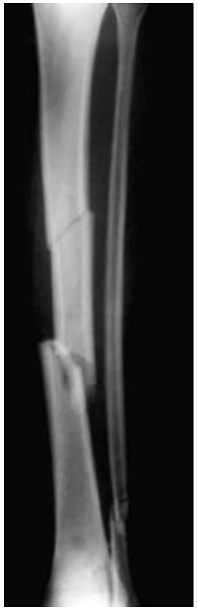
Very short proximal or distal segments are notoriously difficult to control

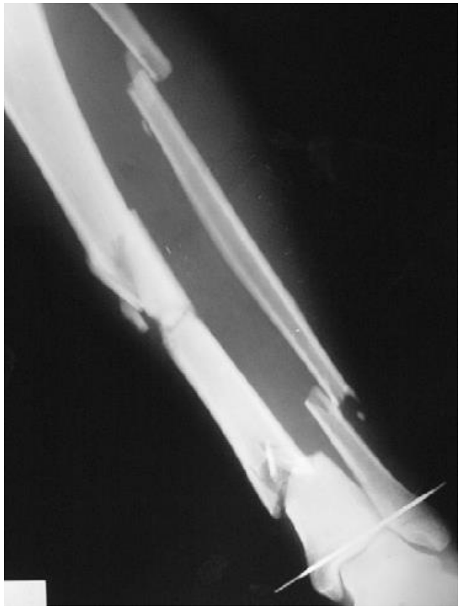


Melis classification

Type I	The fracture lines are situated proximally, so that the proximal fracture lies in the upper third of the shaft and the distal fracture lies in the middle third
Type II	The fracture lines are situated distally, so that the proximal fracture lies in the middle third of the shaft and the distal fracture lies in the lower third
Type III	The fracture lines are at the extremes of the shaft and there is a long intermediate fragment
Type IV	The fracture lines are close to one another and there is a short intermediate fragment in the middle third of the shaft


Type I


Type II


Type III


Type IV

Treatment options

Conservative

Plate fixation

External fixation

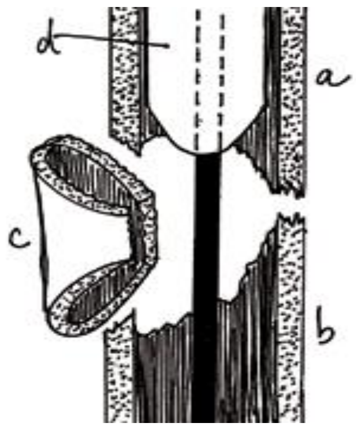
Intramedullary nailing

Diagnosing Segmental Wedge Fracture of the Tibia Before Performing Intramedullary Nailing

August 2013 *The American Journal of Orthopedics®*

Christina Gutowski, MD, MPH, Jeffrey S. Abrams, MD, and W. Thomas Gutowski, MD

Segmental wedge-fracture pattern



1. difficulty in placing the guide wire
2. more displacement on rod insertion
3. cerclage wires or unicortical plate

325/ ACTA CHIRURGIAE ORTHOPAEDICAE ET TRAUMATOLOGIAE ČECHOSL., 75, 2008, p. 325–331

ORIGINAL PAPER
PŮVODNÍ PRÁCE

Functional Treatment of Closed Segmental Fractures of the Tibia

Funkční léčba zavřených segmentálních zlomenin tibie

A. SARMIENTO, L. L. LATTA

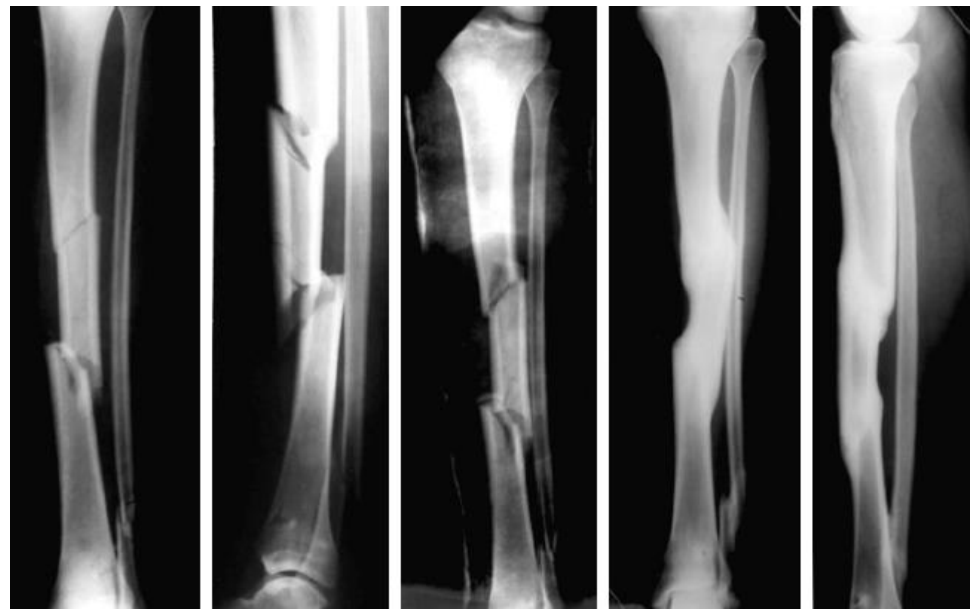
Investigation conducted at the University of Miami and University of Southern California, USA

47 pt, **closed** fractures
inclusion criteria
- initial shortening **<12 mm**,
- angulation corrected to **<7^0**

Mean healing time 15.2 weeks

All fractures united

No complications



Injury, Int. J. Care Injured 40 (2009) 449–454

Open acute segmental tibial fracture fixation using the Less Invasive Stabilisation System (LISS): Study of 23 consecutive cases

Peter Reynders *

Department of Traumatology, University Hospital Leuven, Herestraat 49, 3000 Leuven, Belgium

23 **open** segmental fractures
20 temporarily fixed with ex-fix
4 grade IIIA,
16 grade IIIB
3 grade IIIC

3 compartment syndrome
Dermatofasciotomy in 13 cases
5 cases palsy of EHL
20/23 healed (mean 19 weeks)

Segmental fractures of the tibia treated by circular external fixation

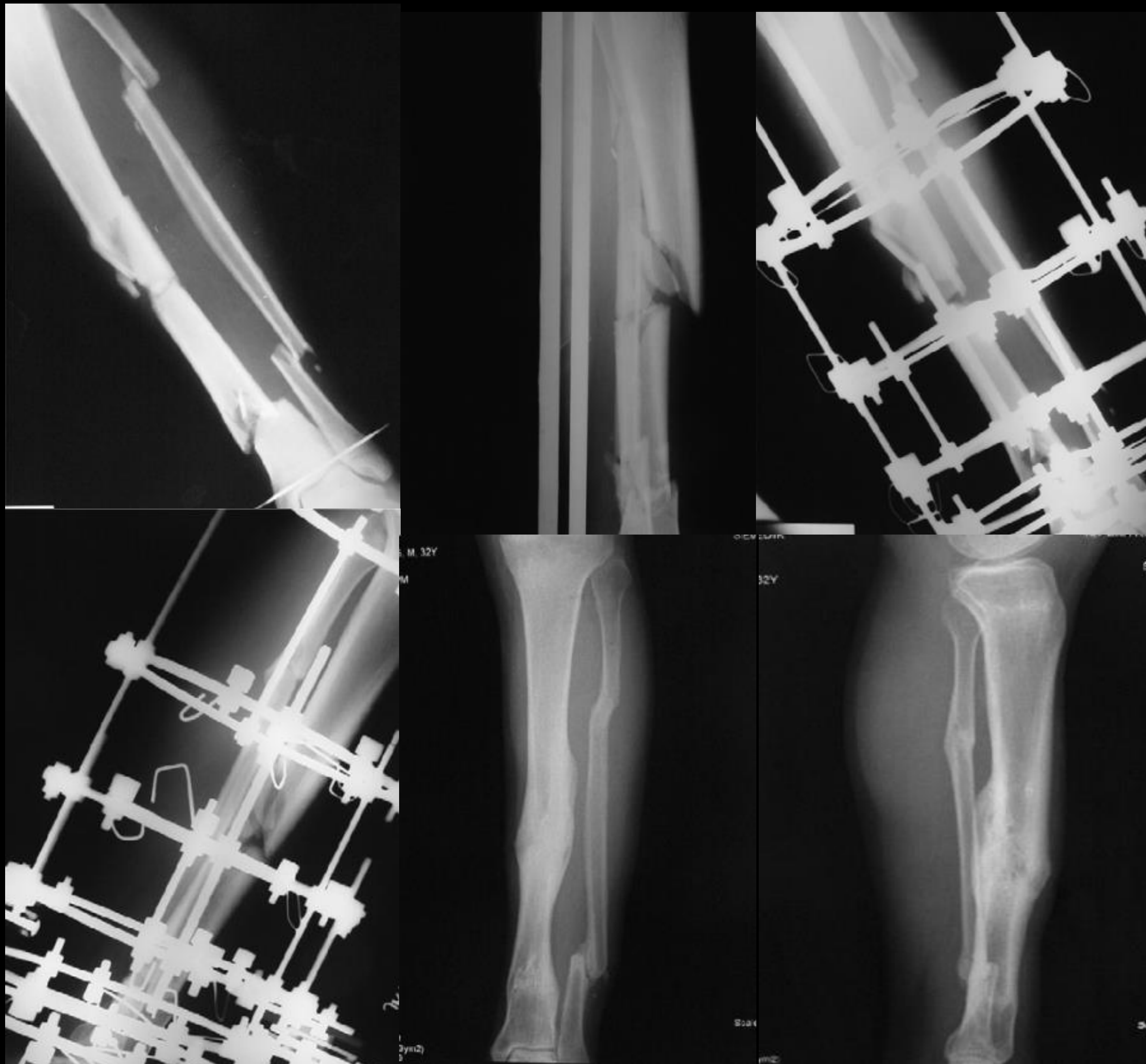
J Bone Joint Surg [Br] 2010;92-B:687-92.

N. Giotakis,
S. K. Panchani,
B. Narayan,
J. J. Larkin,
S. Al Maskari,
S. Nayagam

multilevel stabilization
minimal disruption of soft-tissue
small biological bone ‘footprint’
ability for early ambulation

Pin track infection
Tolerance of the patient

20 pt, 21.7 weeks to union
2 nonunions, 2 reop



CLINICAL ORTHOPAEDICS AND RELATED RESEARCH
Number 460, pp. 196–201

Segmental Tibia Fractures

A Prospective Evaluation

Sanjeev Kakar, MD, MRCS; and Paul Tornetta, III, MD

Primary union 46/51 patients (91%).
average time to union was 5 months
5 reopertions

Unreamed nailing
Semi-extended technique (50%)
back-tapping
mild shortening to obtain cortical contact
early weightbearing (within 2 months)

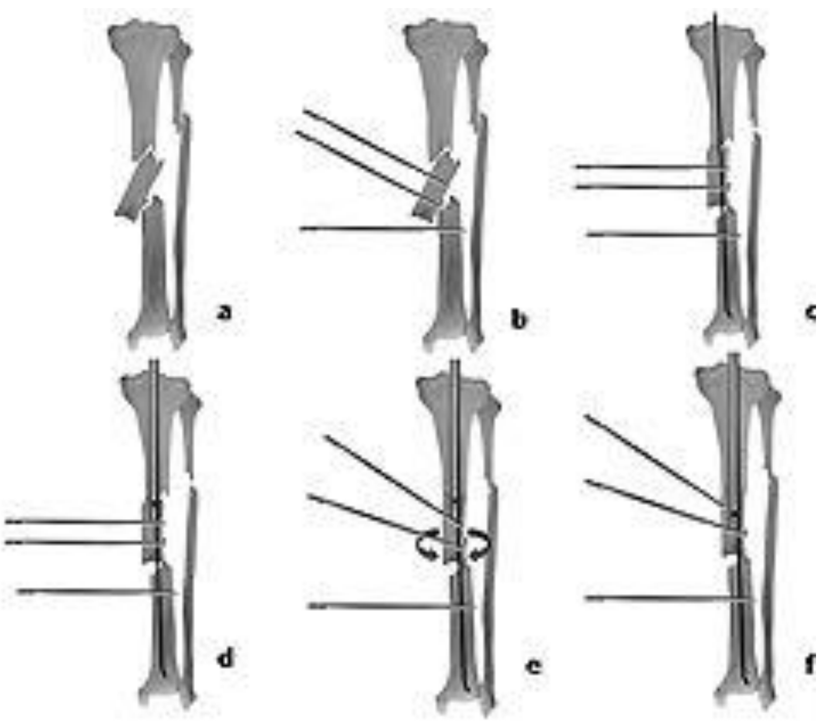
TIPS & TECHNIQUES

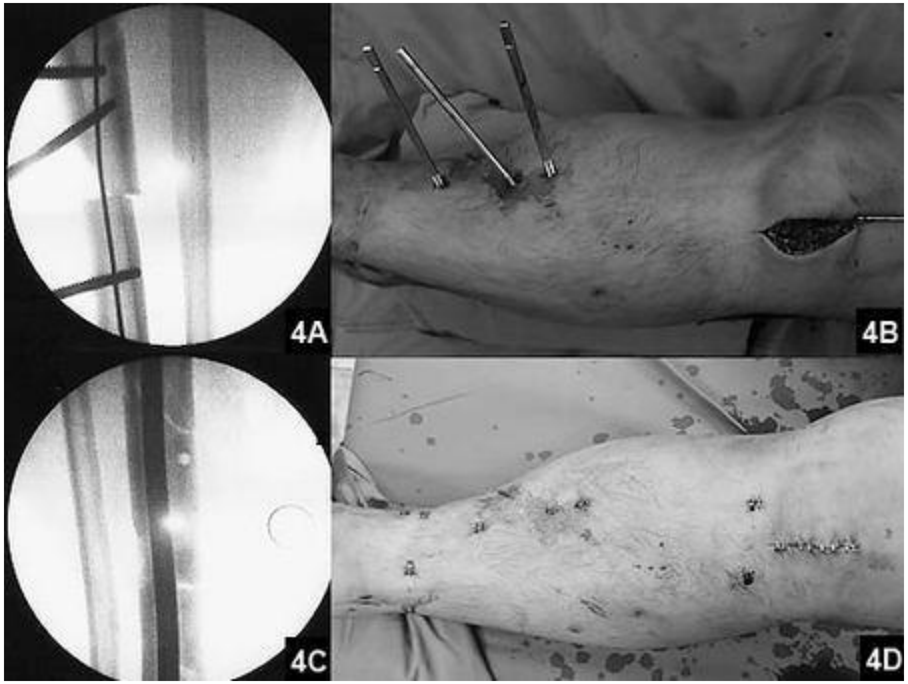
Tibial Unreamed Intramedullary Nailing Using Schanz Screws in Displaced Diaphyseal Segmental Fractures

Kyung Cheon Kim, MD; June Kyu Lee, MD; Deuk Soo Hwang, MD; Jun Young Yang, MD; Young Mo Kim, MD

Orthopedics
November 2007 - Volume 30 · Issue 11

Report of 4 cases
1 delayed union



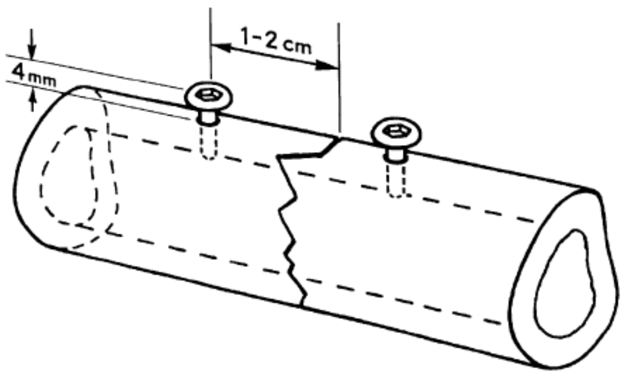


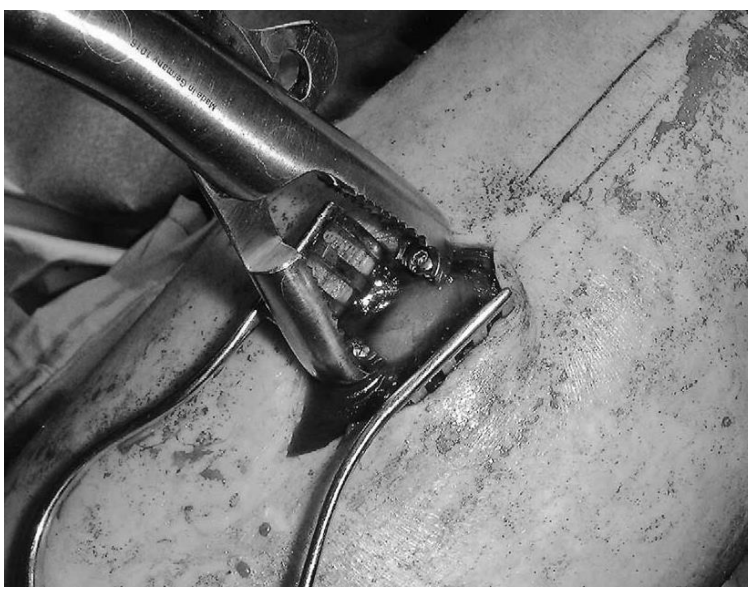
Technical note

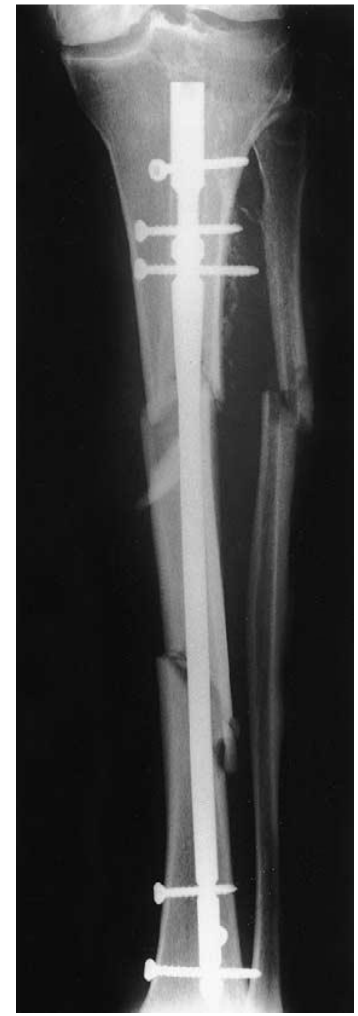
Maintaining reduction during unreamed nailing of a segmental tibial fracture: the use of a Farabeuf clamp

A. Robertson, P.V. Giannoudis, S.J. Matthews*

Injury, Int. J. Care Injured 34 (2003) 389–391







Clinical Outcomes of the Tibia Segmental Fractures Treated by Intramedullary Nail Using Various Reduction Techniques

Oog-Jin Shon, M.D., Ji-Hoon Shin, M.D., Chul-Wung Ha, M.D.

Department of Orthopaedic Surgery, Yeungnam University Medical Center, Yeungnam University College of Medicine, Daegu, Korea

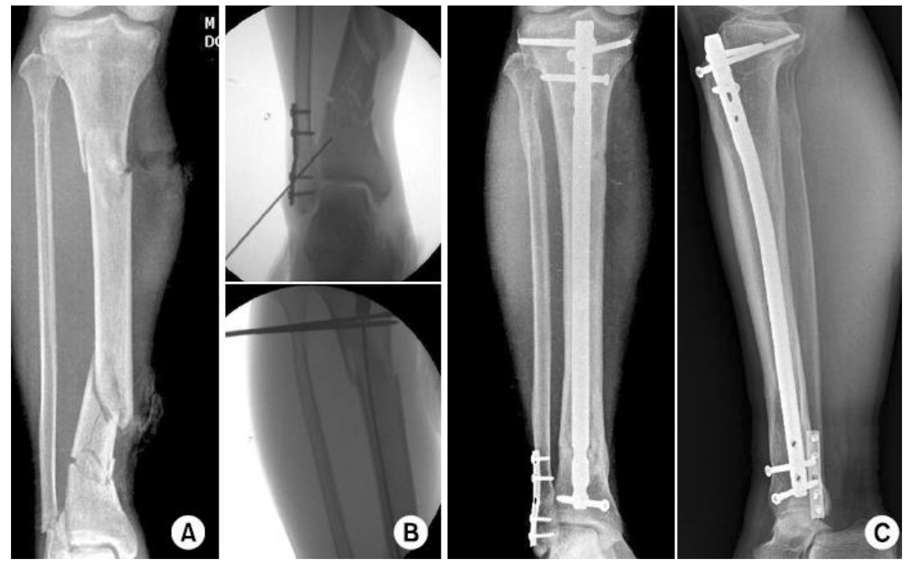
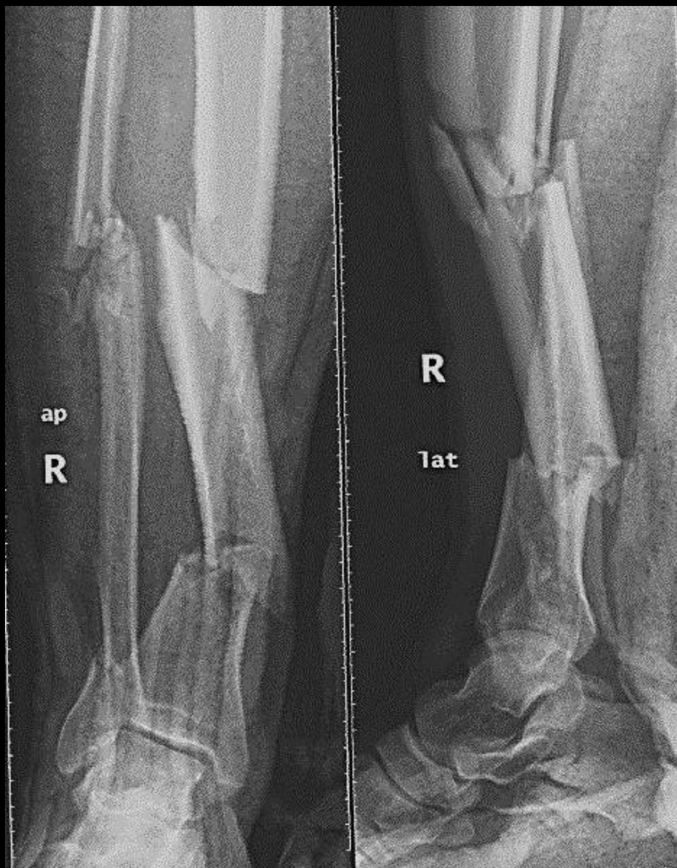


Table 2. Complications

	Case
Delayed union	3/18 (16.6)
Coronal malalignment	1/18 (5.5)
Sagittal angulation	1/18 (5.5)
Local infection	2/18 (11.1)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Proximal non-articular tibia fractures

5% to 12% of all tibial shaft fractures

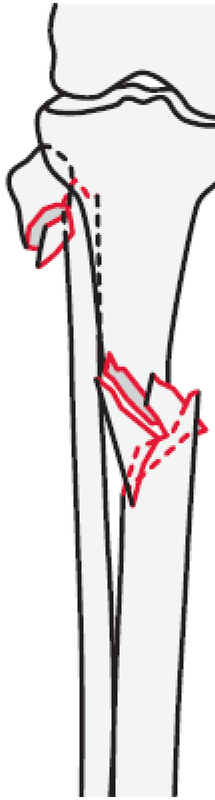
high-velocity injury

usually severe soft tissue damage

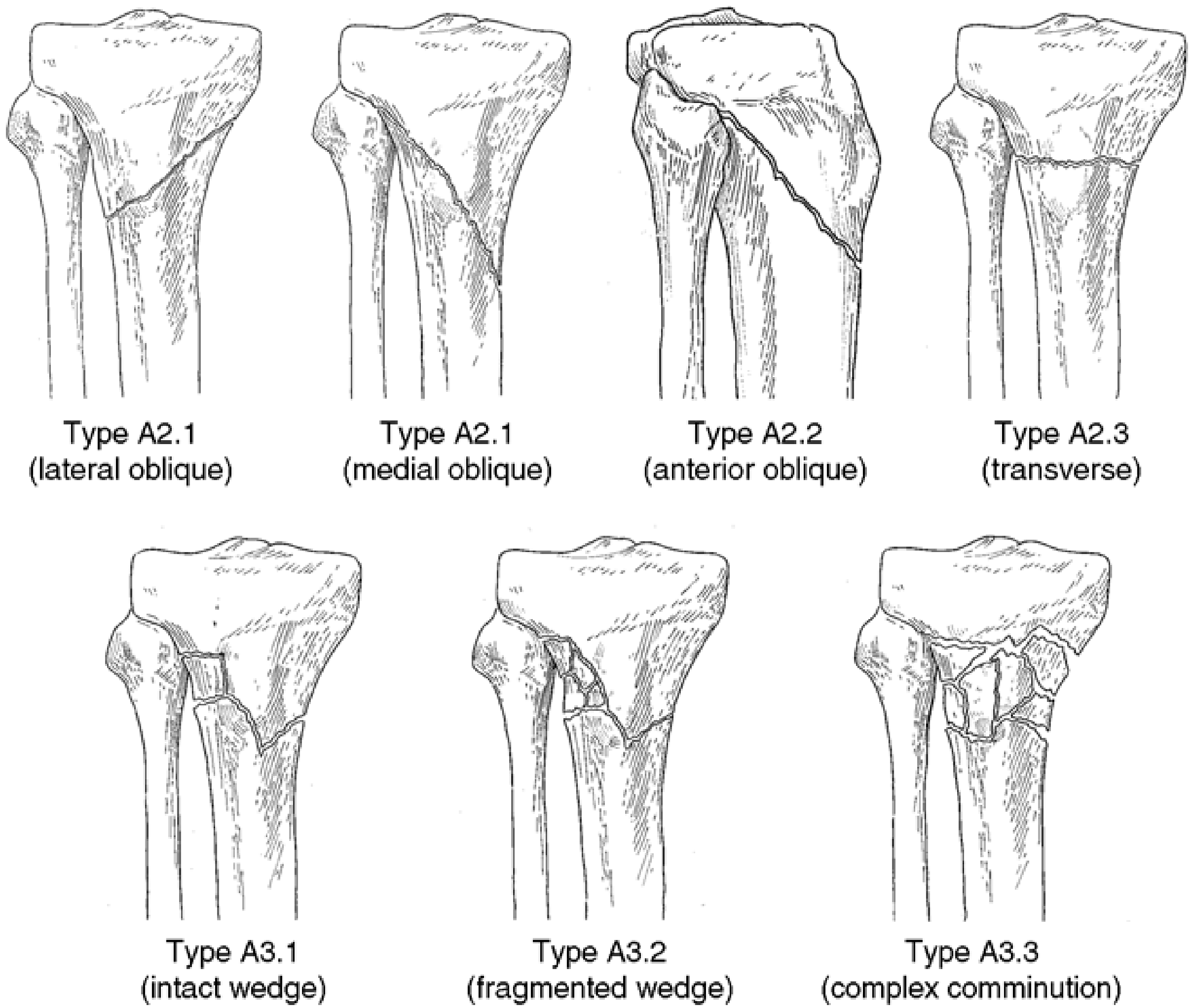
metaphyseal comminution

7% infection & compartment syndrome

malalignment 44% to 84% (IMN)



Classification



Treatment options

Conservative

Plate fixation

External fixation- Ilizarov

Intramedullary nailing?

JOURNAL OF SURGICAL RESEARCH 178 (2012) 722–727

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.JournalofSurgicalResearch.com

Biomechanical evaluation of various fixation methods for proximal extra-articular tibial fractures

Wei Feng, MD,[a] Li Fu, MD,[b] Jianguo Liu, MD,[a,] Xin Qi, MD,[a] Dongsong Li, MD,[a] and Chen Yang, MD[a]*

In compression testing the highest degree of axial stiffness was found in the IMN group

In three-point bending test the DCP demonstrated the highest bending stiffness,

The Ex-Fix had the lowest level of stiffness in both tests

IM in clinical application should be assisted with a plate

Injury, Int. J. Care Injured 44 (2013) 1081–1086

Contents lists available at SciVerse ScienceDirect

Injury

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

Clinical and radiological outcome of percutaneous plating in extra-articular proximal tibia fractures: A prospective study

Monappa A. Naik, Gaurav Arora, Sujit Kumar Tripathy*, Premjit Sujir, Sharath K. Rao

47 pt / 49 fractures

29 closed / **20 open**

4 infections (reop-debridement)

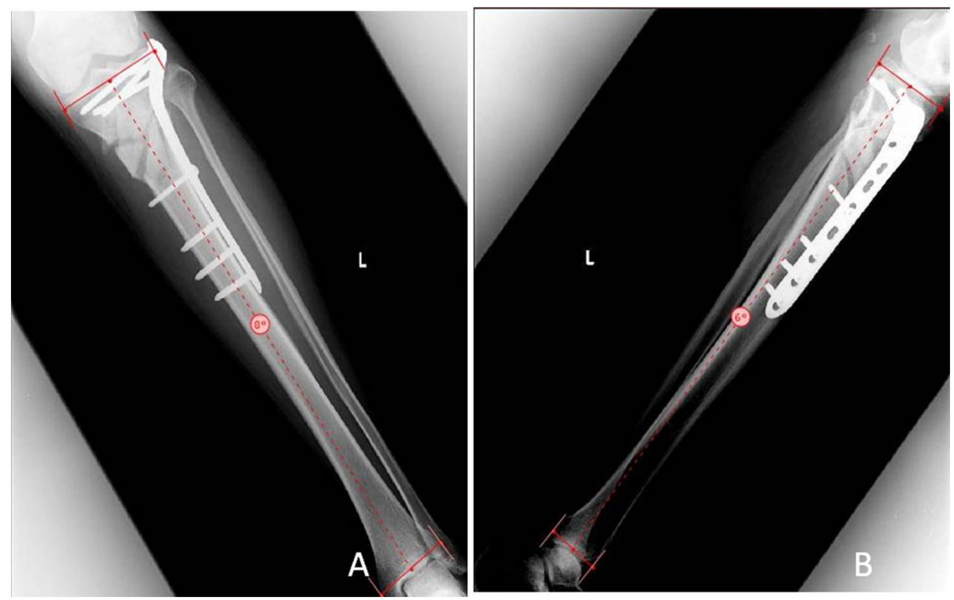
3/4 ended up with nonunion

20 w union in type I open

25 w in type II & III

10 malunions (20.14%)

no difference to knee motion



Orthopaedics & Traumatology: Surgery & Research (2010) 96, 800—809

Available online at ScienceDirect www.sciencedirect.com

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TECHNICAL NOTE

Minimally invasive locking screw plate fixation of non-articular proximal and distal tibia fractures

M. Ehlinger, P. Adam, F. Bonnomet

Intrafocal lever-type KW manipulation

Orthopaedics & Traumatology: Surgery & Research (2010) 96, 800—809

ELSEVIER MASSON

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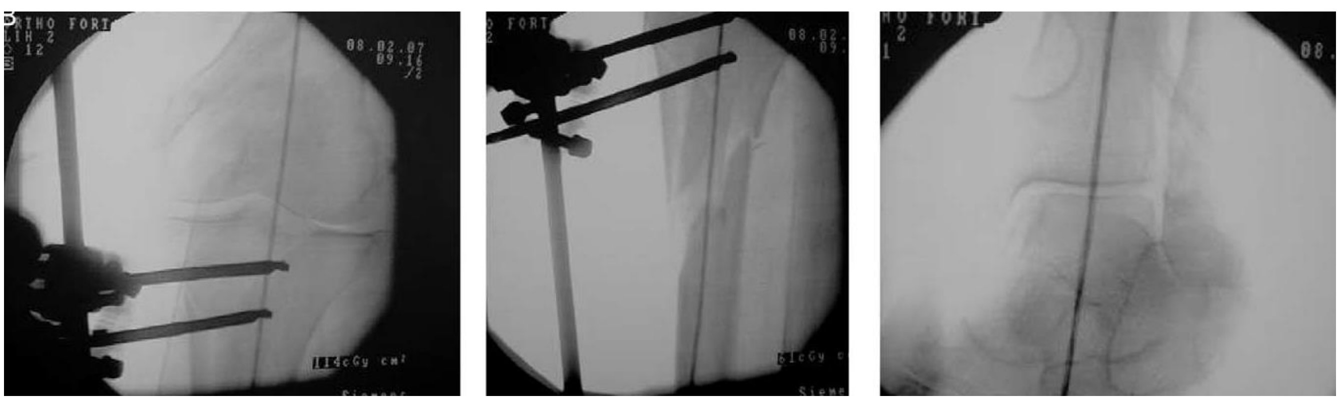
OTSR Orthopaedics & Traumatology Surgery & Research

TECHNICAL NOTE

Minimally invasive locking screw plate fixation of non-articular proximal and distal tibia fractures

M. Ehlinger, P. Adam, F. Bonnomet

Temporary distraction with Ex-Fix and intraoperative assessment of alignment

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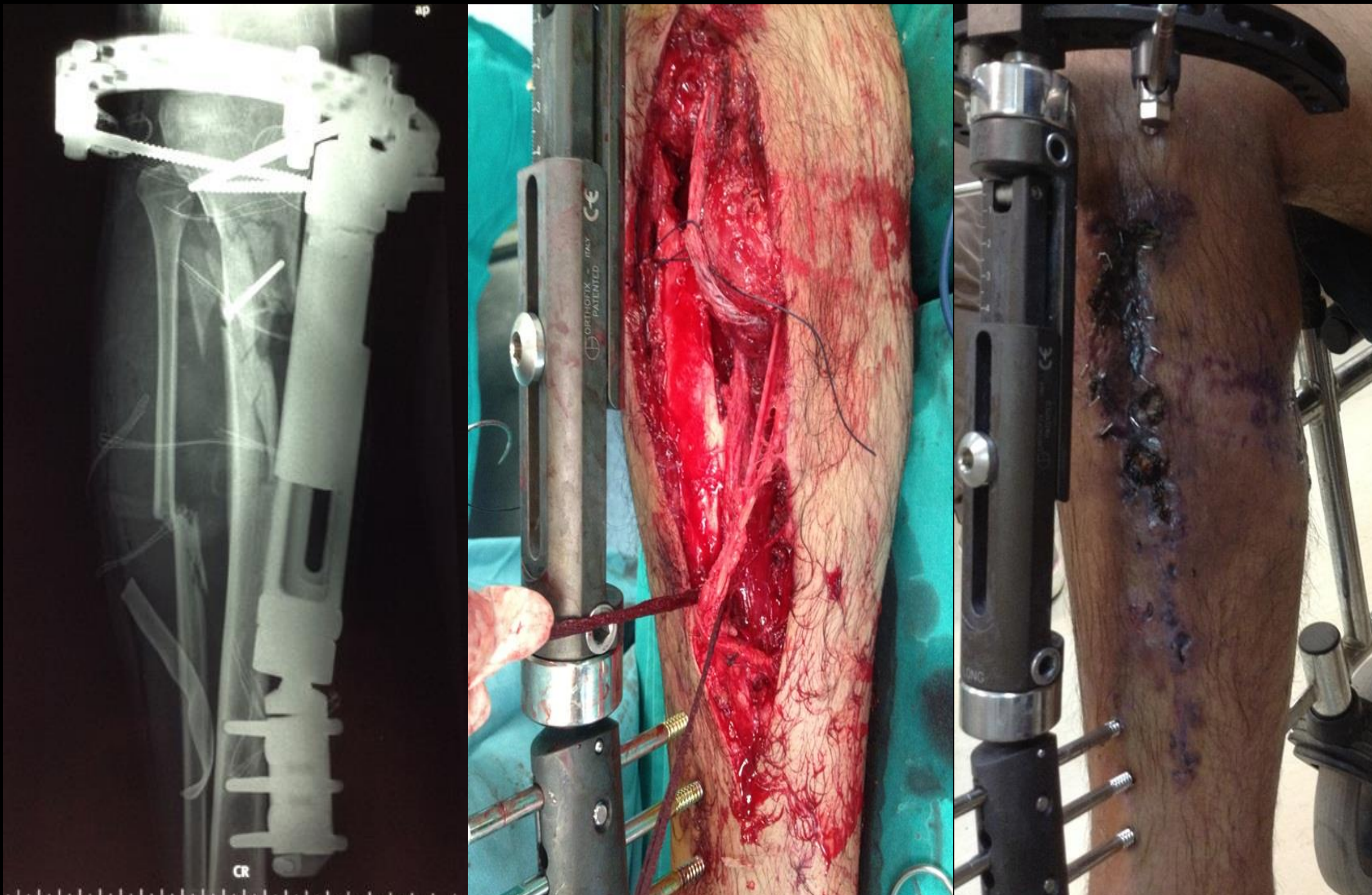
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66.0 kV, 9.998 mAs, 13.89 ms, 2.763 dGycm^2, EI:500
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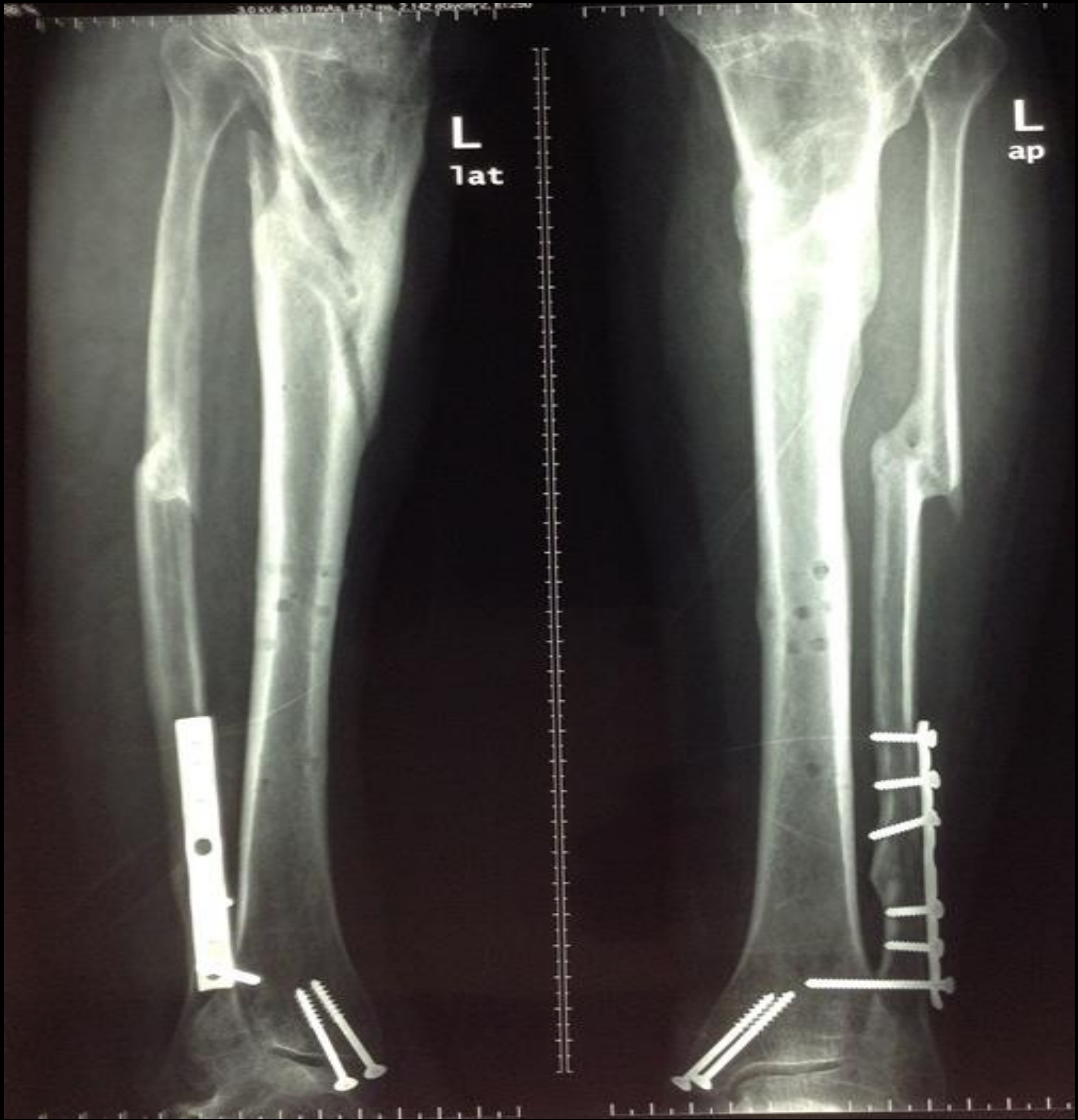
ap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Injury, Int. J. Care Injured 41 (2010) 190–196

Contents lists available at ScienceDirect

Injury

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

Staged external and internal less-invasive stabilisation system plating for open proximal tibial fractures

Ching-Hou Ma, Chin-Hsien Wu, Shang-Won Yu, Cheng-Yo Yen, Yuan-Kun Tu*

First stage

- **Control infection**
  (Radical debridement)
- **Fractures reduction**
  (Open reduction)
- **Provisional external fixation**
  (Locked plate)
- **Soft tissue reconstruction**
  (Repair or flap)
- **Rehabilitation**
  (CPM)

→

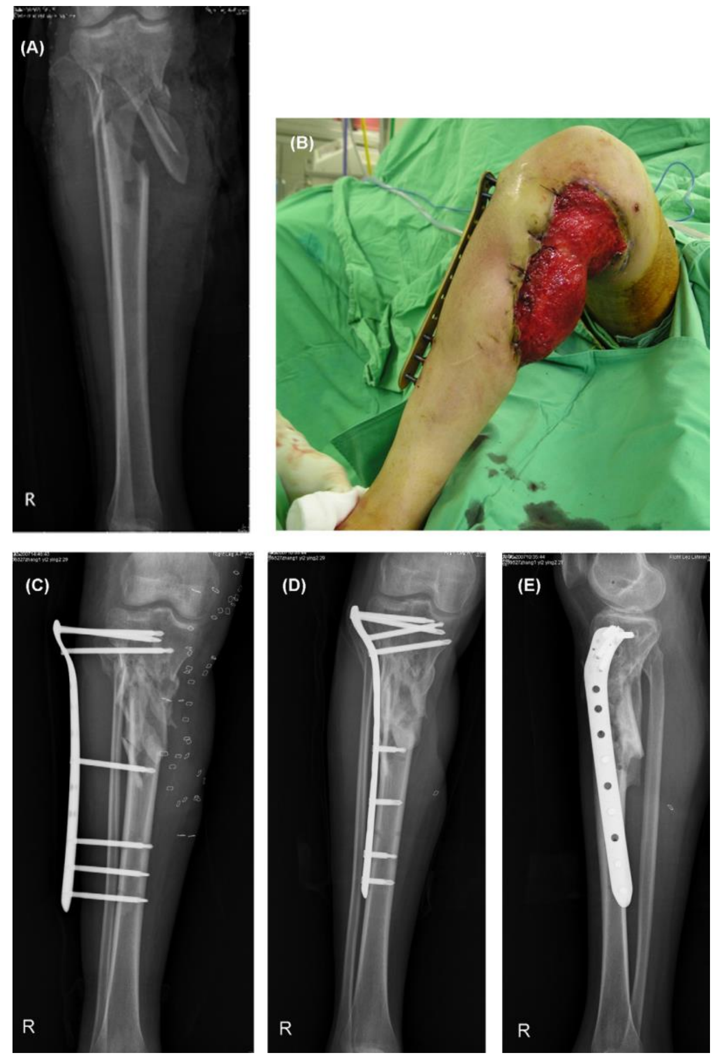
OPD follow-up

(Rehabilitation)

↓

Second stage

Definite internal fixation
(MIPO technique)

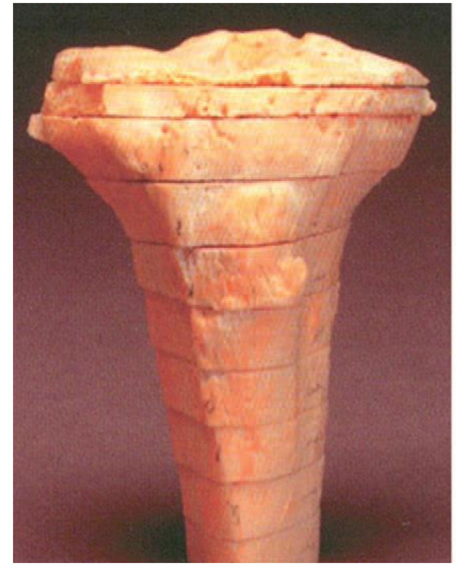


Why IM usually fails?

1. anatomy of intramedullary canal
   - central axis of is slightly lateral to the midline
   - anteroposterior width is narrower medially

2. apex anterior angulation
   - Patellar tendon extends the proximal fragment
   - Hamstring tendons flex the fracture

3. valgus deformity
   - Deforming forces of pes anserinus
   - Pull of the anterior muscles



Problems, Tricks, and Pearls in Intramedullary Nailing of Proximal Third Tibial Fractures

(J Orthop Trauma 2013;27:56–62)

Frank A. Liporace, MD,* Christopher M. Stadler, BS,* and Richard S. Yoon, MD†

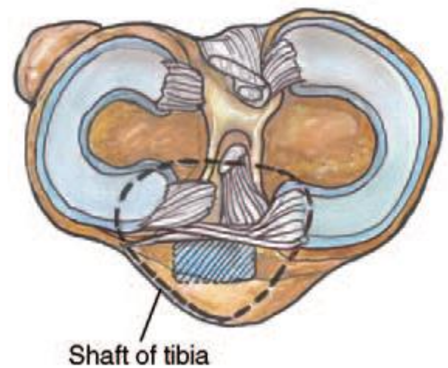
Surgical Options

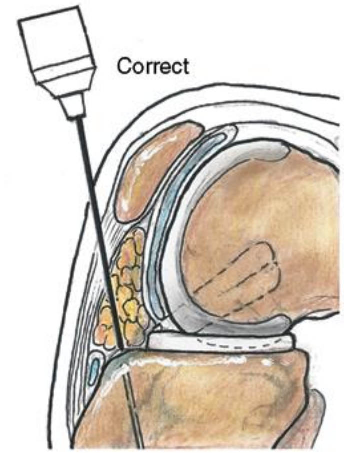
- Extended/semi-extended nailing
  - Median parapatellar
  - Suprapatellar/retropatellar
  - Extra-articular
- Femoral distractor/external fixation
- Poller/blocking screws
- Supplemental plate fixation

Tricks and Pearls for IM

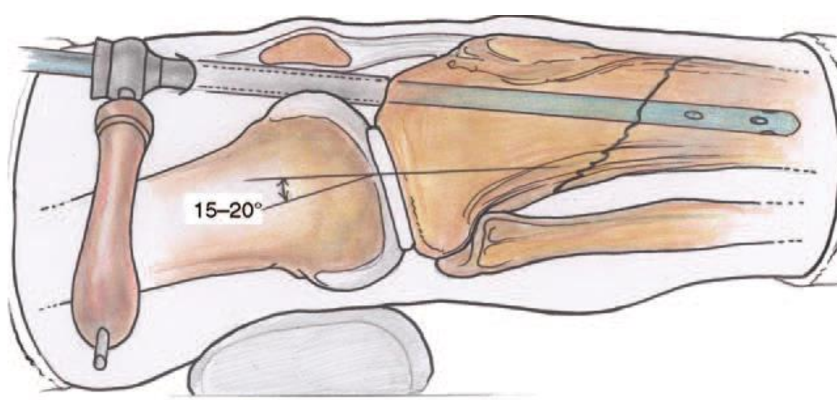
proper starting point

insertion angle





Semi-extended positioning

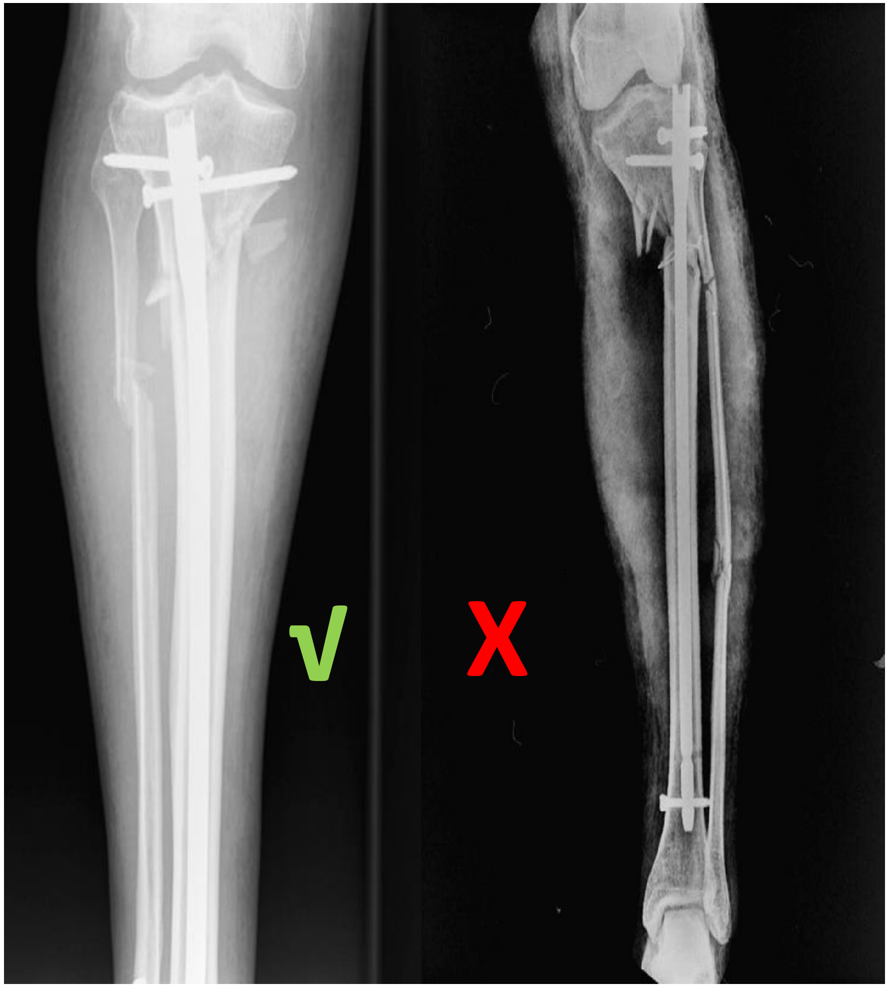


Intramedullary nailing of proximal tibia fractures—An anatomical study comparing three lateral starting points for nail insertion

Patrick Weninger [a,*], Manfred Tschabitscher [b], Hannes Traxler [b], Veronika Pfafl [b], Harald Hertz [c]

Injury, Int. J. Care Injured 41 (2010) 220–225

Entry point	Sample #	Varus (°)	Valgus (°)
Lateral third	1	15	–
	2	21	–
	3	14	–
	4	17	–
	5	16	–
	6	13	–
Middle third	1	10	–
	2	11	–
	3	8	–
	4	9	–
	5	12	–
	6	11	–
Medial third	1	5	–
	2	7	–
	3	–	4
	4	5	–
	5	–	5
	6	4	–

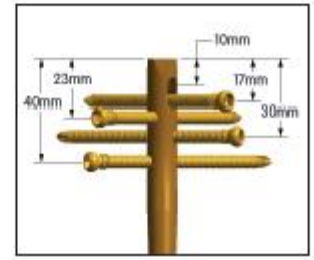


smith&nephew

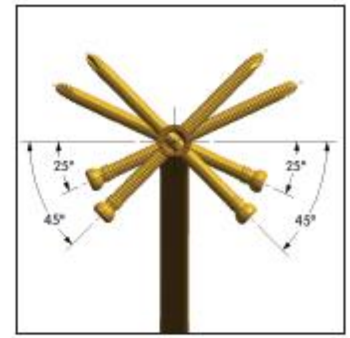
TRIGEN◊ META-NAIL◊

Semi-extended Instrument Set

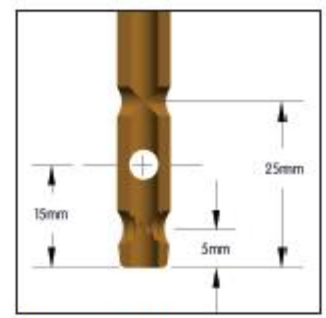
ML view



Distal end of nail (all knee and distal tibial)



Top view of nail



Non-driving end of nail (AP view)

Review Article

Intramedullary Nailing of Extra-articular Proximal Tibia Fractures

Timothy G. Hiesterman, DO
Babar X. Shafiq, MD
Peter A. Cole, MD

J Am Acad Orthop Surg 2011;19: 690-700

Reported Incidence of Malreduction Following Intramedullary Nailing of Proximal Tibia Fracture

Study	No. of Fractures	Management	No. of Malreductions (%)
Benirschke et al[3]	13	Temporary plating, external fixator	0
Cole et al[37]	13	Blocking screws	1 (7.7)
Tornetta and Collins[11]	25	Semiextended position	0
Buehler et al[9]	14	Universal distractor	1 (7.1)
Ricci et al[10]	12	Blocking screws	1 (8.3)
Nork et al[15]	37	Temporary plating, universal distractor	3 (8.1)
Vidyadhara and Sharath[12]	45	Semiextended position, blocking screws	7 (15.6)
Kim et al[23]	9	Temporary plating	1 (11.1)
Wysocki et al[16]	15	External fixator	1 (6.7)

Malreduction rate (0 to 15.5%), with an average of **8.2%**

Distal tibial fractures

8% of all tibial shaft fractures

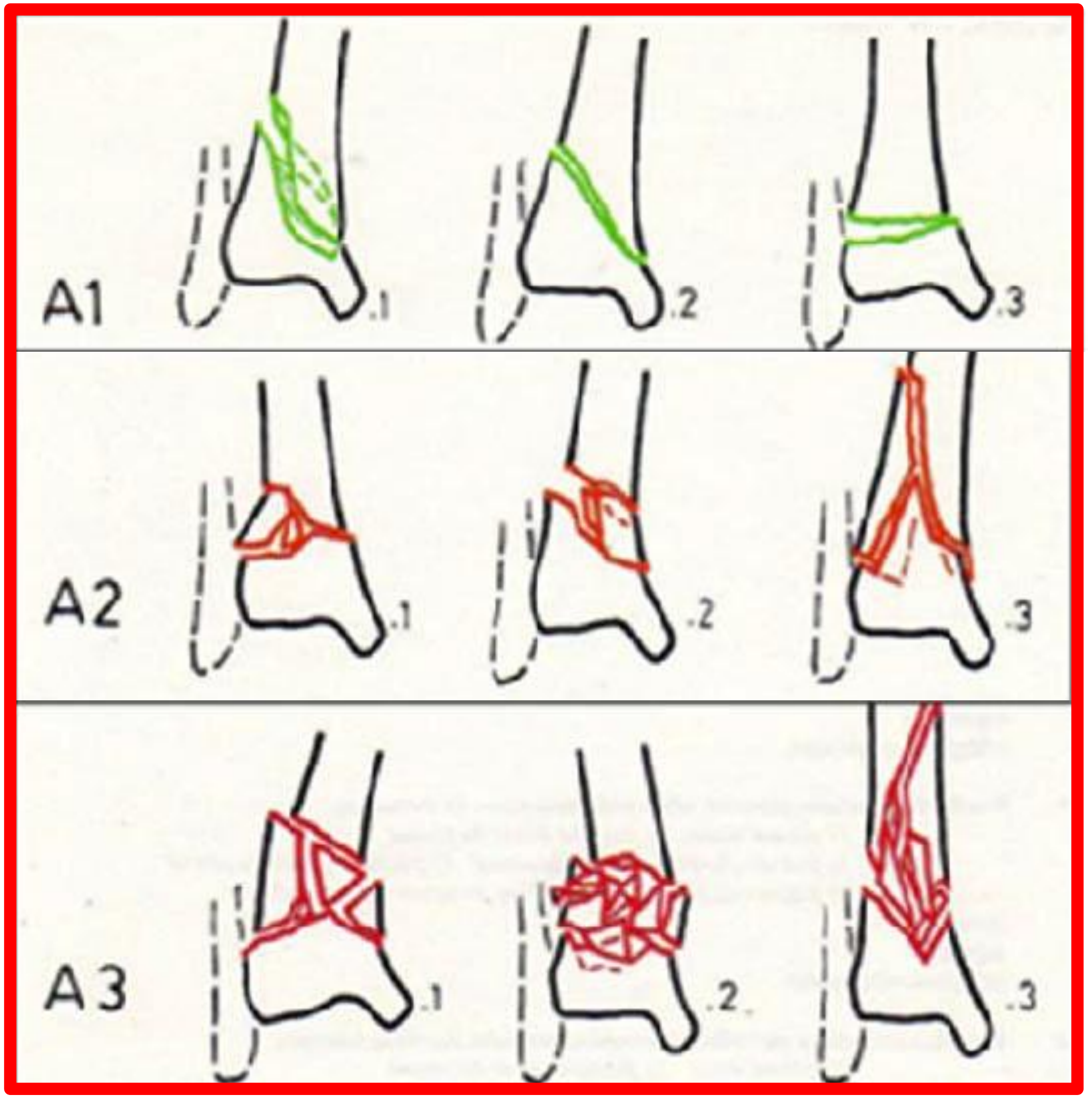
high-velocity injury, soft tissue damage

fibula fixation?

residual varus, valgus, recurvatum, (IM)

difficult reduction and distal locking (IM)
in small metaphyseal fragments

Classification



Treatment options

Conservative?

Plate fixation

Intramedullary nailing

External fixation (temporary)

Hybrid external-fixation

International Orthopaedics (SICOT) (2011) 35:737–742
DOI 10.1007/s00264-010-1052-2

ORIGINAL PAPER

Comparison study of two surgical options for distal tibia fracture—minimally invasive plate osteosynthesis vs. open reduction and internal fixation

Wang Cheng · Ying Li · Wang Manyi

30 cases (15 pairs of ORIF and MIPO)
MIPO not superior to ORIF

Group / statistic	Interval from injury to surgery (days)	Duration of surgery (min)	Drainage volume (ml)	Hospital stay (days)	Healing time (weeks)	Time of recovery to work (weeks)
ORIF	7.1±4.9	87±25.7	175±96.9	12.1±3.8	19.2±23.5	27.7±28.2
MIPO	6.5±3.6	113.3±38.3	104.3±81.4	12.1±3.7	16.8±10.4	21.1±10.5
t value	0.443	−1.942	1.782	−0.134	−0.134	0.909
P value	0.664	0.073	0.096	0.896	0.737	0.379

Injury, Int. J. Care Injured 44 (2013) 1102–1106

Contents lists available at SciVerse ScienceDirect

Injury

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

Comparison of minimally invasive percutaneous plate osteosynthesis with open reduction and internal fixation for treatment of extra-articular distal tibia fractures

Jian Zou, Wei Zhang *, Chang-qing Zhang

	Open group ($n=42$)	Closed group ($n=52$)	*p*-Value
Age (year)	46.0 (36.0, 54.0)	46.5 (39.0, 54.0)	0.599
Gender (male)	27 (64.29%)	39 (75.00%)	0.259
AO/OTA classification			0.273
Type A	25 (59.52%)	27 (51.92%)	
Type B	12 (28.57%)	12 (23.08%)	
Type C	5 (11.90%)	13 (25.00%)	
Operation delayed time (d)	4.0 (3.0, 5.0)	3.5 (3.0, 4.0)	0.068
Operation bleeding (ml)	87.5 (69.0, 115.0)	72.5 (55.5, 113.5)	0.150
Operation time (min)	65.0 (60.0, 77.0)	56.0 (51.5, 65.0)	<0.001*
Follow-up time (month)	14.0 (12.0, 23.0)	15.0 (12.0, 28.0)	0.366
Complications	9 (21.4%)	10 (19.2%)	0.028*
Non-union	4 (9.5%)	1 (1.9%)	
Delayed union	3 (7.1%)	4 (7.7%)	
Infection	2 (4.8%)	0 (0%)	
Malunion	0 (0%)	5 (9.6%)	

No significant difference in healing time Type A and Type B

Type C fractures, had shorter healing time in the closed group

Injury, Int. J. Care Injured 42 (2011) 1031–1037

Contents lists available at ScienceDirect

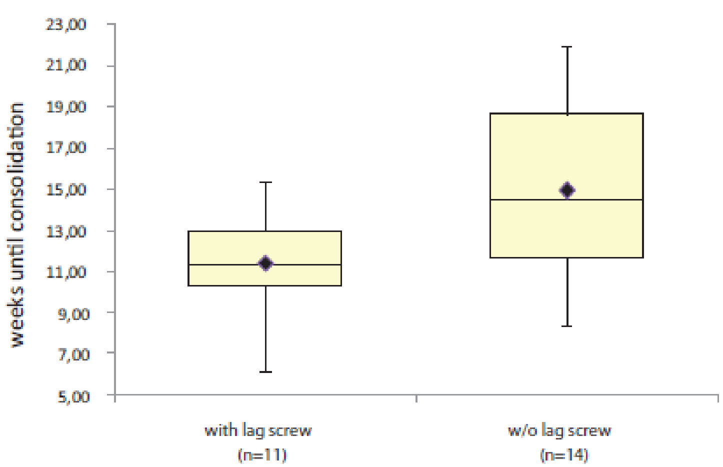
Injury

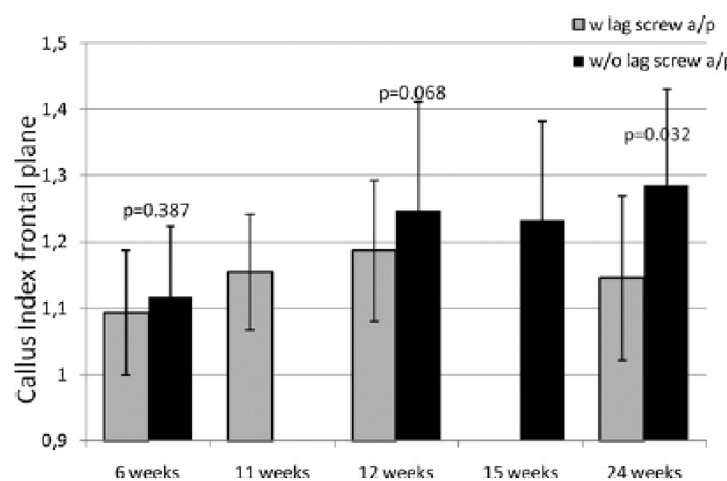
journal homepage: www.elsevier.com/locate/injury

Combination of interfragmentary screws and locking plates in distal meta-diaphyseal fractures of the tibia: A retrospective, single-centre pilot study

C. Horn [b,*], S. Döbele [a], H. Vester [a], A. Schäffler [a], M. Lucke [a], U. Stöckle [a]

41 patients, 30 extra-articular fractures
13/30 extra-articular fractures were treated with interfragmentary screws
11 had shorter time to full WB and heal
Callus index was significantly lesser



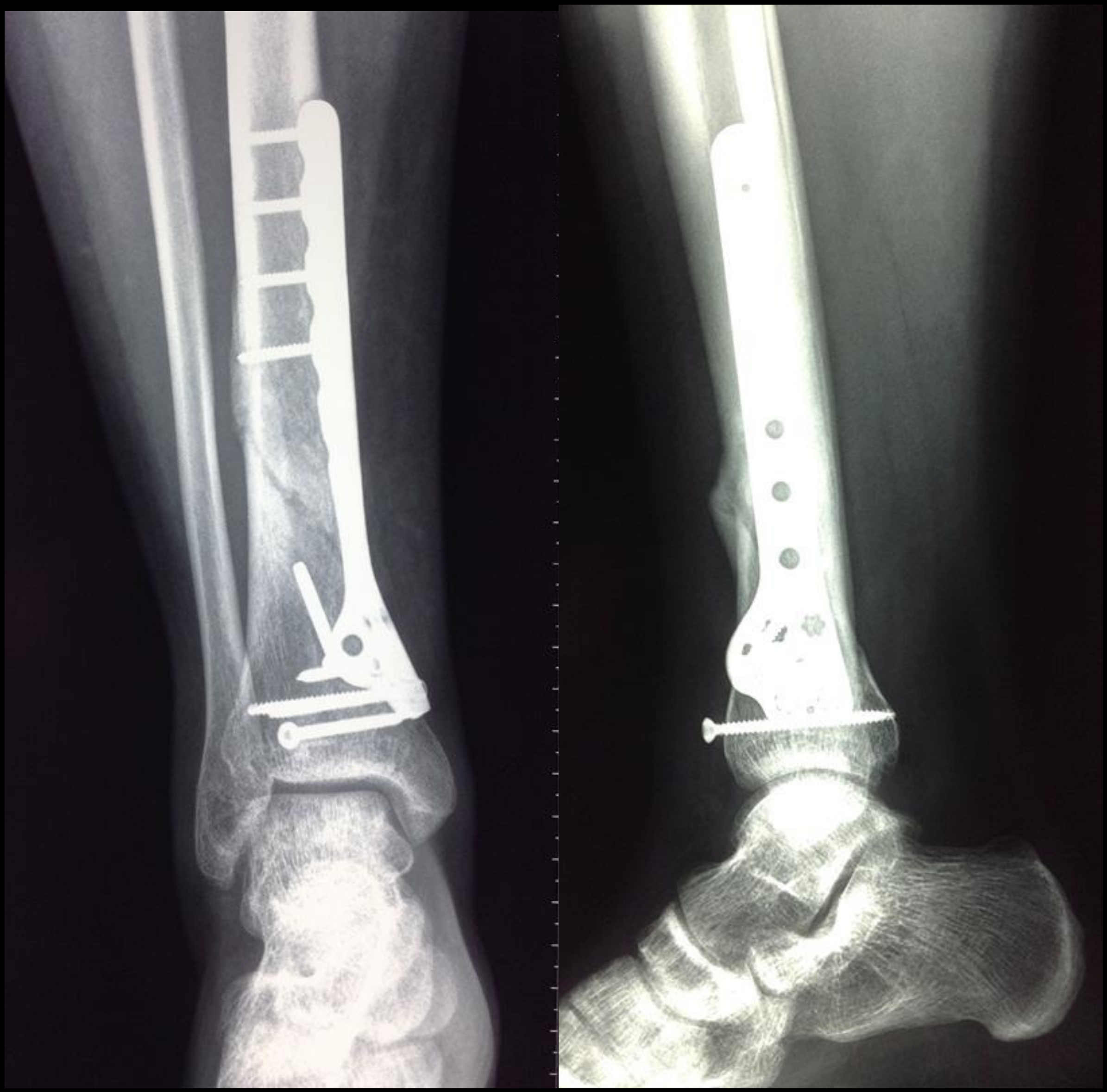


How to facilitate reduction?

Plates

- frame & distraction
- percutaneous forceps
- fracture table
- at least 5 holes above fracture

locking screws should alternate with an empty hole in order to provide a better stress distribution



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Orthopaedics & Traumatology: Surgery & Research (2010) 96, 674–682

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OTSR Orthopaedics & Traumatology Surgery & Research

ORIGINAL ARTICLE

Distal quarter leg fractures fixation: The intramedullary nailing alone option

M. Ehlinger[a,*], P. Adam[a], A. Gabrion[b], L. Jeunet[c], F. Dujardin[d], G. Asencio[e], Sofcot[f]

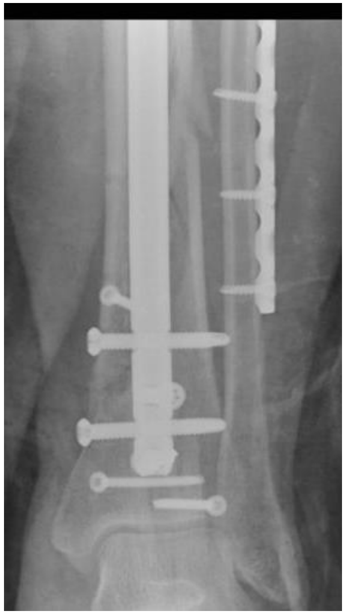
42/51 cases at 1 year
union rate 97.6%
mean 15.7 weeks.
14 **valgus** deviations >5°
4 dynamizations
2 infections

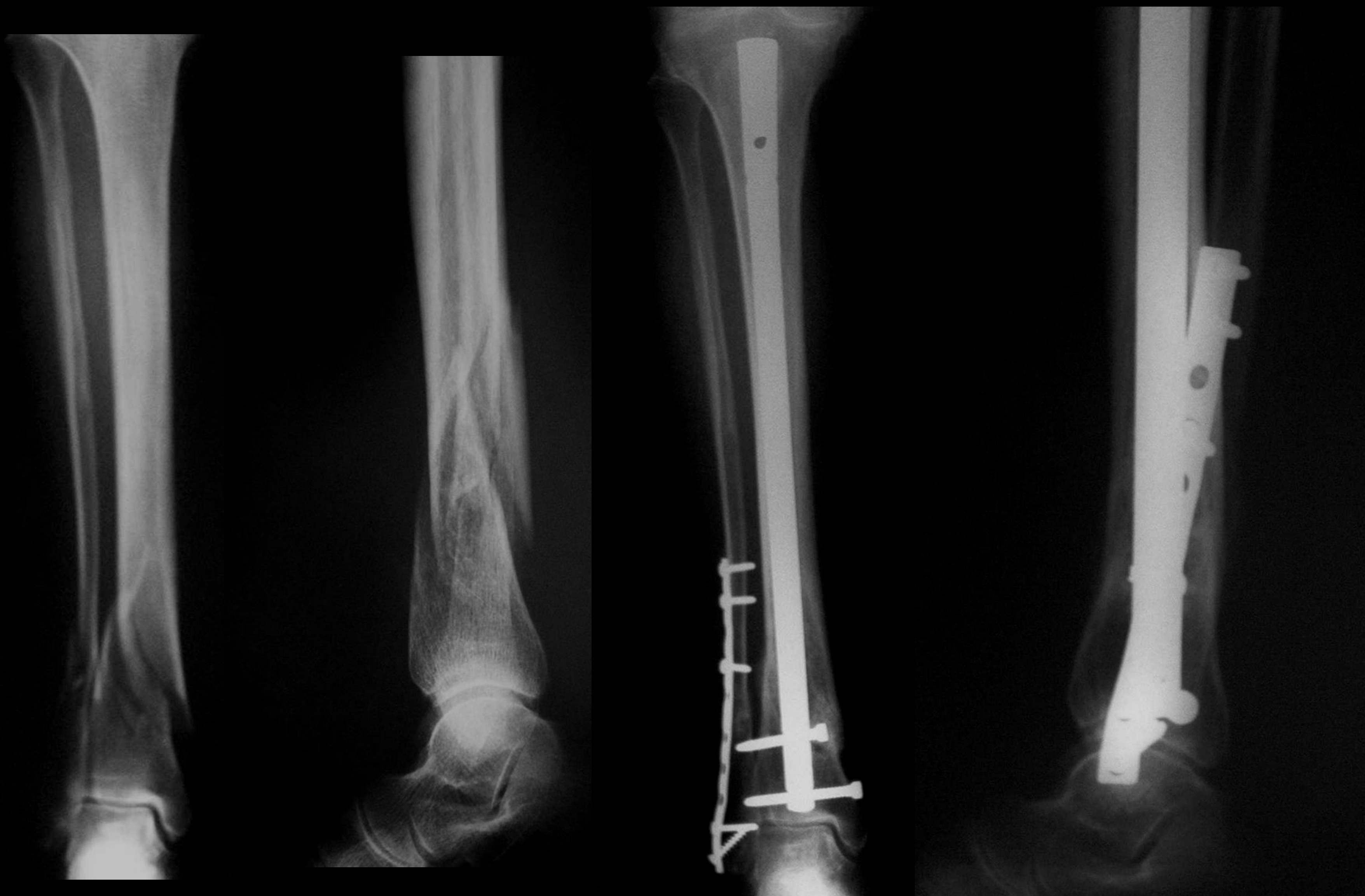
unfixed fibula was the only risk factor for initial axial deviation and fracture instability

How to facilitate reduction?

Nails

- distraction-fracture table
- not ream distal part
- blocking screws
- distal tibial joystick
- fix same level fibula fracture
- distal interlocking with2-3 screws
  at right angles





Injury, Int. J. Care Injured 45 (2014) 408–411

Contents lists available at ScienceDirect

Injury

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

To fix or not to fix? The role of fibular fixation in distal shaft fractures of the leg

M. Berlusconi [a,*], L. Busnelli [a], F. Chiodini [a], N. Portinaro [b]

60 patients with 42 AO shaft fracture

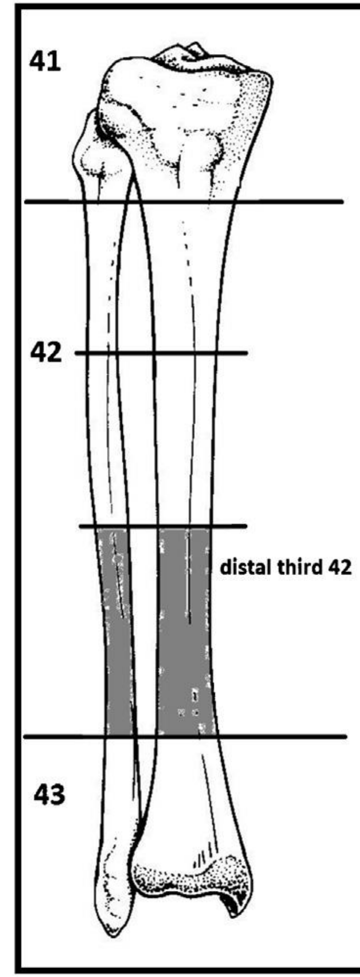
Group I (n = 26) fibula fixed

Group II (n = 34) fibula left

no evidence in favour of fibular fixation

higher tendency to develop a non-union:

- fractures at the same level
- bridging plate in the tibia



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■ TRAUMA

A randomised pilot trial of “locking plate” fixation *versus* intramedullary nailing for extra-articular fractures of the distal tibia

C. Mauffrey,
K. McGuinness,
N. Parsons,
J. Achten,
M. L. Costa

J Bone Joint Surg Br 2012;94-B:704–8.

No statistical significant difference in functional outcome scores between locking-plate and IM nail

	Treatment group	
Complication	**Nail (n = 12)**	**Plate (n = 12)**
Delayed union (> 24 weeks)	1	3
Removal of metalwork	1	4
Delayed wound healing/superficial infection	3	0
Deep infection requiring surgical debridement	0	1
Buckled plate	0	1
Compartment syndrome	1	1

Foot and Ankle Surgery 19 (2013) 143–147

Contents lists available at SciVerse ScienceDirect

Foot and Ankle Surgery

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

Review

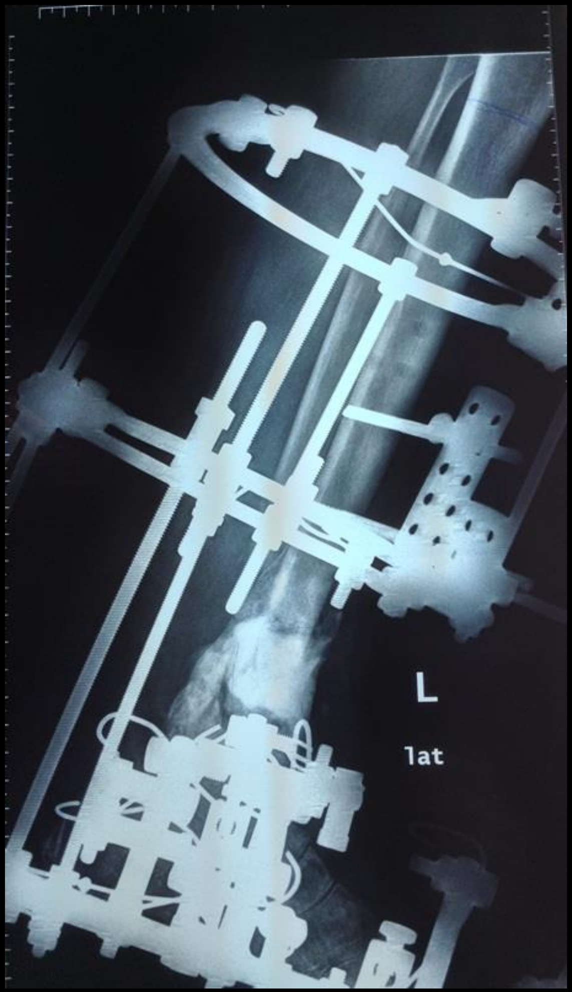
Treatment of distal tibia metaphyseal fractures; plating versus intramedullary nailing: A systematic review of recent evidence

H.J. Iqbal FRCSEd (Tr & Orth)*, P. Pidikiti FRCSEd (Tr & Orth)

- 141 studies evaluated
- 2 prospective randomized controlled trials
- 3 retrospective comparative studies
- relatively higher rate of infection in plating
- malalignment more common with IMN

Summary results.

Treatment	Numbers	Union Rate	Malunion	Nonunion	Infection	Metal removal
Nail	179	95.5%	25.9%	4.5%	5.0%	35.8%
Plate	134	97.8%	5.3%	2.2%	11.2%	45.2%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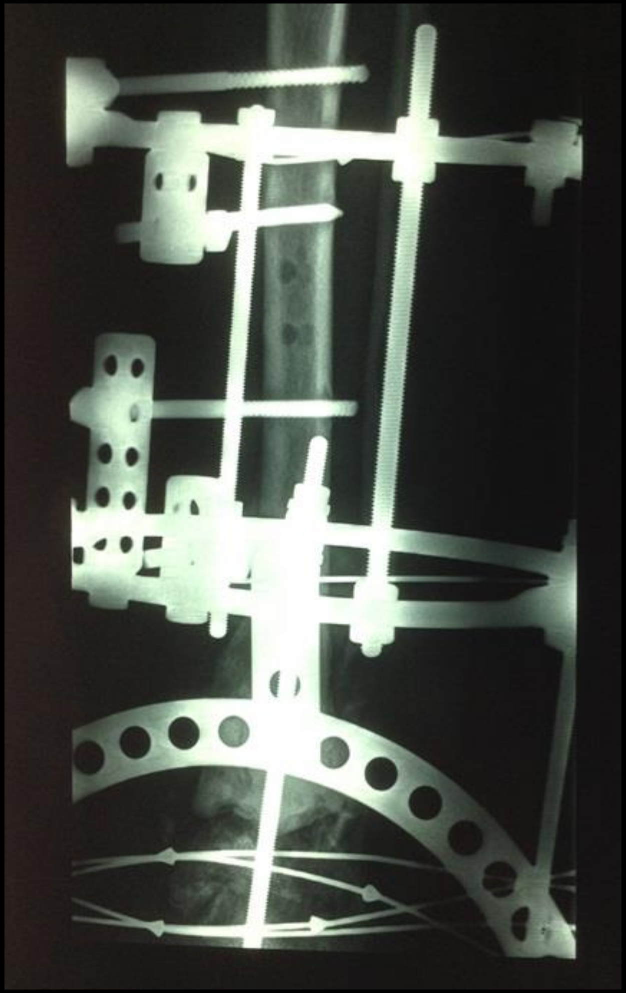


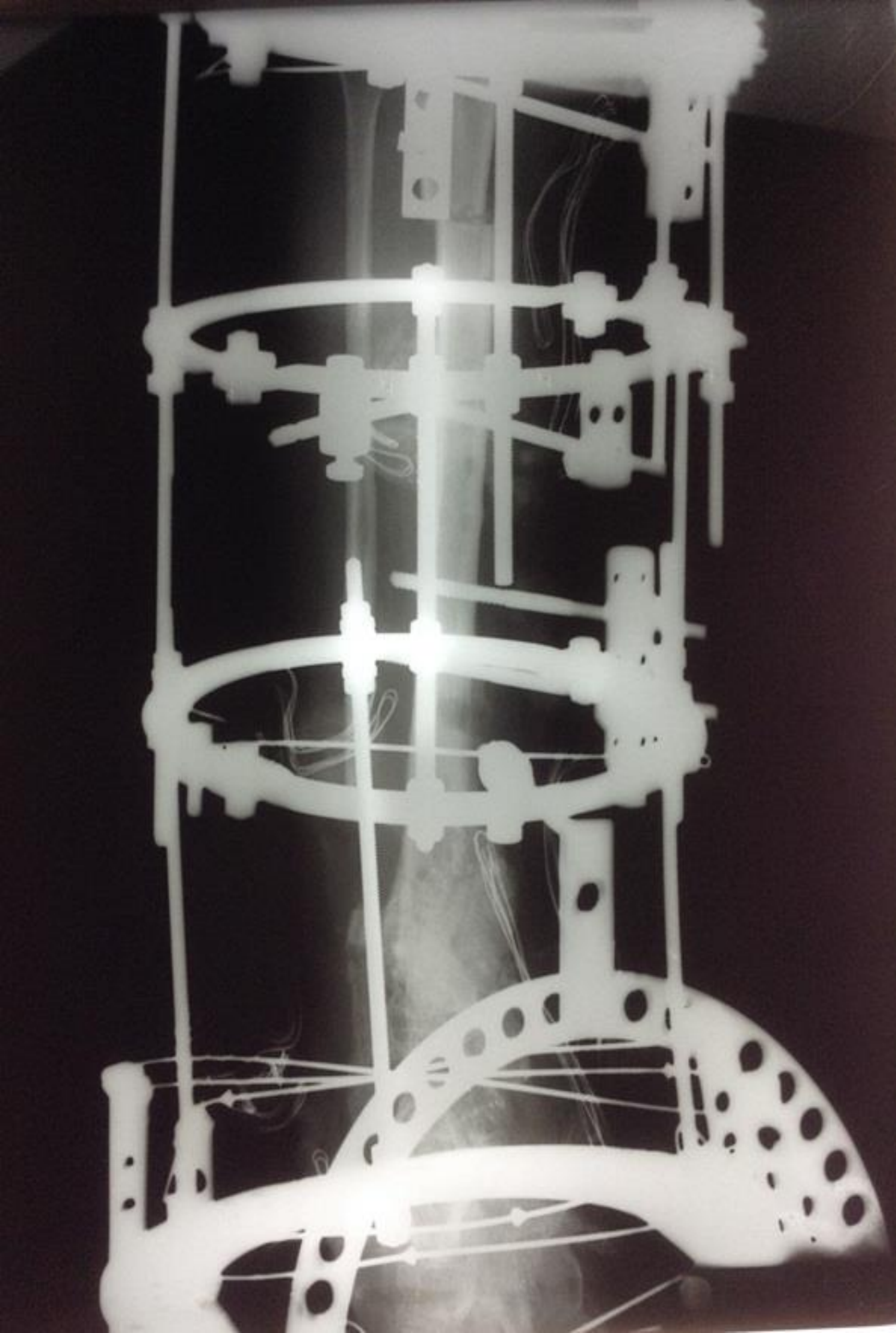


Conclusions

Tibial shaft fractures can be treated with a one or two-stage surgical treatment

Prognosis correlates with injury severity, extent of soft tissue damage and further injuries

Modern plating and IM techniques should be applied in order to achieve adequate reduction and stability

Intramedullary nailing will remain a treatment of choice for diaphyseal fractures but it does seem likely that plating techniques will prove more common for proximal and tibial fractures