Debridment, Irrigation, and Timing of Fixation



Disclosures

• Publications:

- Rockwood and Green, ed; Operative Techniques in Ortho Srugery assoc ed; Tornetta and Einhorn; Subspecialty series, Court-Brown, Tornetta; Trauma, AAOS; OKU Trauma, ICL Trauma, Minimally Invasive Surgery Series, ed; OTA Slide project
- Journals: JOT; Deputy editor, CORR, JBJS, JAAOS; Reviewer

Research

- NIH, OTA, FOT, OREF, AIOD
- Consultant / Designer:
 - Smith Nephew, Kinespring

OTA Evidence Group

Current Practice in the Management of Open Fractures Among Orthopaedic Trauma Surgeons. Part A: Initial Management. A Survey of Orthopaedic Trauma Surgeons

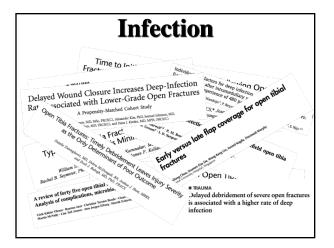
William Obremskey, MD, MPH,* Cesar Molina, MD,* Cory Collinge, MD,† Arvind Nana, MD,† Paul Tornetta III, MD,‡ Claude Sagi, MD,§ Andrew Schmidt, MD, || Robert Probe, MD, § Jaimo Ahn, MD, PhD,** and Bruce D. Browner, MD,† for the Evidence-Based Quality Value and Safety Committee—Orthopaedic Trauma Association, Writing Committee

Author	Y v Title Rating	Journal
Wordsworth	2016 Improving the care of patients with severe open fractures of the tibia: t	Bone Joint J
Westgeest	2016 Factors Associated With Development of Nonunion or Delayed Healing	J Orthop Trauma
Tsang	2016 Exchange nailing for nonunion of diaphyseal fractures of the tibia: our r	Bone Joint J
Prodromidis	2016 The 6-hour rule for surgical debridement of open tibial fractures. A syst	J Orthop Trauma
Penn-Barwell	2016 Factors influencing infection in 10 years of battlefield open tibia fractures	Strategies Trauma Limb Reconstr
Haines	2016 Defining the Lower Limit of a "Critical Bone Defect" in Open Diaphyseal	J Orthop Trauma
Cho	2016 Factors affecting clinical outcomes after treatment of extra-articular o	J Orthop Sci
Burrus	2016 Obesity is associated with increased postoperative complications after	Injury
Blair	2016 Infection and Non-union Following Fasciotomy for Compartment Syndr	J Orthop Trauma
Santolini	2015 Risk	Injury
Olesen	2015 A re	Int Orthop
Metsemakers	2015 India	Injury
fathews	2015 India 2015 Sing 2015 Type	Injury
Madhuchandra	2015 Prec	injury
Lack	2015 Type	J Orthop Trauma
Foote	2015 Whic	Clin Orthop Relat Res
Bernstein	2015 Does	Clin Orthop Relat Res
Weber	2014 Time	J Orthop Trauma
Scolaro	2014 Ciga	J Bone Joint Surg Am
Sanders	2014 CHA 2014 CHA 2014 CHA 2014 EVA 2014 EVA	J Orthop Trauma
Rodriguez	2014 Evid	J Trauma Acute Care Surg
Napierala	2014 Infec	J Trauma Acute Care Surg
Ktistakis	2014 Infec	Injury
lenkinson	2014 Delayed wound closure increases deep-infection rate associated with I	J Bone Joint Surg Am
Hull	2014 Delayed debridement of severe open fractures is associated with a hig	Bone Joint J
D'Alleyrand	2014 Is time to flap coverage of open tibial fractures an independent predicto	J Orthop Trauma
Chua	2014 Early versus late flap coverage for open tibial fractures	J Orthop Surg (Hong Kong)
rusof	2013 Factors associated with the outcome of open tibial fractures	Malays J Med Sci
Large	2013 Does perioperative systemic infection or fever increase surgical infect	J Trauma Acute Care Surg
ong	2013 Predictors of nonunion and reoperation in patients with fractures of the	BMC Musculoskelet Disord
akoor	2013 Assessment of prophylactic bone grafting effect on union of open tibial	Pak J Med Sci
Cheng	2013 Risk of infection with delayed wound coverage by using negative-press	J Plast Reconstr Aesthet Surg
Almeida Matos	2013 Risk factors associated with infection in tibial open fractures	Rev Fac Cien Med Univ Nac Cordob
Soni	2012 Gustilo IIIC fractures in the lower limb: our 15-year experience	J Bone Joint Surg Br
Pasquier	2012 Infections and tourniquet application in severe open tibla fractures fro	J Trauma Acute Care Surg
lile	2012 is non-union of tibial shaft fractures due to ponculturable bacterial path	J Orthon Surg Bes

High Points

- Open fractures are bad
- "Bad" ones are worse
- Infection is the enemy







Infection

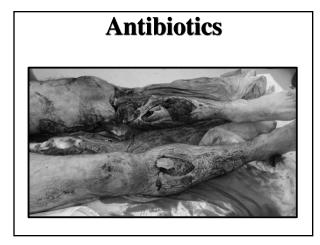
- Time to antibiotics
- Time to debridement
- Soft tissue injury
 - Implant timing?
- Time to coverage
- Type of fixation?

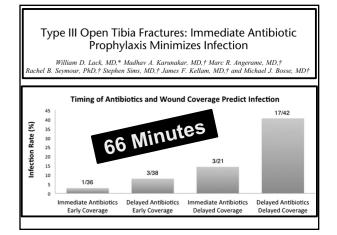


Infection

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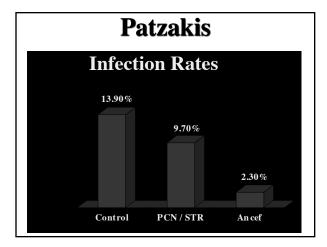




Patzakis

- Randomized trial
- 10 Day course of Ab
 - Control group
 - PCN / Streptomycin
 - Cephalothin







Factors Affecting Infection

< 3 hours = 4.7% infection

> 3 hours = 7.4% infection

Local

- Henry, et al
- Bead pouch technique
 - PMMA + tobra
 - Elutes high levels of local Ab
 - Minimal systemic concentration
 - Bathes the fracture in Ab

Bead Pouch

- Tobramycin levels
 - Serum level = 0.3 1.6 MCG / ml
 - + Local level = 7.2 258 MCG / ml

• Avg. 50 MCG / ml

- Local environment
 - PO₂ = 69 mm Hg



Ostermann

- Systemic Ab = 12% infection
- Bead pouch = 3.7% infection
- Acute infection less in 3B, 3C
- Osteomyelitis less in 2, 3B

Antibiotic Choice

- Seroma, granulation tissue, and bone
- Clindamycin (6gm / 40gm)
 - Best overall
- Tobramycin (9.8gm / 40 gm)
 - Best for seroma, tissue
 - Not as good for bone
- Vancomycin (4gm / 40 gm)
 - Not as good for seroma

	Inje	ction			
Local Injection of Aminoglycosides for Prophylaxis Against Infection in Open Fractures Cheryl Resse Lawing, MD, Feng-Chang Lin, PhD, and Laurence E. Dahners, MD Investigation performed at the University of North Carolina at Chapel Hill, North Carolina					
TABLE III Infection Rates	No Infection	Deep Infection	Deep and Superficial Infection		
Control group (n = 183) Intervention group (n = 168)	80.3% (147 fractures) 90.5% (152 fractures)	14.2% (26 fractures) 6.0% (10 fractures) 0.011	19.7% (36 fractures) 9.5% (16 fractures) 0.010		



Recommendations

- Grade 1
 - + 3 Days of Ancef
 - + PCN if farm
- Grade 2 and 3A
 - 3 Days of ancef
 - Add 24° load of AG if late, contaminated, or tissue in poor condition
 - Add PCN if farm

Debridement

Timing

Time to Initial Operative Treatment Following Open Fracture Does Not Impact Development of Deep Infection: A Prospective Cohort Study of 736 Subjects

Donald Weber, MD, FRCS,* Sukhdeep K. Dulai, MD, MSc, FRCS,* Joseph Bergman, MD, FRCS,* Richard Buckley, MD, FRCS,* and Lauren A. Beaupre, PT, PhD*

Debridement Timing Adequacy!

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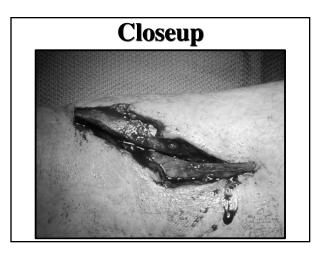
Timing of Wound Closure in Open Fractures Based on Cultures Obtained After Debridement

> By Christopher J. Lenarz, MD, J. Tracy Watson, MD, Berton R. Moed, MD, Heidi Israel, PhD, RN, J. Daniel Mullen, MSPH, BA, BS, and James B. MacDonald, BS

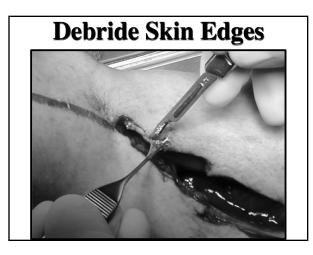






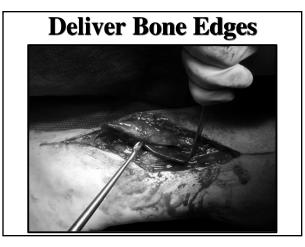


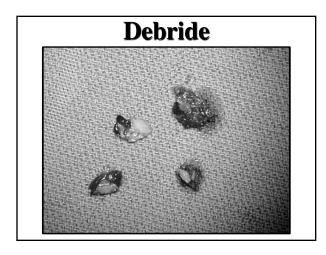




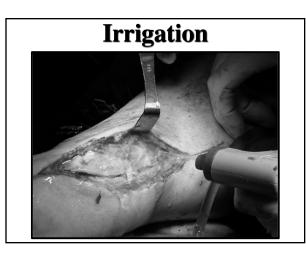












Irrigation

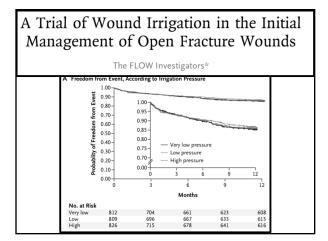
A Trial of Wound Irrigation in the Initial Management of Open Fracture Wounds

The FLOW Investigators*

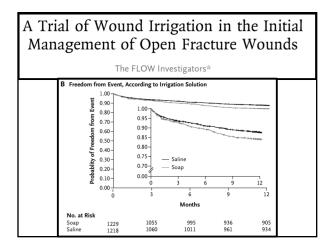
Flow Study

- 2338 Open fractures
 - Tibia, other LE, UE
- Deep infection
 - Tibia > UE
 - Other LE > UE
 - Gustilo type
 - Delayed closure
 - Need for flap

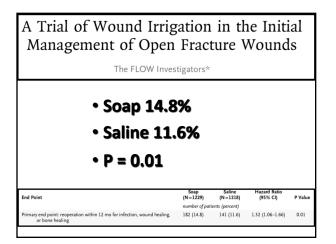














Subgroup	Hazard Ratio (95% CI)
Overall	1.32 (1.06-1.66)
Gustilo-Anderson fracture grade	
lor II H	1.20 (0.89-1.61)
	1.47 (1.05-2.08)
Extremity	
Upper	0.92 (0.49-1.76)
Lower	1.42 (1.12-1.81)
Fracture gap	
<1 cm	1.27 (0.99-1.62)
al on	1.60 (0.84-3.07)
Tibial injury	
No H	1.16 (0.83-1.61)
Yei	1.56 (1.14-2.13)
tes Definitive fluzion	
Intramedullary nail	1.72 (1.16-2.55)
Faternal fixator	1.39 (0.89-2.17)
Plate	1.39 (0.89-2.17)
Articular involvement	1.00 (0.65-1.54)
Intraanticular	120 (0.84-1.70)
Extraarticular	1.42 (1.05-1.92)
Surgical preparation in emergency department	
Yes	1.18 (0.72-1.95)
No	1.36 (1.06-1.76)
Surgical preparation solution	
Chlorhexidine H	1.29 (0.92-1.80)
lodine H	1.34 (0.94-1.91)
Alcohol or other	1.55 (0.80-3.00)
Adequate volume of fluid	
Grade III fracture	
No -	 1.92 (0.16-22.53
Yes	1.36 (1.00-1.85)
Grade I or II fracture	
No	-
Yes	1.21 (0.86-1.70)
Wound contamination	
Mid	1.32 (1.00-1.76)
Moderate	1.47 (0.90-2.39)
Severe	1.48 (0.74-2.95)
Duration of antibiotic use within first wk after surgery	
of days	1.87 (1.28-2.74)
ət days	1.08 (0.81-1.44)
Time from injury to surgery	
sight	0.93 (0.58-1.48)
6-12 hr	1.59 (1.12-2.26)
	1.37 (1.12-2.28)
214.00	0 20 30 40

Any Infection

Not related to:

- Time to debridement
 - •6, 12, 24 hours (p=0.13)
 - 108 > 24 hours
- Smoking
- Bone loss
- Initial bone graft
- OR time > 120 minutes

Any Infection				
Hazzard Ratio	Р			
5.13	< 0.001			
3.63	< 0.001			
2.12	0.004			
1.08	0.004			
1.82	0.017			
0.61	0.02			
	Hazzard Ratio 5.13 3.63 2.12 1.08 1.82			



Deep Infection			
Factor	Hazzard Ratio	Р	
Tibia vs UE	2.72	< 0.001	
LE vs UE	2.98	< 0.001	
Delayed closure	1.89	0.003	
Type 3 Injury	1.57	0.016	
Need for flap	2.05	0.017	

Deep Infection			
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Infection

- Time to antibiotics
- Time to debridement
- Soft tissue injury
 - Implant timing?
- Time to coverage
- Type of fixation?



Contamination! Single-stage orthoplastic reconstruction of Gustilo-Anderson Grade III open tibial fractures greatly reduces infection rates

J.A. Mathews^{*}, J. Ward, T.W. Chapman, U.M. Khan, M.B. Kelly

	on in patients presenting led by nature of operati	with Gustilo-Anderson ons.	Grade III open
Combined single-stage orthoplastic fixation and coverage	Deep infection		
	No (%)	Yes (%)	Total
No	17 (65.4%)	9 (34.6%)	26
1/	46 (95.8%)	2 (4.2%)	48
Yes		11 (14.9%)	74
Yes Overall	63 (85.1%)		



Jonathan Charlu, Jerald Westberg, Emily Wagstrom, Saam Morshed, Abigail Cortez, Peter Krause, Andrew Marcantonio, Gillian Soles, Jason

Implant to Flap Time

- Exposed implant
- Contamination



Increase infection?

Purpose

- Evaluate
- Factors affecting infection
 - Time to coverage from injury
 - Time to coverage from fixation
- Open tibias requiring coverage

Methods

- Multicenter study
 - 14 Trauma centers
 - Retrospective



Infection

- Clinical infection
- IV antibiotics > 1 week
- Debridement in OR



Demographics				
	Total	Infected	%	
Ν	296	96	32.4	
Male	227	77	33.9	
Female	69	19	27.5	
Age	40.34	39.88		
Smoker	143	46	32.2	
Diabetic	15	5	33.3	

Treatment

- 35 Definitive ex-fix
- 81 Fixation on 1st I&D
- 215 Delay in fixation



Soft Tissue Procedures

• 46% Rotational flap



- 38% Free muscle flap
- 16% Fasciocutaneous flap

Timing					
Dava to flan	Infec	ted?	р		
Days to flap	Yes (96)	No	P		
Debridemen t	12.7 ± 11.7	9.7 ± 7.3	0.007		
Fixation	7.3 ± 9.2	4.9 ± 6.6	0.01		

Infection: Univariate		
	P value	
Temporary internal fixation	0.6	
Time 1 st debridement to flap	0.13	
Time fixation to flap	0.004	
Flap failure	<0.001	



Infection: Univariate

P value
0.6
0.13
0.004
<0.001

_		

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Infection Multivariate							
Coef P value							
Temp internal fixation	0.372	0.498					
Time 1 st debride - flap	-0.002	0.918					
Time fixation to flap	0.058	0.093					
Flap failure	1.794	<0.001					
Constant -1.967 0							

Infection Multivariate				
	Coef	P value		
Temp internal fixation	0.372	0.498		
Time 1 st debride - flap	-0.002	0.918		
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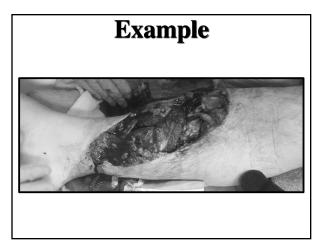
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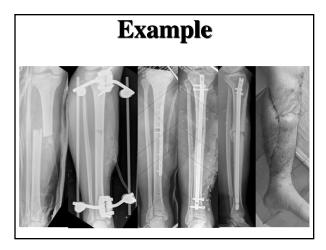


Summary

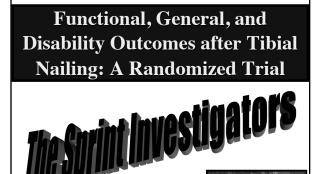
- 296 patients
- High grade open tibias
 - + 215 Delayed fixation
- Infection correlated with:
 - Time from fixation and flap
 - Flap failure

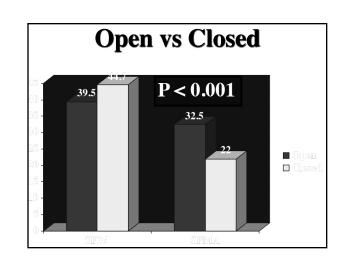




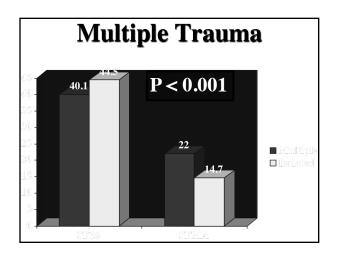


Functional Outcome?

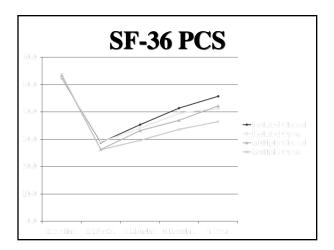




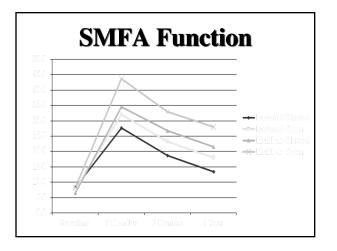














Activity Return						
RETURN OF	All (661)	Open (205)	Closed (456)	Isolated (435)	Multitrauma (226)	Isolated Closed (307)
Exercise	56%	45%	61%	64%	40%	69%
Training	53%	43%	58%	60%	37%	65%
Sports	44%	33%	48%	50%	31%	54%
Employment	65%	50%	71%	73%	48%	79%

Summary

- Time to antibiotics
- Debridement
 - Adequacy
- Irrigation
 - Saline
- Timing of definitive fixation

