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A Comparison of More and Less Aggressive Bone Debridement Protocols for the Treatment of Open Supracondylar Femur Fractures

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Abstract

Objectives—This study compared results of aggressive and nonaggressive debridement protocols for the treatment of high energy open supracondylar femur fractures after the primary procedure, with respect to the requirement for secondary bone grafting procedures, and deep infection.

Design—Retrospective review

Setting—Level I and Level II Trauma Centers

Patients/Participants—Twenty-nine consecutive patients with high grade open (Gustilo Types II and III) supracondylar femur fractures (OTA/AO 33A and C) treated with debridement and locked plating.

Intervention—Surgeons at two different Level I trauma centers had different debridement protocols for open supracondylar femur fractures. One center used a More Aggressive (MA) protocol in their patients (n=17) that included removal of all devitalized bone and placement of antibiotic cement spacers to fill large segmental defects. The other center used a Less Aggressive (LA) protocol in their patients (n=12) that included debridement of grossly contaminated bone with retention of other bone fragments and no use of antibiotic cement spacers. All other aspects of the treatment protocol at the two centers were similar: definitive fixation with locked plates in all cases; IV antibiotics were used until definitive wound closure; and weight bearing was advanced upon clinical and radiographic evidence of fracture healing.

Main Outcome Measurements—Healing after the primary procedure, requirement for secondary bone grafting procedures, and the presence of deep infection.

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Level of Evidence: Therapeutic Level III. See Instructions for Authors for a complete description of levels of evidence.

Results—Demographics were similar between included patients at each center with regard to: age; gender; rate of open fractures; open fracture classification; mechanism; and smoking ($p>.05$). Patients at the MA center were more often diabetic ($p<.05$). Cement spacers to fill segmental defects were used more often after MA debridement (35% vs 0%, $p<0.006$) and more patients had a plan for staged bone grafting after MA debridement (71% vs 8%, $p<0.006$). Healing after the index fixation procedure occurred more often after LA debridement (92% vs 35%, $p<0.003$). There was no difference in infection rate between the two protocols: 25% with the LA protocol; and 18% with the MA protocol, ($p=0.63$). All patients in both groups eventually healed and were without evidence of infection at an average of 1.8 years of follow-up.

Conclusion—The degree to which bone should be debrided after a high energy, high grade, open supracondylar femur fracture is a matter of surgeon judgment and falls along a continuous spectrum. Based on the results of the current study, the theoretic tradeoff between infection risk and osseous healing potential, seems to favor a less aggressive approach towards bone debridement in the initial treatment.

Keywords

Open Fracture; Debridement; Infection; Nonunion

Introduction

Open fractures are known to be at an increased risk for complications, especially healing complications and infection(1-6). Initial treatment of open fractures, especially high energy open fractures, requires a thorough surgical debridement with wound irrigation(2). Much debate and multiple investigations have addressed the optimal timing of such debridements and the preferred irrigant solution(7-11). Little emphasis has been placed on the appropriate aggressiveness of such debridements. Debridement of devitalized non-articular bone and retention of well perfused bone with robust soft tissue attachments are generally recommended(12, 13). There is little known regarding the optimal management of fragments with marginal viability, those with between minimal and moderate soft tissue attachments. Relatively aggressive debridement of such marginally vital bone theoretically minimizes infection risk but may lead to segmental bone defects that require secondary surgical interventions. Less aggressive bone debridement may increase the risk of infection, but leaves behind more bone for potential healing. This study attempted to compare the results of aggressive versus nonaggressive debridement protocols for the treatment of high energy, open supracondylar femur fractures with regard to healing after the primary procedure, requirement for secondary bone grafting procedures, and deep infection.

Methods

Surgical Protocols

Fellowship trained orthopaedic trauma surgeons at two trauma centers (one Level I and one Level II) had different debridement protocols for open supracondylar femur fractures. One center used a More Aggressive (MA) protocol that included removal of all non-vitalized and most marginally vitalized bone with placement of antibiotic cement spacers to fill large

segmental defects. Patients with low grade open fractures that did not have large defects did not have cement spacer implanted. The other center utilized a Less Aggressive (LA) protocol that included debridement of grossly contaminated or completely devascularized bone with retention of other bone fragments but did not employ antibiotic cement spacers. Soft tissue debridement was similar at each center, devitalized soft tissues were debrided entirely.

All other aspects of treatment protocols at the two centers were similar: definitive fixation was performed using locked plates in all cases; IV antibiotics were used until definitive wound closure; bone stimulators were not utilized, and weight bearing was advanced upon clinical and radiographic evidence of fracture healing. The expected requirement for secondary bone grafting to fill defects created by debridement was determined at the time of final debridement. Data was extracted retrospectively from patient charts, operative reports, clinic notes and radiographs.

Patients

Consecutive adult patients treated between November 1999 and January 2009 with locked plates for supracondylar femur fractures (OTA 33)(14) at the two centers were identified from various databases according to an IRB approved protocol. There were 113 patients at the MA center and eighty at the LA center. From among these 193 patients and according to the Gustilo et al (15)classification, twenty-nine (15%) had high grade open fractures (Types II and III): seventeen treated at the MA center (average age 50 years, range 30-78 years, 12 male) and 12 at the LA center (average age 53 years, range 27-80 years, 7 male) (Table 1).

Fractures

According to the OTA classification(14), all 17 fractures at the MA center and 9/12 at the LA center had metaphyseal comminution (OTA A2, A3, C2, C3), consistent with the high energy associated with open distal femur fractures. There were 15 Type III open fractures and 2 Type II in the MA group and 11 Type III and 1 Type II in the LA group(15). Additional demographic details are presented in Table 1.

Outcomes

Reoperation to promote union and deep infection were defined as primary outcome measures and used as dependent variables in statistical analyses. Reoperation to promote union was defined as any re-operation including planned or unplanned procedures for the purpose of promoting fracture union. Deep infection was defined by clinical signs of infection that necessitated surgical irrigation and debridement and antibiotic treatment.

Statistics

Dichotomous variables (use of a cement spacer, open fracture type, requirement for bone grafting, fracture healing, smoking status, diabetic status, open fracture frequency, and gender) were compared using the Chi squared test and continuous variables (age) were compared using a two-tailed Student's t-Test. Statistical significance was considered for $p < 0.05$.

A deep infection rate of 20% was considered as expected after plating of Type II and Type III open distal femur fractures. An infection rate of less than 16% or greater than 24% (20% different) was considered clinically relevant. Power calculation with $\alpha < 0.05$, $\beta \leq 20\%$ (power $\geq 80\%$) and an expected effect size of 0.2, using independent samples t-test to analyze the difference in means between groups, showed a sample size of 191 subjects was required to avoid type-2 error. The sample size of 29 in the current study had a 19% power at $p < 0.05$ for deep infection.

Results

Comparison of Patient and Fracture Characteristics and Treatments

Demographics were similar between each group with regard to: age; gender; frequency of open and closed fractures; open fracture classification; and smoking ($p > 0.05$). Patients in the MA group were more often diabetic ($p < 0.05$) (Table 1). Cement spacers to fill segmental defects were used more often after debridement for patients in the MA group (35% vs 0%, $p < 0.006$) (Table 2).

Comparison of Healing and Infection

Of the seventeen patients in the MA group, eleven required additional surgery and five of these required more than one additional procedures to promote union. One patient required two additional procedures. In the LA group, one patient required bone grafting to achieve union. Healing after the index fixation procedure occurred more often in the LA group (92% vs 35%), ($p < 0.003$). There was no difference in infection rate between the two protocols: 25% with the LA group; and 18% in the MA group ($p = 0.63$). All patients in both groups were followed to eventually healing and all were without evidence of infection at an average of 1.8 years of follow-up.

Discussion

Surgical debridement and irrigation represents an important part of the treatment algorithm for patients with open fractures. Relatively aggressive debridement to include excision of all non-viable soft tissues and bone has been the “de facto” standard for the current generation of surgeons dealing with these injuries. Just as the “six hour rule” for time to debridement of open fractures has recently been challenged(11), the current study was meant to question the utility of aggressive debridement protocols for open fracture management. Surely, the optimal degree of bone debridement falls along a continuum: inadequate debridement leads to one set of potential problems (infection) and overly aggressive debridement leads to a different set of potential problems (nonunion). Distal femur fractures treated with locked plates were used as the model for this investigation because this combination of injury and treatment is relatively common and is associated with a sufficiently high rate of healing complications to be clinically relevant(16-21). The results of the current investigation indicate that a highly aggressive debridement protocol appears not to be optimal, and supports a somewhat less aggressive approach.

In the current study, a strategy of aggressive debridement for open supracondylar femur fractures used at one center included removal of all non-vital bone fragments, which resulted

in segmental bone defects large enough to support placement of an antibiotic spacer to fill the void in 35% of patients. The protocol is consistent with the Masquelet technique(22). The theoretical advantage of this strategy is to minimize deep infection while accepting the requirement for additional bone grafting procedures to accomplish healing in a large subset of patients. An unintended consequence of this protocol was the requirement for multiple additional procedures in five patients (29%) to promote union. This represented substantial added morbidity and time before union occurred.

Less aggressive debridement without use of antibiotic spacers, as part of a protocol at the other center participating in this study, was used to maximize the healing potential. The degree of debridement was considered to be sufficient to minimize infection risk. Despite being termed “less aggressive” in this study, it should be emphasized that the critical basic principles of open fracture debridement was applied, e.g. all contamination and completely devascularized tissues were removed. The results of the study supported the theoretical benefit of less aggressive debridement. Healing without the requirement for secondary procedures occurred more often with less aggressive debridements (92%) versus the more aggressive debridement approach (35%). This difference was statistically significant and, we believe, is highly clinically significant. The trade-off, a potential for higher infection, was not found to be statistically significant. It must be noted that the study population was found to be underpowered with regard to differences in infection rates. Approximately 200 patients would be required to identify a difference in infection rates of 16% in one group compared to 24% in the other as being statistically significant with 80% power and a p value of 0.05. The fact that all fractures in both groups healed without signs of residual infection might make such an increased infection rate relatively more acceptable, especially if associated with a substantially reduced need for secondary bone grafting procedures, a reduced period of functional limitation.

Several limitations of the present study should be considered. The retrospective nature of the study provides for inherent biases. Although one center generally performed more aggressive debridements than the other, the relative aggressiveness for any given patient was not controlled. Given the standard of care associated with surgical debridement after open fracture, we believe that without the retrospective pilot data provided in the current study, subjecting patients to a less aggressive debridement than standard, as part of a prospective protocol, might not be ethically feasible. Also, patients receiving more aggressive debridement were more often diabetic. This may have skewed healing and infection results.

The degree to which bone should be debrided after open fracture is a matter of surgeon judgment and falls along a continuum. The theoretic tradeoff between infection risk and osseous healing potential, based on the results of the current study, seems to favor less aggressive debridement for the initial treatment of high energy, high grade, open supracondylar femur fractures treated with locked plating.

References

1. Court-Brown CM, Keating JF, McQueen MM. Infection after intramedullary nailing of the tibia. Incidence and protocol for management. *JBone Joint Surg[Br]*. 1992; 74:770–774.

2. Bucholz, RW.; Court-Brown, CM.; Heckman, JD., et al., editors. Rockwood and Green's Fractures in Adults. Philadelphia: Wolters Kluwer: Lippincott Williams & Wilkins; 2010. Initial management of open fractures; p. 283-302.
3. Court-Brown CM, Rimmer S, Prakash U, et al. The epidemiology of open long bone fractures. *Injury*. 1998; 29:529–534. [PubMed: 10193496]
4. Merritt K. Factors Increasing the Risk of Infection in Patients with Open Fractures. *JTrauma*. 1988; 28(6):823–827. [PubMed: 3385826]
5. Dellinger EP, Miller SD, Wertz MJ. Risk of Infection after open fracture of the arm or leg. *ArchSurg*. 1987; 123:1320–1327.
6. Patzakakis MJ, Wilkins J. Factors influencing infection rate in open fracture wounds. *Clin Orthop Relat Res*. 1989;36–40. [PubMed: 2721073]
7. Petrisor B, Sun X, Bhandari M, et al. Fluid lavage of open wounds (FLOW): a multicenter, blinded, factorial pilot trial comparing alternative irrigating solutions and pressures in patients with open fractures. *J Trauma*. 71:596–606. [PubMed: 21378581]
8. Stannard JP, Volgas DA, McGwin G 3rd, et al. Incisional negative pressure wound therapy after high-risk lower extremity fractures. *J Orthop Trauma*. 26:37–42. [PubMed: 21804414]
9. Pollak AN, Jones AL, Castillo RC, et al. The Relationship Between Time to Surgical Debridement and Incidence of Infection After Open High-Energy Lower Extremity Trauma. *Journal of Bone and Joint Surgery*. 2010; 92:7–15. [PubMed: 20048090]
10. Lenarz CJ, Watson JT, Moed BR, et al. Timing of Wound Closure in Open Fractures Based on Cultures Obtained After Debridement. *Journal of Bone and Joint Surgery*. 2010; 92:1921–1926. [PubMed: 20660225]
11. Schenker ML, Yannascoli S, Baldwin KD, et al. Does timing to operative debridement affect infectious complications in open long-bone fractures? A systematic review. *J Bone Joint Surg Am*. 2012; 94:1057–1064. [PubMed: 22572980]
12. Dunbar, RPG.; G, MJ. Initial management of Open Fractures. In: Bucholz, RW.; C-B, CM.; Heckman, JD.; Tornetta, P., III, editors. Rockwood and Green's Fractures in Adults. Philadelphia: Lippincott; 2010. p. 283-302.
13. Behrens, FF.; S, MS. Fractures with Soft Tissue Injuries. In: Browner, BD.; J, JB.; Levine, AM.; Trafton, PG., editors. *Skeletal trauma*. Philadelphia, PA: Saunders; 2003. p. 293-319.
14. Marsh JL, Slongo TF, Agel J, et al. Fracture and Dislocation Classification Compendium - 2007: Orthopaedic Trauma Association Classification, Database and Outcomes Committee. *Journal of Orthopaedic Trauma*. 2007; 21
15. Gustilo RB, Anderson JT. Prevention of Infection in the Treatment of One Thousand and Twenty-Five Open Fractures of Long Bones: A Retrospective and Prospective Analysis. *JBone Joint Surg[Am]*. 1976; 58A:453–458.
16. Vallier HA, Immler W. Comparison of the 95-degree angled blade plate and the locking condylar plate for the treatment of distal femoral fractures. *J Orthop Trauma*. 2012; 26:327–332. [PubMed: 22183200]
17. Henderson CE, Lujan TJ, Kuhl LL, et al. 2010 mid-America Orthopaedic Association Physician in Training Award: healing complications are common after locked plating for distal femur fractures. *Clin Orthop Relat Res*. 2011; 469:1757–1765. [PubMed: 21424831]
18. Lujan TJ, Henderson CE, Madey SM, et al. Locked plating of distal femur fractures leads to inconsistent and asymmetric callus formation. *J Orthop Trauma*. 2010; 24:156–162. [PubMed: 20182251]
19. Streubel PN, Gardner MJ, Morshed S, et al. Are extreme distal periprosthetic supracondylar fractures of the femur too distal to fix using a lateral locked plate? *J Bone Joint Surg Br*. 2010; 92:527–534. [PubMed: 20357329]
20. Ricci WM, Loftus T, Cox C, et al. Locked plates combined with minimally invasive insertion technique for the treatment of periprosthetic supracondylar femur fractures above a total knee arthroplasty. *JOrthopTrauma*. 2006; 20:190–196.
21. Henderson CE, Kuhl LL, Fitzpatrick DC, et al. Locking plates for distal femur fractures: is there a problem with fracture healing? *J Orthop Trauma*. 2011; 25(Suppl 1):S8–14. [PubMed: 21248560]

22. Masquelet AC, Begue T. The concept of induced membrane for reconstruction of long bone defects. *Orthop Clin North Am.* 2010; 41:27–37. table of contents. [PubMed: 19931050]

Table 1
Patient and Fracture Characteristics

	More Aggressive	Less Aggressive	p-value
Number of Patients	17	12	
Average Age (Range)	50 (30-78)	53 (27-80)	.68
Male / Female	12 / 5	10 / 2	.49
Diabetics	5	0	.04
Smokers	5	2	.43
OTA			
A2	0	1	
A3	2	0	
C1	0	3	
C2	7	5	
C3	8	3	
Type II Open	1	2	0.76
Type III Open	11	15	

Table 2
Treatment Characteristics and Outcomes

	More Aggressive N=17	Less Aggressive N=12	p-value
Cement Spacer	6	0	<.03
Healed after Index Procedure	6	11	<.003
Required Re-operation to Promote Union	11	1	<.003
Infection	3	3	.63