Does a Staged Posterior Approach Have a Negative Effect on OTA 43C Fracture Outcomes?

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Objective: To determine whether multiple approaches pose an increased risk to fracture healing when compared with a standard single approach in the treatment of pilon (OTA 43C) fractures.

Design: Retrospective review of a prospective database.

Setting: Level I academic trauma center and level II community trauma center.

Methods: From January 1, 2005 to December 31, 2011, all records of patients treated for OTA 43C fractures of the distal tibia were reviewed. Patients were grouped according to multiple (posterior-anterior) and single (anterior-alone) approaches. Medical charts and surgical documentation were reviewed and postoperative computed tomography (CT) scans were examined for residual articular displacement and quantified. Ultimate union rate was correlated with approach strategy. Articular reduction was subdivided into 3 groups (<1, 1–2, and >2 mm).

Results: A total of 116 patients were identified as having had 43C fractures treated surgically with postoperative CT scans completed. Twenty-six fractures presented as an open injury. Of these 116 patients, 35 underwent staged fixation of the posterior malleolar component at an average of 2 days postinjury, followed by delayed anterior fixation at an average of 14 days postinjury. The remaining 81 patients underwent anterior fixation alone, on average 17 days postinjury. Twenty-one patients were lost to follow-up before 12 months. Of the 95 patients with sufficient follow-up (≥12 months), there were 24 nonunions. There was a statistically significant association of nonunion with staged posterior approach (40% vs. 19%, $P = 0.015$). CT reduction for staged posterior versus anterior-alone approach was not significantly different for any of the 3 categories (63% vs. 57% <1 mm, 31% vs. 26% 1–2 mm, and 6% vs. 17% >2 mm).

Conclusions: In this series, there was no statistically proven benefit to combined surgical approaches to tibial pilon fractures with regard to the quality of articular reduction. It appears from this investigation that there may be a significantly higher risk of nonunion associated with the addition of the staged posterior approach. Although articular reduction is of paramount importance, multiple approaches for direct reduction and fixation of all fragments may lead to further complications.

Key Words: pilon, staged, posterior, approach, posterolateral, 43C

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

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INTRODUCTION

Historically, intraarticular distal tibia fractures had presented the orthopaedic surgeon with a problem for which there were few good solutions. The high-energy nature of these injuries leads to a compromised soft-tissue envelope that can preclude safe surgical approaches for days to weeks. Even with successful open treatment, the historical results dissuaded many surgeons from attempting surgical fixation.[1,2] Cast immobilization, delayed fusion, and distraction external fixation have all been advocated previously as reasonable approaches to avoid the problems of wound complications and infections. The historically high rate of complications[3] associated with open reduction and internal fixation of complete articular fractures often led surgeons to explore alternative fixation strategies.[4–7]

Temporized treatment with initial external fixation followed by staged internal fixation has allowed anatomic restoration of the articular surface while minimizing soft-tissue complications.[8,9] With the popularity of staged reconstruction, formal open reduction and internal fixation has become the standard of care, with an expectation of reasonably functional outcomes. Computed tomography (CT) evaluation has been shown to be a critical step in selecting surgical approach for open treatment. Through a careful selection of the proper anterior surgical approach, the treating surgeon can expect to achieve a reliable articular reduction and fixation of fracture fragments.

With disruption of the posterior cortex, restoration of the articular surface as well as the normal mechanical axis becomes more difficult. To better facilitate reconstruction of normal anatomy, some authors have advocated staged fixation of the tibia, with separate incisions for the posterior and anterior fracture fragments. Through this sequential fixation, excellent restoration of the anatomy has been shown, with

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reliable reproducibility. A posterolateral incision is typically used to reduce and fix the posterior malleolar fragment to the tibial metaphysis.[10] After a delay sufficient to safely approach anteriorly, the remainder of the articular surface is rebuilt to the now reconstructed posterior tibia and fixed in place through this anterior exposure.

A recently published study has shown a high rate of anatomic or near anatomic restoration of the articular surface using this dual incision approach.[10] To date, no study has been published investigating potential complications with a circumferential approach to the tibia. This study was designed to investigate the differences in outcomes comparing a staged posterior–anterior approach versus anterior approach alone for OTA 43C tibial pilon fractures.[11]

PATIENTS AND METHODS

After an institutional review board approval was obtained for this retrospective investigation of data collected prospectively in our orthopaedic trauma registry, which was queried to identify all OTA 43C tibia fractures treated between January 1, 2005 and December 31, 2011. Patient demographics were recorded for age, gender, and systemic comorbidities. Fracture characteristics recorded included OTA subtypes (43C1,2,or 3), open fracture, and whether acute bone grafting and/or soft-tissue reconstruction were performed. Additionally, the initial surgical treatment was stratified by whether the patient underwent initial external fixation, time to index procedure, surgical approaches used, and, if staged tibial fixation was performed, the delay between posterior and anterior fixation was quantified. Posterior dissection for fixation was subdivided into metaphyseal and metadiaphyseal exposure. If fractures extended one plafond width or more proximal from the articular surface, it was considered a metadiaphyseal fracture, and applied fixation required a metadiaphyseal exposure. Postoperative records were examined to determine the presence of infection, wound complication, nonunion, and secondary surgeries. Patients without postoperative CT scans were not included. Patients were divided into 2 groups, stratified according to approach: group A: a single (anterior-alone) exposure or group B: multiple (combined posterior-anterior) exposures. All radiographs were reviewed by the fellowship-trained orthopaedic trauma attending to assess union and alignment. Successful union criteria was the radiographic presence of callus formation bridging at least 3 cortices on orthogonal views of the fracture within the initial 6-month postoperative period. Subjects with $<$12 months follow-up were excluded from the final analysis of union but included in reduction and complication analysis.

CT scans performed immediately postoperatively were evaluated for articular reduction. The CT analysis protocol used was the same as that published by Ketz and Sanders.[10] On sagittal CT scan cuts, the maximum displacement measurement was used for evaluation. They were graded as $<$ 1, 1–2, or $>$2 mm step-off. For loss of congruity of the articular surface, those fractures were graded as greater than 2 mm. All plain film radiographs and CT scans were reviewed and fractures classified by a single fellowship-trained orthopaedic traumatologist.

Statistical analysis of all data was performed to evaluate for difference in infection, nonunion rate, and wound complication. Groups A and B were compared, as were fracture classification groups. These differences were then correlated to demographic data, whether the fracture was open or not, presence of initial external fixation, and time to internal fixation.

RESULTS

Initial query of the registry produced 128 OTA 43C tibia fractures (124 patients) that underwent operative treatment by 4 orthopaedic trauma fellowship-trained surgeons. Twelve of the 128 fractures were excluded for lack of postoperative CT. Of the remaining surgically treated 116 patients with 43C fractures and postoperative CT scans, 35 underwent staged fixation of the posterior malleolus (group B), whereas 81 underwent anterior-only fixation (group A). Demographic characteristics for the 2 groups (including mechanism of injury), seen in Table 1, did not vary significantly except for the use of bone graft. Fracture classification and characteristics are seen in Table 2. There was no significant difference in OTA 43C fracture severity and whether those injuries were treated by anterior-only or staged-dual approaches ($P > 0.05$).

Group A patients underwent definitive internal fixation at an average of 17 days. Among group B patients, posterior fixation was performed at an average of 2 days postinjury,

TABLE 1. Patient Demographics

	Group A (n = 80)	Group B (n = 34)	Test, *P*
Age, mean (SD)	41 (15)	47 (15)	*t* test, $P = 0.06$
Gender, male, n (%)	58 (71.6)	24 (68.6)	χ^2, $P = 0.7$
Side, right, n (%)	47 (58)	27 (77.1)	χ^2, $P = 0.05$
Open wound, n (%)	22 (27.2)	4 (11.4)	χ^2, $P = 0.06$
Smoker, n (%)	25 (30.9)	14 (40)	χ^2, $P = 0.3$
Ex-fix, n (%)	70 (86.4)	33 (94.3)	Fisher exact, $P = 0.3$
Postcolumn day, median (range)	—	2 (0–9)	—
Definitive fix day, median (range)	17 (0–40)	14 (2–26)	Mann–Whitney, $P = 0.4$
Soft tissue cover, n (%)	18 (22.2)	11 (31.4)	χ^2, $P = 0.7$
Bone graft, n (%)	36 (44.4)	7 (20)	χ^2, $P = 0.01$

TABLE 2. Fracture Classification and Articular Reduction

	Group A (n = 81)	Group B (n = 35)
Fracture Classification*		
43C1.1	11	5
43C1.2	6	0
43C1.3	9	0
43C2.1	5	4
43C2.2	7	3
43C2.3	10	0
43C3.1	0	4
43C3.2	13	12
43C3.3	20	7
Sagittal CT Max Displacement†		
<1 mm	46	22
1–2 mm	21	11
>2 mm	14	2

*$P > 0.05$, Mann–Whitney.
†$P > 0.05$, χ^2 test.

followed by delayed anterior fixation at an average of 14 days postinjury. Multinomial logistic regression analysis (using <1 mm as reference group) of CT reduction was performed. Analyzed variables included age, side, open wound, ex-fix day, bone graft, soft-tissue reconstruction, posterior column fixation, smoking, and time to definitive fixation. No statistically significant association was found among any of the included variables. Postoperative CT reduction for anterior-alone versus staged posterior approach was not significantly different for any of the 3 categories (57% vs. 63% <1 mm, 26% vs. 31% 1–2 mm, 17% vs. 6% >2 mm; chi-square, $P = 0.543$; Table 2).

Twenty-one patients were lost to follow-up before 12 months. Of the 95 patients (68 group A, 27 group B) with sufficient follow-up, there were 24 nonunions. Thirteen nonunions occurred in group A (11/81 = 19%), and 11 in group B (11/35 = 40%). Logistic regression analysis was performed for nonunion risk factors (using union as reference, forward likelihood ratio method of entry) included the flowing variables: age, side, open fracture, acute bone grafting, soft-tissue reconstruction, tobacco use, posterior column first fixation, and time to definitive fixation. It is important to explain that despite the significant difference in the use of bone graft between groups, that when a logistic regression analysis was performed to determine the significant factors associated with nonunion, bone graft use (or lack thereof) was not one of them. Significant associated factors toward nonunion were open fractures ($P = 0.005$) and posterior column fixation ($P = 0.015$). Fifteen of 24 nonunions were culture positive for deep infection. Logistic regression was also performed to examine risk factors for culture-positive deep infection. Using absence of infection as reference (forward likelihood ratio method of entry), analyzing age, side, diagnosis of an open fracture, acute bone grafting, soft-tissue reconstruction, use of tobacco, combined posterior column first fixation, and time to definitive fixation, only diagnosis of open fracture showed statistical significance ($P = 0.011$). Comparison of group A and group B patients using multivariate analysis found union rate as the only statistically significant difference between the 2 groups (Table 3).

In evaluating whether more proximal posterior dissection and fixation was associated with nonunion, group B was analyzed according to the proximal extent of posterior dissection/fixation. The extent of the proximal dissection was determined by the most proximal extent of the posterior fixation (irrespective of size or number of plates or screws). When comparing distal tibia exposure alone (43C1) versus more proximal metadiaphyseal (43C3) exposure, there was no statistical correlation for an increased risk of nonunion (Table 4). Further subgroup analysis of group B using Fisher exact test, evaluating for correlation of time between approaches and nonunion, also failed to show statistical significance ($P = 0.671$). Of the 27 patients with posterior fixation and sufficient follow-up, there was no statistical correlation between the extent of dissection and presence of nonunion.

DISCUSSION

It has been described that converting an OTA 43C-type intraarticular fracture of the distal tibia to B-type fracture would enable achieving an improved articular reduction.[12] This study reached similar articular reduction conclusions; however, it also suggests that a multiple incision approach to the distal tibia carries an inherent risk for nonunion. This risk does appear to be elevated in the dual posterior–anterior fixation group. Again, care with the soft tissue and amount of stripping posteriorly did not correlate with the rate of nonunion. Our study did not show any significance in wound infection with dual approaches, suggesting that, from a soft tissue perspective, combined approaches appear to be safe.

Complete articular disruption of the distal tibia poses reduction challenges in both articular restoration and limb alignment. Several studies have described the technique of staged fixation of the tibia.[10,12] Through initial direct approach and fixation of the posterior fragment, an OTA 43C fracture is converted to a B-type fracture. Ketz and Sanders reported in their series all articular reductions were

TABLE 3. Summary of Results

	Group A	Group B	Test	*P*
Lost to follow-up, n (%)	13 (16)	8 (22.8)	Fisher exact	0.434
Union, n (%)	55 (80.9)	16 (59.3)	χ^2	0.029
Time to union	135 (65–508)	141 (3–450)	Mann–Whitney *U*	0.934
Wound complication, n (%)	15 (22.1)	7 (25.9)	χ^2	0.691
Culture-positive infection, n (%)	10 (14.7)	4 (14.8)	Fisher exact	1.0

TABLE 4. Subgroup B Analysis

	43C1	43C3	Test	P
Number	25	45		
Nonunion, n (%)	3 (12)	13 (29)	χ^2	0.097

<2 mm using this staged protocol. This study suggested that this technique allows for reliable restoration of the joint surface. Our study used the same CT analysis methods to verify previously published findings. We verified this finding of joint restoration, as among the posterior-first fixation in our data; there were only 2 cases (6%) of articular reduction after posterior fixation with > 2 mm of malalignment. The anterior-only group had a much higher rate of malreduction (17%), but the data failed to show statistical significance. There is no clear explanation for this result based on the review of the fracture patterns of those cases with poor reductions. For future studies analyzing joint reduction, multiplanar analysis of CT studies may provide a more accurate measurement of joint reconstruction.

Although more extensile or combined approaches to fractures allow for a more accurate reduction, increased soft tissue handling raises concern for negative effects on fracture healing and ultimate union. There is a paucity of literature on tibial pilon nonunions. Early results showed a relatively high rate of delayed union or nonunion. McFerran et al reported a 19% rate of nonunion in their early series,[3] half of which were infected nonunions. Bhattacharyya et al demonstrated nonunion in 2 of 19 patients in their series of tibial pilons treated exclusively through a posterolateral approach.[13] In a series of tibial pilon fractures treated through a direct lateral exposure of the tibia, Grose et al published a nonunion rate of 11%.[14] Other studies have shown a similar rate of nonunions among subjects without predisposing factors.[15] Our data demonstrated a similar rate of nonunion within the anterior-only fixation group (19%). Group B showed a significantly higher rate of nonunion without any significant difference in patient or injury characteristics.

Transition from primary fixation of tibial pilon fractures to delayed internal fixation has dramatically improved soft-tissue complication rates.[9] Multiple studies support the safety of direct operative fixation of the articular surface after a period of soft-tissue rest. Early studies of delayed fixation reported no soft-tissue healing complications among closed fractures.[8,9] Bhattacharyya et al reported 6 of 19 patients with wound complications after posterolateral fixation, whereas Grose et al demonstrated a more typically low rate of wound complications in their series (2/41). In a study of the efficacy of early primary open reduction and internal fixation of pilon fractures, White et al demonstrated a low rate of wound complications in closed injuries treated within 48 hours.[16] Even patients with preexisting risk factors for wound complications have not shown an elevated risk when soft-tissue integrity is considered before attempting fixation.[15] Our data demonstrate that multiple exposures to the distal tibia should not increase the risk for wound complications, provided the surgeon is judicious in timing the approach relative to the tolerance of the soft tissue (swelling, blisters, etc).

In our series of pilon fractures, combined approach to the tibia showed a statistical association with higher rates of nonunion. This study is limited by a small group of patients in the posterior fixation group, and a nonrandomized study design. It is difficult to draw large-scale definitive conclusions from such a series. Nevertheless, this association gives pause to the promising early results in conversion of 43C to 43B fractures. The development of nonunions is impossible to definitively correlate to a single factor. The complexity of the fracture, integrity of the soft-tissue envelope, and development of infection have all been shown to increase nonunion risk in a variety of fracture types. Surgical technique and tissue handling are variables that are difficult to control for investigational studies, but likely play as important a role in fracture healing as the injury itself. Similarly, potential differences in surgical technique of the 4 surgeons involved in our study may also be a weakness and a variable difficult to control.

Similarly, despite the lack of differences in fracture patterns between groups, difference in surgical preference regarding approach may have a role in articular reduction. Specifically, the reason for the direct posterior approach is difficult to measure, particularly as a nonrandomized study. The displacement of the posterior fragment may be a significant persuader for a direct posterior approach, as well as a significant reason for the quality of reduction obtained; however, such displacement may also represent soft-tissue injury already compromised where surgical dissection increases nonunion risk. This selection bias due to 4 surgeons' individual decision making as part of the retrospective nature of this investigation is a weakness of the study.

This is a retrospective investigation and does not include outcomes measurements. It is possible that the trend toward improved articular reduction using a staged posterior approach may also mean that these patients have less posttraumatic arthritis, fewer ankle fusions or arthroplasty, more metaphyseal nonunion repairs, and better overall outcomes. Future large prospective randomized studies are needed to address surgeon preference variability, as well as include both clinical and functional outcome measurements.

This study is the first comparative investigation of the complications of OTA 43C tibial pilon fractures treated with multiple versus a single anterior approach. Our results suggest that the improvements seen in combined approaches may not be uniform, and the treating surgeon should be selective in approaching pilon fractures in this manner, reserving posterior approaches only for those that can predictably be improved enough to justify the increased risk.

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Invited Commentaries

The understanding of tibial pilon fractures has substantially improved over the last several decades. The assessment and appreciation of the concomitant soft tissue injury, delineation of the articular fracture pattern, and morphology using computerized tomography scanning, and the concept of staged management to minimize complications has provided surgeons a workable framework for the effective application of open reduction and internal fixation techniques. Although a number of variables related to outcome are outside the control of the surgeon (socioeconomic status, level of education, etc.), a number of variables are under our control (accuracy of articular reduction, axial alignment, minimization of perioperative complications, etc) and the maximization of these variables as it pertains to improved outcomes should occur. Despite advances, the challenge of surgically managing tibial pilon fractures remains problematic. The conundrum of balancing an accurate surgical articular reduction with minimization of soft tissue dissection and subsequent nonunion and infection is nicely illustrated in this study. The authors demonstrate no statistically significant difference in the accuracy of articular reduction when comparing staged posterior–anterior exposures versus isolated anterior exposures; however, a significantly higher risk of nonunion was associated with the addition of the staged posterior approach.

What also becomes apparent with this study is that the final outcome of a pilon fracture is the result of a number of complex factors that function as independent variables, but more likely, are corelated and the interplay between these variables is challenging to discern. To illustrate, and as the authors indicate, a more highly displaced posterior plafond fragment may drive the surgeon into performing a supplemental posterior exposure, but it may also indicate a greater degree of soft tissue disruption as a result of that injury. Was the subsequent nonunion the result of the injury, the surgical dissection, or both? The decision to proceed with multiple approaches to the C-type tibial pilon fracture (particularly when considering an adjunctive posterior approach) requires the surgeon to consider a number of factors, and therefore, the decision to proceed with multiple approaches in the setting of a complex distal tibial pilon fracture should not be entered into lightly. There are a number of techniques available to reduce displaced posterior plafond fracture fragments, including ligamentotaxis with early fibular open reduction internal fixation, percutaneous clamp or joystick manipulation combined with anterior exposure visualization, or direct manipulation with an anterior exposure, joint distraction, and visualization. This study, unfortunately, does not detail these maneuvers. The surgeon's experience dictates whether the displaced posterior plafond can be accurately reduced entirely from an anterior exposure and therefore becomes a prime unaccounted for variable in truly determining whether the surgical groups (A and B) are comparable. Furthermore, the technical execution of an operative procedure remains one of the most significant confounding variables that plagues many surgical studies, limiting their generalizability. It is the surgeon's experience and expertise that also identifies and distinguishes fracture patterns that cannot be differentiated based on current classification systems, further adding to the problem of heterogeneity of the study populations. However, even in experienced hands, direct manipulation of increasingly comminuted tibial plafond fractures carries with it the potential for fragment devitalization and nonunion. Determining the risk/benefit tipping point, therefore, becomes highly individualized. In my own personal practice, and in keeping with the results of this study, determining this remains an ongoing challenge in the treatment of these fractures.

Regardless of its limitations, the value of this study is in highlighting the risk/benefit balance of surgical choices in managing complex tibial plafond fractures. Prioritization and achieving as anatomic articular reduction as possible by multiple approaches comes with a potential biologic cost. In many situations, most would undoubtedly choose to manage

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