Clinical/Basic Science Research Article

OPEN

Impaction fractures of the anterior tibial plafond

Outcomes after fractures around the ankle: Is the anterior impaction plafond fracture a problem?

Moaz B.Y. Chohan, MBBS[a], Christopher Del Balso, MBBS, MSc, FRCSC[a], Michael Ching, MD[a], Emil Schemitsch, MD, FRCSC[b], Abdel Rahman Lawendy, MD, PhD, FRCSC[b], David W. Sanders, MD, MSc, FRCSC[b,*]

Abstract

Objectives: To determine whether patients with AO/OTA 43-B anterior impaction tibial plafond fractures have worse clinical outcomes, and an increased risk of progression to ankle arthrodesis.

Design: Retrospective cohort study.

Setting: Level 1 academic trauma center.

Patients: One hundred sixty-eight patients were included in the study, all of whom had tibial plafond fractures.

Intervention: Study patients underwent external fixation and/or open reduction internal fixation (ORIF) as indicated by fracture/injury pattern.

Main outcome measurements: Arthrodesis rate.

Results: AO 43-B Anterior impaction tibial plafond fractures have an increased risk of progression to arthrodesis when compared to AO 43-B nonanterior impaction type fractures (19.4% vs 8%).

Conclusions: AO 43-B anterior impaction tibial plafond fractures have a worse clinical outcome compared to AO 43-B nonanterior impaction fractures. These fractures also confer increased risk of progression to arthrodesis.

Keywords: impaction, OTA 43-B fractures, OTA 43-C fractures, outcome, tibial plafond fractures

1. Introduction

Posttraumatic osteoarthritis (PTOA) is a known complication of ankle injuries.[1] The rate of PTOA for plafond injuries is higher than that for other injuries to the ankle joint.[2–5] Tibial plafond fractures represent an injury adjacent to the ankle that may involve a wide array of articular, metaphyseal, and soft-tissue compromise.[6,7] The AO/OTA classification is widely used to describe long bone injuries, with AO/OTA 43-C fractures corresponding to the majority of high-energy plafond fractures.[8] As such, AO/OTA 43-C fractures are expected to have the highest rates of PTOA and the worst functional outcomes.[9–12] However, the experience at our institution has been that AO/OTA 43-B fractures with anterior plafond impaction have higher rates of PTOA and the need for subsequent surgical treatment than would be anticipated on the basis of the AO/OTA classification system. A distal tibial type of anterior impaction fracture is a type of partial articular fracture that involves displacement of the anterior articular plafond fracture fragment with subluxation of the talus anterior to the long axis of the tibia (Fig. 1).

PTOA as a result of plafond fracture causes significant morbidity. A recent retrospective review[13] of a group of patients followed an average of 6 years following tibial plafond fractures postinjury found only 72% to be satisfied with their function. 77% complained of pain, and 70% complained of swelling. The overall health of patients following tibial plafond fracture is also affected, with this being significantly poorer when compared to an age and gender-matched cohort.[10] If patients with PTOA of

Institutional Research Support Funding from Stryker Canada.

The Western University HSREB operates in compliance with, and is constituted in ccordance with, the requirements of the TriCouncil Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2); the International Conference on Harmonisation Good Clinical Practice Consolidated Guideline (ICH GCP); Part C, Division 5 of the Food and Drug Regulations; Part 4 of the Natural Health Products Regulations; Part 3 of the Medical Devices Regulations and the provisions of the Ontario Personal Health Information Protection Act (PHIPA 2004) and its applicable regulations. The HSREB is registered with the U.S. Department of Health & Human Services under the IRB registration number IRB 00000940.

IRB internal application number was 112181 and it was approved under Dr. David Sanders as the PI.

Source of funding: Nil.

The authors have no conflicts of interest to disclose.

[a] Western University, [b] London Health Sciences Center, London, ON, Canada.

[*] Corresponding author. Address: Rm E1-326, Ext. 58086, Victoria Hospital, London Health Sciences Center, London, ON, Canada N6A5W9.
E-mail: address: David.Sanders@lhsc.on.ca (D. W. Sanders).

OTA (2020) e076

Received: 31 May 2019 / Accepted: 22 January 2020

Published online 23 May 2020

http://dx.doi.org/10.1097/OI9.0000000000000076

Figure 1. (A) Sagittal computed tomography (CT) cut of distal tibia and ankle. There is a tibial plafond fracture with impaction and displacement of an anterior fragment. (B) Sagittal CT cut of the distal tibia and ankle with proximal migration of an anterior plafond fragment and talus. The talus is also subluxated anteriorly relative to the long axis of the tibia. (C) Sagittal CT cut of distal tibia. Impaction of articular surface is seen with an intact anterior cortex.

the ankle have refractory pain and are functionally limited, surgical intervention in the form of tibiotalar arthrodesis or total ankle arthroplasty (TAA) may be indicated.[2,12,14] At our institution, these patients are managed with tibiotalar arthrodesis, which is known to provide effective pain relief.[15]

The objective of the current study is to analyze rates of PTOA and ankle arthrodesis in patients who sustained tibial plafond (AO/OTA 43) fractures and its subgroups. We hypothesize that individuals with AO/OTA 43-B fractures with anterior plafond impaction have an increased risk for PTOA and ankle arthrodesis when compared with other fractures of the plafond.

2. Methods

Study participants were identified through billing codes and institutional records of the investigating surgeons. Study participants included those with fractures of AO/OTA 43, its subtypes and who received operative intervention by 1 of 3 surgeons from September 2012 to September 2017. Demographic data and imaging were accessed through institutional chart review. X-rays and computed tomography (CT) scans were utilized for differentiation between tibial plafond, bi-malleolar, and tri-malleolar fractures. The images were reviewed by a board-certified orthopaedic foot and ankle surgeon and another physician with a graduate degree in surgical research and an interest in orthopaedic trauma surgery. The criteria for imaging classification of anterior impaction fracture required at least 10% involvement of the intra-articular plafond surface starting from the anterior lip and some degree of subluxation of the talus. Exclusion criteria included associated tibial metaphyseal and diaphyseal fractures. One hundred sixty-eight tibial plafond fractures were identified and included in the study (Fig. 1).

2.1. Intervention and outcome measurements

Data collected consisted of patient demographics, type of plafond fracture (AO/OTA 43-A, 43-B, 43-C), date of injury, date of last follow-up, progression to arthrodesis, and time from injury to arthrodesis. Plafond fracture classification was subdivided into extra-articular (AO 43-A), partial articular (AO 43-B), and complex articular group (AO 43-C).[16] Data collected for prognosis included postoperative complications (reoperation, amputation), type of initial fixation (type and position of the plate), fibular fracture, previous operation, usage of external fixators, as well as type of open wound. Patient comorbidities (coronary artery disease, hypertension, renal disease, and diabetes) and smoking status were also recorded. The effect of medical comorbidities, and smoking status on arthrodesis was additionally analyzed.

2.2. Statistical analysis

Continuous variables were presented as mean ± standard deviation (SD). The rate of ankle fusion was expressed as a percentage. Chi-square analysis was performed for dichotomous data. A value of $P \leq .05$ indicated significant differences. Logistic regression was performed to control confounding. We performed a logistic regression analysis to assess the relationship in plafond fracture patients between tibiotalar arthrodesis, external fixator application, open fractures, previous operation, and fibular fractures. Kaplan–Meier survival analysis was utilized to calculate mean and median times to fusion. A post-hoc power calculation was performed. For an α of 0.05 and a power of 0.8, 143 patients in each group (Anterior Impaction/ Non-Anterior Impaction) were required for this analysis to reach statistical significance. Statistical analysis was performed using IBM SPSS, Version 26 (Chicago, Illinois).

Table 1

Patient demographic data and characteristics.

Characteristic	Number (n)	Mean ± SD	Ankle arthrodesis (%)	*P* value
Age		51.3 ± 16.63 years		
Weight		85.9 ± 22.39 kg		
Height		171.8 ± 10.34 cm		
Side (L/R)	74/94			
BMI		29.6 ± 7.32		
Sex (M/F)	108/60		13 (12)/9 (15)	.585
Syndesmosis injury	12		1 (8.3)	.612
Fibular fracture	104		14 (13.5)	.858
Previous Operation	69		14 (20.3)	.021
Hypertension	21		2 (9.5)	.604
Diabetes Mellitus	11		2 (18.2)	.605
CKD	1		0	.697
Smoker	40		5 (12.5)	.898
CAD	5		0	.378
Open/Closed injury	21/147		7 (33.3)/15 (10.2)	.003
Ex-Fix/No Ex-Fix	66/102		17 (25.7)/5 (4.9)	<.001

3. Results

Table 1 contains patient characteristics and arthrodesis data. Mean age was 51.3 ± 16.63 years with an average height of 171.8 ± 10.34 cm, weight of 85.9 ± 22.39 kg, and BMI of 29.6 ± 7.32. The overall rate of fusion in all 168 patients was 13.1%. There was no difference on the basis of gender ($P = .59$). The rate of subsequent fusion in patients who were reoperated on after definitive fixation surgery was 32.1% vs 3.6% in patients who did not have any more surgeries after their definitive surgery ($P < .001$). No medical comorbidities (hypertension, diabetes mellitus, coronary artery disease, chronic kidney disease) had a statistically significant influence on the rate of ankle arthrodesis. Smoking had no effect on the rate of arthrodesis as well (Table 2).

Patients with an initial provisional external fixator placement had a 6.8-fold increased risk of proceeding to tibiotalar arthrodesis (odds ratio = 6.8, $P < .01$). Patients with open fractures had a 3-fold increased risk of proceeding to ankle arthrodesis when compared to closed injuries (odds ratio = 3.3, $P = .05$). In many instances, external fixators were reserved for more complex fractures, with an anticipated higher rate of developing PTOA. Similarly, open fractures are thought to be at a higher risk of PTOA.

The AO 43-A injuries had an arthrodesis rate of 0%, the AO 43-B group rate was 11.8%, and the arthrodesis rate in the AO 43-C group was 17.7% ($P = .000$). Lastly, the AO 43-B anterior impaction group had an arthrodesis rate of 19.4% compared with the AO 43-B nonanterior impaction group's arthrodesis rate of 8% (Table 3).

The mean follow-up times for AO 43-A, 43-B, and 43-C were 12.5, 12.73, 20.13 months. The mean time to fusion for AO 43-A was not available as we did not have any cases with fusion in this fracture pattern. Mean (median) time to fusion for AO 43-B and 43-C was 8.9 (8) and 16 (5) months. The mean follow-up time for AO 43-B Anterior Impaction and Non-Anterior impaction patterns was 11.52 and 13.34 months. The mean (median) time to fusion for these fractures was 8.4 (8) and 8.8 (6) months.

4. Discussion

Tibial plafond fractures have long been known to have poor outcomes; speculated to be related to the high-energy mechanism commonly associated with these injuries. PTOA rates of 39% have been reported.[12] A relationship is known to exist between injury severity and patient outcomes ($r = 0.3$, $P = .04$), grade of arthrosis ($r = 0.4$, $P < .01$), and return to work status.[17,18] Poor patient outcomes in the published literature about plafond fractures focus on treatment modalities and have largely been attributed to AO/OTA 43-C complex articular fracture patterns. AO/OTA 43-C fractures are endorsed to have the worst outcome following plafond fractures with PTOA rates up to 53%.[12] This outcome can partly be explained by extensive intra-articular involvement which accelerates chondrocyte death in the damaged joint.[19] Little has been published about the AO/OTA 43-B partial articular fracture. The question remains whether these fractures have an equally poor outcome.[18] At our institution, we have noted that the AO 43-B class may have similarly poor

Table 2

Risk factor analysis for ankle arthrodesis.

Risk factor	Rate of arthrodesis
Hypertension	9.5%
Diabetes mellitus	18.2%
Smoking	12.5%
External fixators	25.7%
Open injury	33.3%
Previous operation	20.3%

Table 3

Rate of fusion by type and subtypes of fractures.

Type of fracture	Number fused (total)	Percentage	*P* value
AO 43-A	0 (13)	0%	.000
AO 43-B	11 (93)	11.8%	
AO 43-C	11 (62)	17.7%	
43-B Anterior Impaction	6 (31)	19.4%	.112
43-B Non-Anterior Impaction	5 (62)	8%	

Note: The AO 43-A, B, and C were compared to each other for rate of fusion ($P = .000$). The second comparison was between rate of fusion in AO-43-B Anterior Impaction and Non-Anterior Impaction fractures.

outcomes, in particular, the anterior impaction subset of partial articular fractures.

To date, this is the only study to compare ankle arthrodesis rates in patients having sustained tibial plafond anterior impaction fractures. In the present investigation, AO 43-B fractures had an arthrodesis rate of 11.8% with AO 43-C fractures going on to arthrodesis in a significantly increased 17.7% ($P < .01$) of cases. Previously, Bonato et al[18] speculated that AO 43-B fractures have worse functional outcomes when compared to AO 43-C fractures. We postulate that this may be related to the subset of AO 43-B fractures of interest in this study, specifically, anterior impaction fractures.

Previous investigation has reported a PTOA incidence of 53.4% in AO 43-C fractures, and 68.8% in externally fixated AO 43-C fractures.[12] It stands to reason that external fixation, and open fractures may be associated with an increased risk of developing PTOA.[10,12,20,21] Here, patients who underwent external fixation proceeded to arthrodesis at a rate of 25.7% vs 4.9% in patients who did not get an external fixator (P value $< .01$, Tables 1, 2). Open fracture conferred an increased rate of arthrodesis compared to closed fracture (33.3 vs 10.2%, $P < .01$). These findings are not surprising; as patients with open fractures and temporizing external fixation often have sustained higher energy trauma. Previous surgery before definitive fixation also seemed to be associated with an increased risk of arthrodesis as shown in Table 1.

No statistically significant relationship between common comorbid conditions and their relationship to arthrodesis (diabetes, hypertension, coronary artery disease, and chronic kidney disease) was found. Smoking did not confer any increased risk of arthrodesis as well.

In AO 43-B anterior impaction type fractures, a higher rate of ankle arthrodesis was observed when compared to AO 43-B nonanterior impaction type fractures (19.4% vs 8%). While the rate of arthrodesis was more than 2-fold greater, this was not statistically significant. The present investigation included 31 AO 43-B anterior impaction type fractures and 62 AO 43-B nonanterior impaction type fractures, which is underpowered for this comparison. Ideally, 143 patients in each group might have given a statistically significant difference. Another important finding was a lower but not statistically significant rate of arthrodesis in AO 43-C fractures compared with AO 43-B anterior impaction fractures (17.7% vs 19.4%). This suggests partial articular anterior impaction fractures may have a similar or worse outcome when compared with complex articular fractures.

The reason that the anterior impaction fracture pattern leads to an increased rate of arthrodesis is not well understood. It is likely related to the biomechanics of the ankle joint. It is known that up to 70% of end-stage ankle arthrosis is posttraumatic in nature.[4] Of all joints in the body, the ankle joint is subjected to the highest forces per square centimeter, add to this the effects of cartilage damage and the end result will be poor.[7] The mechanism postulated is as follows: in dorsiflexion, the anterosuperior talus is loaded through the anterior aspect of the tibial plafond; over time, any subtle articular incongruity will promote degenerative changes, and osteophytes that may cause erosion and damage to articular cartilage causing PTOA.

In a recent multicenter trial published by Sommer et al, 4 radiographic criteria predicted poor outcomes after plafond fractures. In particular, anterior distal tibial angle and anterior talar shift were said to have a relationship with poor outcomes. This article, like our present study, found worse outcomes in fractures with anterior talar shift as we noted with anterior impaction fractures.[22]

This study has limitations inherent to its retrospective cohort design. As the anterior impaction subtype of AO 43-B fracture is relatively uncommon, this study was underpowered to show a statistically significant difference in arthrodesis rates despite a 2-fold increase in frequency of arthrodesis with this pattern of injury compared with the nonanterior impaction subtype. In addition, 5-year and 10-year follow-up data are lacking for patients in this study. A future direction of this project is to collaborate with other academic centers to obtain a sample size which is large enough to draw definitive conclusions. Another important question to address in the future is to find out whether a 1-stage or a 2-stage procedure is beneficial in such circumstances.[23–25] Lastly, an analysis of survival of such injuries may prove valuable to predict outcomes.

5. Conclusions

In the plafond fracture group, AO 43-C fractures have the highest rate of arthrodesis compared with AO-43-A and 43-B fractures. The AO 43-B anterior impaction fractures have a higher but not statistically significant rate of ankle arthrodesis when compared with nonanterior impaction fractures and similar outcome to AO 43-C fractures. There is a need for early recognition of AO 43-B anterior impaction fractures to manage expectations and potentially avoid poor outcomes.

References

1. Horisberger M, Valderrabano V, Hintermann B. Posttraumatic ankle osteoarthritis after ankle-related fractures. J Orthop Trauma. 2009; 23:60–67.
2. Greaser M. Ankle arthritis. J Arthritis. 2014;3:1–5.
3. Buckwalter JA, Saltzman C, Brown T. The impact of osteoarthritis. Clin Orthopaedics Relat Res. 2004;427:S6–S15.
4. Valderrabano V, Horisberger M, Russell I, et al. Etiology of ankle osteoarthritis. Clin Orthop Relat Res. 2009;467:1800–1806.
5. Saltzman CL, Salamon ML, Blanchard GM, et al. Epidemiology of ankle arthritis: report of a consecutive series of 639 patients from a tertiary orthopaedic center. Iowa Orthop J. 2005;25:44–46.
6. Kottmeier SA, Madison RD, Divaris N. Pilon fracture: preventing complications. J Am Acad Orthop Surg. 2018;26:640–651.
7. Marsh JL, Buckwalter JA, Gelberman R, et al. Articular fractures: does an anatomic reduction really change the result? J Bone Joint Surg Am. 2002;84-A:1259–1271.
8. Jacob N, Amin A, Giotakis N, et al. Management of high-energy tibial pilon fractures. Strategies Trauma Limb Reconstr. 2015;10:137–147.
9. Thordarson DB. <Complications After Treatment of Tibial Pilon Fractures Prevention and Management Strategies.pdf>. *J Am Acad Orthopaedic Surg*. 2000;8:253–265.
10. Pollak AN, McCarthy MA, Bess RS. Outcomes after treatment of high energy tibial plafond fractures. J Bone Joint Surg Am. 2003;85:1893–1900.
11. Anderson DD, Killburg AT. Expedited CT-based methods for evaluating fracture severity to assess risk of post-traumatic osteoarthritis after articular fractures. *Iowa Orthopedic J*. 2016;36:46-52.
12. Harris AM, Patterson BM. Results and outcomes after operative treatment of high-energy tibial plafond fractures. Foot Ankle Int. 2006; 27:256–265.
13. Duckworth AD, Jefferies JG, Clement ND, et al. Type C tibial pilon fractures: short- and long-term outcome following operative intervention. Bone Joint J. 2016;98-B:1106–1111.
14. Morash J, Walton DM, Glazebrook M. Ankle arthrodesis versus total ankle arthroplasty. Foot Ankle Clin. 2017;22:251–266.
15. Maffulli N, Longo UG, Locher J, et al. Outcome of ankle arthrodesis and ankle prosthesis: a review of the current status. Br Med Bull. 2017;124:91–112.
16. Hessmann M, Nork S, Sommer C, Twaddle B. AO Pilon Fx Classification. In: AO Foundation; 2008.

17. Marsh JL, Weigel DP. Tibial plafond fractures How do these ankle function over time. J Bone Joint Surg. 2003;85-A:287–295.
18. Bonato LJ, Edwards ER, Gosling CM, et al. Patient reported health related quality of life early outcomes at 12 months after surgically managed tibial plafond fracture. Injury. 2017;48:946–953.
19. Tochigi Y, Buckwalter JA, Martin JA. <Distribution and Progression of Chondrocyte Damage in a whole organ model of Human Ankle Intra-Articular Fracture.pdf>. TJ Bone Joint Surg. 2011;93-A:533–539.
20. Duckwort AD, Jefferies JG, Clement ND, et al. Type C tibial pilon fractures short and long-term outcome following operative intervention. Bone Joint J. 2016;98-B:1106–1111.
21. Davidovitch RI, Elkhechen RJ, Romo S, et al. Open reduction with internal fixation versus limited internal fixation and external fixation for high grade pilon fractures (OTA type 43C). Foot Ankle Int. 2011;32:955–961.
22. Sommer C, Nork SE, Graves M, et al. Quality of fracture reduction assessed by radiological parameters and its influence on functional results in patients with pilon fractures: a prospective multicentre study. Injury. 2017;48:2853–2863.
23. Korkmaz A, Ciftdemir M, Ozcan M, et al. The analysis of the variables, affecting outcome in surgically treated tibia pilon fractured patients. Injury. 2013;44:1270–1274.
24. Wyrsch B, McFerran MA, McAndrew M. Operative treatment of fractures of the tibial plafond. J Bone Joint Surg Am. 1996;78:1646–1657.
25. White TO, Guy P, Cooke CJ. The results of early primary open reduction and internal fixation for treatment of OTA 43-C. J Orthop Trauma. 2010;24:1000.