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Effect of BMI on the clinical and radiological outcomes of pilon fractures

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Objective: The aim of this study was to evaluate the effect of BMI on clinical and radiological outcomes of pilon fractures. We hypothesized that obese patients, defined as having a BMI of 30 or higher, would not have worse functional and radiological outcome compared to non-obese patients.

Methods: This study retrospectively reviewed 42 patients (33 males and 9 females; mean age: 42.67±12.29 years, range: 18 to 67 years) who sustained tibial pilon fractures between January 2008 and May 2011. Each patient's postoperative course, including the incidence of postoperative complications, and the length of hospital stay was determined from medical charts. At the final follow-up, clinical assessment was made according to the AOFAS score and radiological evaluation was made according to the Kellgren-Lawrence classification.

Results: Twenty-nine patients had low-energy trauma, while 13 had high-energy trauma. Mean BMI was 28.96±4.86 kg/m^2. There were 18 obese patients and 24 non-obese patients. Mean AOFAS score at the final follow-up was 68.36±20.71. The average follow-up time was 30.0±11.48 months. Superficial infection in the obese group occurred at a statistically significantly higher rate ($p<0.05$). Operation and hospitalization times occurred at a significantly higher rate in the obese group ($p=0.001$ and $p=0.041$, respectively).

Conclusion: Body mass index does not affect the clinical and radiological outcomes of tibial pilon fractures, with the exception of superficial infection. Obese patients could be treated as non-obese patients with close monitoring of the wound.

Key words: AOFAS score; BMI; obese; pilon fracture.

Pilon fractures are relatively rare injuries representing 5 to 7% of all tibial fractures.[1] Pilon fractures are serious and complex injuries, due to associated soft tissue damage and severe fracture patterns. Several successful treatment methods have been described in recent years. The injury pattern, fracture type, and anatomic reduction of the joint are the main factors affecting the final outcomes.[2,3]

Body mass index (BMI), is calculated by dividing the patient's weight in kilograms by the square of their height in meters, and classified as 'obese' when the value exceeds 30 kg/m^2. The impact of BMI on the outcome of orthopedic surgical procedures is variable. It has been shown that increased BMI increases perioperative complication rates.[4-7] There is limited published reporting

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Table 1. Distribution and evaluation of general characteristics.

	Mean±SD (range)
Age	42.67±12.29 (18-67)
BMI	28.96±4.86 (20.87-37.33)
Operation time (min)	71.21±14.54 (50.91)
Time from injury to operation (days)	8.38±1.36 (6-12)
Follow-up time (months)	30.0±11.48 (12-48)
Union time (weeks)	17.40±4.30 (10-32)
Hospitalization time (days)	11.09±1.98 (8-18)
Kellgren-Lawrence grade	2.24±1.12 (1-4)
AOFAS score	68.36±20.71 (22-97)
Gender	
Male	33 (78.6%)
Female	9 (21.4%)
Side	
Right	25 (59.5%)
Left	17 (40.5%)
Dominant side	
Right	37 (88.1%)
Left	5 (11.9%)
AO/OTA fracture type	
B2	12 (28.6%)
C1	9 (21.4%)
C2	8 (19%)
C3	13 (31%)
Malunion	8 (19%)
Trauma mechanism	
High-energy	21 (50%)
Low-energy	21 (50%)
Delayed union	2 (4.8%)
Superficial infection	4 (9.5%)

on the comparison of obese and normal weight patients with pilon fractures treated with open reduction and internal fixation.

The aim of this study was to evaluate the effect of BMI on the clinical and radiological outcomes. We hypothesized that obese patients would not have worse functional and radiological outcomes compared to non-obese patients.

Patients and methods

This study was approved by the local ethical committees of Dr. Lütfi Kırdar Kartal Research and Training Hospital, and all study participants signed an informed consent statement. A retrospective review of a prospectively gathered orthopedic trauma database was reviewed to identify patients who had sustained tibial pilon fractures between January 2008 and May 2011. According to the medical record charts, 70 cases of tibial pilon fractures required surgery.

The inclusion criteria were; presence of unilateral pilon fracture without any associated fractures and lack of any psychological or psychiatric conditions that could affect the subjective evaluation. Exclusion criteria included skeletal immaturity, Gustilo and Anderson Type 2 or 3 open wounds, previous surgery to the involved foot, patients with traumatic brain injury, or an ipsilateral fracture of the femur, patella, tibia or dislocation of the knee. Ten cases were excluded as they had associated fractures, 10 were excluded due to lack of follow-up and 8 were excluded due to pathological fractures. This study included 42 patients (33 males and 9 females; mean age: 42.67±12.29 years, range: 18 to 67 years).

Fracture type was determined according to AO/OTA classification.[8] Preoperative planning was performed based on plain radiographs and computed tomography (CT) scans with reconstructions.[9] The affected leg of all patients was immobilized in an above knee plaster of Paris splint before surgery. Ice and mannitol (intravenous, 250 mg/day) were used preoperatively to decrease swelling.[10] Operations were carried out when the skin appeared wrinkled (when the wrinkle test was [+]).[2,11,12]

Mean time to operation was 8.25 days in non-obese patients and 8.56 days in obese patients (Tables 1 and 2).

Operations were carried out by two senior orthopedic surgeons with more than 15 years of experience in their specialty. All patients underwent operation on a standard radiolucent table in the supine position. A tourniquet was used on all patients. After surgical exposure of the fracture, anatomic reduction was achieved and internal fixation was completed with compression plates. In addition to compression plates, joint restorations were performed with additional full-threaded free screws in 2 Type C1 patients, 5 Type C2 patients and 8 Type C3 patients according to AO/OTA classification.[8]

Hemovac drains were used in all cases. A plaster cast splint and elastic bandage was applied to all patients after surgery and the plaster cast was removed every 8 hours for 10 minutes of active resistive exercises. The Hemovac drains were removed on the 1st postoperative day. Surgical wounds were checked 48 hours postoperatively. Patients with actively draining wounds were hos-

Fig. 1. Fifty-year-old female suffered a pilon fracture (AO/OTA Type C3), as a result of high-energy trauma. **(a)** Preoperative anteroposterior and lateral radiographs of the involved leg. **(b)** Early postoperative anteroposterior/lateral radiographs showing fixation of the tibia and fibula with plates. **(c)** Radiographs of the involved leg at 3 years follow-up. AOFAS score: 58. Kellgren-Lawrence grade: 3.

pitalized for elevation and dressing changes. On the 14th postoperative day, sutures and the splint were removed. The patients were kept non-weight-bearing with two crutches for 6 weeks. At the 6th week follow-up, patients were allowed to bear weight as tolerated and were examined postoperatively at 6 week intervals until clinical and radiological fracture union. Progressive weight-bearing was allowed once there was radiographic evidence of callus formation and clinical union. Clinical union was defined as pain-free full weight-bearing. Radiographic union was defined as the presence of callus in three of the four cortices as seen on anteroposterior and lateral radiographs. After bony union was achieved, patients were followed up at 6 month intervals for the first year and then annually.

Nonunion was defined as a lack of evidence of clinical and radiographic union at 9 months. Malunion was defined as >7 degrees valgus/varus or >10 degrees procurvatum/recurvatum on the final radiographic evaluation. Any soft tissue infection treated by oral antibiotics was considered a minor soft tissue infection, while a major soft tissue infection was defined as requiring intravenous antibiotics and/or return to the operating room. At the final follow-up, clinical assessment was made according to the AOFAS score[13] and radiological evaluation was made according to the Kellgren-Lawrence classification.14 Results were evaluated according to the AOFAS score. Postoperative complications were recorded. Body mass index was calculated based on the patient's height and weight as recorded at the time of initial hospital presentation (BMI = weight (kg)/height (m)2) (Fig. 1).

Each patient's postoperative course, including the incidence of postoperative complications, and the length of hospital stay was determined from medical charts.

Statistical analysis was performed using SPSS for Windows v.15.0 (SPSS Inc., Chicago, IL, USA). Student's t-test and Fisher's exact test were used to compare the AO/OTA fracture type and AOFAS score with the Kellgren-Lawrence arthrosis grade. Student's t-test was used to evaluate the difference in groups in terms of AOFAS score, time from injury to operation, operation time, age and union time. Fischer's exact test was used to determine the difference with respect to AO/OTA fracture type, malunion, smoking, diabetes mellitus (DM) and superficial infection. The Mann-Whitney U test was used to compare the difference in hospitalization time and Kellgren-Lawrence[14] arthrosis grade. An independent statistician, who was not directly involved in the study, performed the statistical analysis. A p value of <0.05 showed statistical significance.

Results

According to the AO/OTA classification, there were 12 Type B2, 9 Type C1, 8 Type C2 and 13 Type C3 fractures. The left limb was involved in 17 (40%) patients and the right in 25 (60%). In 22 (52.4%) patients the fracture was on the dominant side. Twenty-one (50%) patients had low-energy trauma and 21 (50%) high-energy trauma.

Mean BMI was 28.96±4.86 (range: 20.87 to 37.33) kg/m^2. There were 18 (42.9%) patients with a BMI greater than 30 kg/m^2 (obese) and 24 (57.1%) patients with a BMI less than 30 kg/m^2 (non-obese). Mean AOFAS score at the final follow-up was 68.36±20.71 (range: 22 to 97). The average follow-up time was 30.0±11.48 (range: 16 to 48) months (Table 1).

There was no statistically significant difference in the rate of malunion, arthrosis grade, AO/OTA fracture type, AOFAS scores, union time, BMI, age, gender, incidence of DM and smoking between the two groups (Table 2). Complications occurred in 6 (33.3%) of the 18 obese patients and in 2 (8.3%) of the 24 non-obese patients (Table 3). Superficial infection occurred at a statistically significant higher rate in the obese group

Table 2. Comparison of age, gender, smoking and DM in patient groups according to BMI.

		BMI		
		Non-obese	Obese	p
Age (mean±SD)		40.0±12.49	46.22±11.37	[1]0.105
Sex	Female (n; %)	5 (20.8%)	4 (22.2%)	[2]1.000
	Male (n; %)	19 (79.2%)	14 (77.8%)	
Smoking	+ (n; %)	6 (25%)	3 (16.7%)	[3]0.708
	- (n; %)	18 (75%)	15 (83.3%)	
Diabetes mellitus	(n; %)	4 (16.7%)	6 (33.3%)	[3]0.281

[1]Student's t-test; [2]Continuity correction (Yates) test; [3]Fisher's exact test.

Table 3. Results of both groups according to BMI.

	BMI		
	Non-obese	Obese	p
AOFAS score (mean±SD)	73.33±17.75	61.72±22.94	[1]0.072
Kellgren-Lawrence grade (mean±SD; median)	2.04±1.04 (2)	2.50±1.20 (2.5)	[2]0.204
Time from injury to operation (day) (mean±SD)	8.25±1.29	8.56±1.46	[1]0.478
Operation time (min) (mean±SD)	61.08±9.24	84.72±7.49	[1]0.001†
Hospitalization time (day) (mean±SD)	10.50±1.5	11.89±2.49	[2]0.041*
Union time (weeks) (mean±SD)	17.17±4.31	17.72±4.39	[1]0.684
Superficial infection (n; %)	0 (0%)	4 (22.2%)	[3]0.027*
Malunion (n; %)	2 (8.3%)	2 (11.1%)	[3]1.000
AO/OTA fracture type			
B2 (n; %)	7 (29.2%)	5 (27.8%)	
C1 (n; %)	7 (29.2%)	2 (11.1%)	[3]0.351
C2 (n; %)	5 (20.8%)	3 (16.7%)	
C3 (n; %)	5 (20.8%)	8 (44.4%)	
Trauma mechanism			
High-energy (n; %)	9 (37.5%)	12 (66.7%)	[4]0.119
Low-energy (n; %)	15 (62.5%)	6 (33.3%)	

[1]Student's t-test; [2]Mann-Whitney U-test; [3]Fisher's exact test; [4]Continuity correction (Yates) test; *p<0.05, †p<0.01.

(p<0.05). Four patients in the obese group had superficial wound infections, resolved with local wound care. None of the patients had major complications (pneumonia, pulmonary embolism, DVT, deep wound infection) during the initial hospital stay. There was no statistically significant difference between obese and non-obese patients regarding trauma mechanism and type of fractures. Mean operation time was 61 minutes in non-obese patients and 84 minutes in obese patients (Table 3). Operation and total hospitalization times were significantly longer in the obese group (p=0.001 and p=0.041, respectively).

Discussion

The most important findings of the study were that hospitalization time, surgery time and superficial wound infection rates were higher in obese patients compared to non-obese whereas BMI had no effect on the AO/OTA fracture pattern. Previous studies reported that obese patients were more likely than non-obese individuals to sustain ankle fractures, particularly severe fracture.[15,16] The impact of obesity on complication rates and outcomes is challenging.[16-18]

Obesity is a risk factor for orthopedic surgery, especially for postoperative wound dehiscence and su-

perficial wound infection. Everhart el al. reported that obesity was a risk factor for infection in total hip arthroplasty.[19] Likewise, open treatment of pilon fractures is associated with wound healing complications. A traumatized, limited soft tissue envelope contributes to wound healing complications. Obese patients have larger soft tissue envelopes around the ankle, which while theoretically providing a greater area for energy distribution and more accommodation to implants, prolongs hospitalization time for wounds of obese patients prone to dehiscence in the early postoperative period.[20] In the current study, 4 patients (22.2%) in the obese group had superficial wound dehiscence in the early postoperative days, which recovered with hospitalization and local wound care. These patients had no medical comorbidities that could assess the wound dehiscence. Graves et al. reported that wound problems were common in obese patients, but not statistically significant in their retrospective study of 114 pilon fractures.[20] However, in our study, there was a statistically significant difference between the two groups ($p=0.027$). Amri et al. concluded that BMI was incrementally associated with wound-related complications.[21] Prevention of wound problems can be achieved by delaying the surgery until the appearance of the wrinkle sign, and delayed reconstruction is essential in treating these complex fractures, as Sirkin et al. stated.[22]

In this study, the obese patients had a significantly longer operative time than non-obese patients ($p<0.05$). Due to the bulky soft tissue around the fracture zone, operations are difficult and time is required to achieve adequate reduction, thus the surgical exposure was longer in obese patients.[5-7]

There was no statistically significant difference in the fracture pattern with regard to BMI (Table 1). While Böstman[23] observed that obesity was a significant risk factor for the severity of the fracture pattern, Graves et al.[20] reviewed 114 pilon fractures and stated that BMI did not affect fracture severity. This study corroborated the study of Graves et al.[20] Injury pattern should be the predictive factor for the fracture pattern of the pilon, rather than BMI. Collinge et al. reported that OTA Type 3C fractures occurred due to high-energy trauma.[24] However, to determine whether these results are generalizable, comparative prospective trials between BMI and fracture type are called for.

There were no statistically significant differences between the obese and non-obese groups in terms of clinical outcomes (AOFAS scores) ($p>0.05$). However, this result cannot be generalized, due to the small sample size and short follow-up time. As the fracture pattern progressed, the quality of reduction diminished.

A major concern in intra-articular fractures is the quality of the reduction, with poor reduction predisposing posttraumatic joint degeneration.[25] In the current study, mean AOFAS foot and ankle scores at the final follow-up were 61.72 ± 22.94 for the obese group and 73.33 ± 17.75 for the non-obese group. Collinge et al. reported a mean AOFAS score of 83.24 Leonard et al.[26] found that excellent AOFAS results were obtained at mean follow-up of two years in 83% (20/24) of patients operated on due to C2-C3 pilon fractures. The presence of arthrosis had only weak correlations with clinical outcome, as measured with the Iowa Ankle Score, the Ankle Osteoarthritis Scale, and the SF-36. Etter and Ganz also noted this lack of correlation.[27]

Graves et al. and White et al. detected some problems during the healing process of pilon fractures in smokers with Type 2 DM.12, 20 Collinge et al. reported that smoking and DM could increase complication rates in pilon fracture recovery, requiring secondary operations.[24] In this study, during the management of patients with pilon fractures, there was no statistically significant evidence showing the unfavorable effects of smoking and DM. The small sample size may have prevented the identification of potentially meaningful associations. Finally, with longer follow-up of these patients, a stronger association between arthrosis and clinical outcome may become apparent.

Limitations of this study included the small number of patients, retrospective analysis and the reliance on medical charts to collect patient data. Additional complications may have occurred that were not documented. The degree of restoration of articular congruity after operative treatment was not evaluated as postoperative radiographs after treatment of pilon fractures is inherently flawed due to hardware, often obscuring the details of articular alignment. Although every effort was made to contact all patients, follow-up data could be obtained on only 81% (n=42) of the 52 potentially available patients. Due to the limited sample size, the results should not be generalized. Further prospective, multicenter studies with similar fracture patterns; comorbidities and age are necessary to form a reliable conclusion for this retrospectively designed study.

In conclusion, as with non-obese patients, early operation is suitable for obese patients with a positive wrinkle test (+) in which adequate precautions have been taken (providing disinfection of the surgical site, meticulous dissection and gentle retraction). There is no difference between each group with respect to the clinical and radiological outcomes.

Conflicts of Interest: No conflicts declared.

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