Does obesity influence the outcome after the operative treatment of ankle fractures?

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Many orthopaedic surgeons believe that obese patients have a higher rate of peri-operative complications and a worse functional outcome than non-obese patients. There is, however, inconsistency in the literature supporting this notion.

This study was performed to evaluate the effect of body mass index (BMI) on injury characteristics, the incidence of complications, and the functional outcome after the operative management of unstable ankle fractures.

We retrospectively reviewed 279 patients (99 obese (BMI ≥ 30) and 180 non-obese (BMI < 30) patients who underwent surgical fixation of an unstable fracture of the ankle. We found that obese patients had a higher number of medical co-morbidities, and more Orthopaedic Trauma Association type B and C fracture types than non-obese patients. At two years from the time of injury, however, the presence of obesity did not affect the incidence of complications, the time to fracture union or the level of function.

These findings suggest that obese patients should be treated in line with standard procedures, keeping in mind any known associated medical co-morbidities.

Ankle fracture injuries are common with an incidence of approximately 187 per 100 000 person-years.¹ Previous clinical investigations have identified certain factors associated with poor prognosis after the operative management of unstable ankle fractures. These include increased patient age, the presence of diabetes, skin problems, and peripheral vascular disease.^{2,3}

Obesity has become a major health epidemic, with recent reports citing that one in five Americans is obese.⁴ This correlates with a 61% increase in the prevalence of obesity since 1991.⁵ A recent epidemiologic study projected that, by 2025, 40% of the American population will be clinically obese.⁴ While the negative effect of an increased body mass index (BMI) on surgical morbidity is widely accepted, the literature supporting this concept is inconsistent.⁶⁻¹¹ Similarly, the relationship between BMI and outcome after orthopaedic surgical procedures is variable. While increased BMI has been shown to increase the peri-operative complication rate after total knee replacement,^{12,13} fixation of acetabular fractures¹⁴ and calcaneal fractures,¹⁵ this relationship has not been demonstrated with respect to the management of unstable ankle fractures.

The current study aimed to evaluate the effect of obesity on injury characteristics, the incidence of complications, and the functional outcome after the operative management of unstable ankle fractures. Our hypothesis was that obese patients, defined as having a BMI ≥ 30 , would have more severe injuries, an increased peri-operative complication rate and a worse functional outcome compared to non-obese patients whose ankle fractures required operative treatment.

Patients and Methods

This was a retrospective review of prospectively collected data. All patients who sustained unstable ankle fractures requiring surgical intervention at our institution were entered into a database and prospectively followed. All operations were performed by four fellowship trained orthopaedic traumatologists (KAE, KJK, and two who were not authors).

At the time of hospital admission, all demographic information, medical history (specifically of diabetes mellitus), and history of smoking of each patient were recorded. A baseline functional evaluation using the American Orthopaedic Foot and Ankle Society (AOFAS) scoring system¹⁶ and the Short Musculoskeletal Function Assessment (SMFA) scoring system¹⁷ was obtained.

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The BMI was calculated based on the patient's height and weight as recorded at the time of initial hospital presentation ($\text{BMI} = \text{weight (kg)} / \text{height (m)}^2$). Recorded into the database at time of surgery were injury characteristics (including mechanism of injury and mortise displacement measured as widening of the medial joint space), American Society of Anesthesiologists (ASA) classification¹⁸ of operative risk and operative parameters including tourniquet time. All fractures were classified according to the Orthopaedic Trauma Association (OTA) system.¹⁹ Also recorded was each patient's post-operative course, including the incidence of post-operative complications, such as medical, surgical, thromboembolic, and genitourinary complications, the number of physiotherapy sessions and the length of hospital stay.

Post-operatively, all ankles were splinted and kept immobilised for between seven and ten days. At the first post-operative visit, sutures were removed and patients were provided with a functional brace. At this time, active-assisted ankle movements were supervised by a trained physiotherapist. All patients were kept non-weight-bearing. At the six-week follow-up visit, patients were allowed to bear weight as tolerated, with the exception of insulin-dependent diabetics and those with a syndesmosis screw, both of whom were prevented from full weight-bearing for eight to ten weeks.

The patients were examined post-operatively at three, six, 12 and 24 months. The examination, by the treating physician, included an evaluation of tenderness, active range of movement of the ankle, mobility and strength testing. Radiographs (anteroposterior (AP), lateral and mortise views) were assessed for bony union, maintenance of the ankle mortise, breakage of metal and for the development of osteoarthritis. Fracture union was defined as loss of the fracture lines in the distal fibula and medial malleolus. Functional status was evaluated at each follow-up visit using the AOFAS and SMFA outcome tools.

The patients were divided into those with a BMI of < 30 (the non-obese group) and those with a BMI of ≥ 30 (the obese group).^{20,21} Comparisons were made between the groups using unpaired Student *t*-tests, and Fisher's exact test with a *p*-value of < 0.05 defining statistical significance. In order to evaluate the effect that patient age had on our results, logistic regression analyses were performed, examining the effect of age on each outcome parameter.

A subset analysis including 18 patients with morbid obesity, defined as a BMI ≥ 40 , was then performed for all parameters, comparing this cohort to patients with a BMI < 40 .^{20,21} This subset was examined in order to evaluate the worst-case scenario with respect to BMI and its impact on injury characteristics, complication rate and functional outcome.

Results

Between 20 October and 5 December 2004 a total of 315 patients who underwent surgery for an unstable ankle

Fig. 1

Distribution of baseline medical condition (* indicates statistically significant higher number of medical comorbidities among the obese patient cohort) (Med Co-mrb, medical co-morbidities; DM, diabetes mellitus).

fracture were entered into the database. Of these, 279 (89%) had complete follow-up, allowing inclusion in the study, of which 99 (35.5%) were obese and 180 (64.5%) were non-obese. The total number of medical co-morbidities and the ASA class were significantly higher in the obese group compared to the non-obese group ($p < 0.01$ and $p < 0.001$, respectively). However, the incidence of diabetes mellitus ($p = 0.46$) and cigarette smoking ($p = 0.45$) was not different between the two groups (Fig. 1).

Injury characteristics and surgical data. The injury characteristics are set out in Table I. There were significantly more OTA type B and C fractures in the obese group than in the non-obese group ($p < 0.01$). In contrast OTA type A ankle fractures were seen in only 1% of obese patients compared with 11% of non-obese patients. There was no significant difference between the two groups with respect to mortise displacement, the incidence of open fracture and the incidence of fracture dislocation.

Mean tourniquet times were similar between the groups (59.9 minutes for obese and 62.0 minutes for non-obese; $p = 0.68$). The mean length of hospital stay (4.4 days for obese and 4.1 days for non-obese) and the mean number of physiotherapy sessions received during hospital admission (1.7 for obese and 2.1 for non-obese) showed no difference between the two groups ($p = 0.47$ and $p = 0.43$ respectively). The incidence of post-operative complications was also similar in the two groups, occurring in 8% of obese and 6.7% of non-obese patients ($p = 0.80$).

Table I. Injury characteristics

	Obese group (99 patients)	Non-obese group (180 patients)	p-value
Open vs closed ankle fracture (%)			
Closed injuries	97 (98.0)	174 (96.7)	0.53
Open injuries	2 (2.0)	6 (3.3)	0.71
Fracture vs fracture-dislocation (%)			
Fracture	72 (72.7)	114 (63.3)	0.11
Fracture-dislocation	27 (27.3)	66 (36.7)	0.13
OTA* classification distribution (%)			
Type A	1 (1.0)	20 (11.1)	< 0.001
Type B	76 (76.8)	126 (70.0)	< 0.001
Type C	22 (22.2)	34 (18.9)	< 0.001
Fracture displacement (%)			
< 5 mm displacement	72 (72.7)	116 (64.4)	0.30
> 5 mm displacement	27 (27.3)	64 (35.6)	0.16

* OTA, orthopaedic trauma association

Fig. 2

Time to fracture union.

Time to fracture union. There was no difference between the two groups with respect to time to radiological fracture union (Fig. 2). By three months, 96 (97.0%) fractures in patients with obesity and 174 (96.7%) fractures in patients without obesity had united ($p = 1.00$). By six months, only one fracture had not united. This fracture was in a non-obese patient and it finally united by one year without surgical intervention (Fig. 2).

The rate of metal removal was similar between groups (7% for obese and 8.4% for non-obese; $p = 0.82$) as was the overall re-operation rate (10% for obese and 9.3% for non-obese; $p = 1.00$).

Functional outcome. At three months, the mean AOFAS score for the obese group was 79.3 (58 to 100) compared with 78.8 (56 to 100) in the non-obese group ($p = 0.80$).

The mean values were similar between the two groups with respect to scores of pain (29.9 (20 to 40) for obese and 29.3 (20 to 40) for non-obese), function (6.5 *vs* 6.1), maximum walking distance (3.7 *vs* 4.0), walking surface (3.4 *vs* 3.5), gait abnormality (5.9 *vs* 6.2), sagittal motion (6.9 *vs* 6.7), hindfoot motion (5.3 for both groups), ankle-hindfoot stability (7.9 for both groups), and alignment (9.9 *vs* 9.8). Similarly, there was no difference between the groups with respect to mean AOFAS score at the six-, 12- and 24-month follow-up (Table II).

At three-months, the mean SMFA dysfunction and bother indices were 22.2 (0 to 52) and 24.9 (0 to 65) for the obese patients respectively, compared to 19.6 (0 to 48) and 23.5 (0 to 54) for the non-obese cohort ($p = 0.23$ and $p = 0.38$). Mean values were not significantly different at the six-month ($p = 0.08$ and $p = 0.09$ respectively), 12-month ($p = 0.21$ and $p = 0.15$ respectively) and 24-month ($p = 0.26$ and $p = 0.20$) follow-up visits.

Effect of age on results. Regression analysis showed that when controlled for age, there was no significant difference in injury characteristics, time to union, incidence of complications or functional outcome scores between the obese and non-obese patient cohorts at any of the study time points. The range of calculated odds ratio was between 0.99 and 1.02 for each study parameter examined.

Effect of morbid obesity. Comparison of the 18 patients with a BMI ≥ 40 with the remainder of the patients (BMI < 40) showed no difference in the distribution of fracture types ($p = 0.45$), the incidence of open fractures ($p = 0.66$), or mortise displacement ($p = 0.41$). The mean tourniquet time and length of hospital stay were also similar between the groups ($p = 0.32$ and $p = 0.61$ respectively). The mean AOFAS scores were not significantly different at three months (79.0 *vs* 79.8; $p = 0.82$), six months (85.6 *vs* 86.8;

Table II. Mean functional outcome (range) using the American Orthopaedic Foot and Ankle society (AOFAS) score¹⁶

Follow-up (months)	Obese group	Non-obese group	p-value
3	79.3 (58 to 100)	78.8 (56 to 100)	0.80
6	85.0 (62 to 100)	87.1 (64 to 100)	0.28
12	85.0 (63 to 100)	87.2 (65 to 100)	0.25
24	89.9 (64 to 100)	88.2 (66 to 100)	0.41

p = 0.70), 12 months (84.9 *vs* 87.7; p = 0.14) and 24 months (90.2 *vs* 89.7; p = 0.82), nor were the dysfunction or bother indices of the SMFA system (three months p = 0.44 and p = 0.60; six months p = 0.18 and p = 0.19; 12 months p = 0.36 and p = 0.25; 24 months p = 0.49 and p = 0.43). Once again, regression analysis showed that age had no effect on the results.

Discussion

As expected, our data demonstrated that obese patients with unstable ankle fractures have a higher number of medical co-morbidities and ASA scores than non-obese patients. Patients with a BMI < 30 were more likely to sustain infra-syndesmotom injuries (OTA type A fractures), whereas patients with a BMI ≥ 30 were more likely to have trans-syndesmotom or supra-syndesmotom injuries (OTA types B and C fractures). This increased incidence of OTA types B and C may be interpreted as an increase in fracture severity although there was no difference in the number of open fractures, mortise displacement, or number of fractures *versus* fracture-dislocations between the two groups. Additionally, there was no difference in time to union between the two groups. Interestingly, we found no relationship between BMI and the incidence of post-operative complications or length of hospital stay. Moreover, there was no difference in the post-operative functional outcome at each time-interval up to two years. Regression analysis showed that age had no significant effect on the differences between injury parameters and outcome between the obese and non-obese patients.

While obesity is commonly considered a risk factor for surgical complications, the reported effects of obesity on surgical complications have varied in the literature.^{5,10,12,14,15,22-25}

In the elective general surgery population, a recent prospective study demonstrated only an increase in superficial wound infections among the obese group, with all other parameters being similar between the obese and non-obese groups.¹¹ In a review of coronary artery bypass patients, obesity did not contribute to increased risks of peri-operative morbidity or mortality.¹⁰

Within the orthopaedic surgery literature, the effects of obesity on complication rates and outcome are similarly varied.^{8,9,12,14,24,26} Total knee replacements in morbidly obese patients have been shown to have higher rates of infection, complications in wound healing, and avulsions of the medial collateral ligament.¹² However, a study of 125 hip replacement patients reported no increased risk of infection, delay in wound healing, wound dehiscence, or

prosthetic loosening associated with obesity.²⁴ In this study, the obese patient cohort differed from the non-obese cohort only with respect to peri-operative blood loss.²⁴ Obese patients undergoing acetabular fracture fixation have been shown to have increased blood loss, wound infection rates and prevalence of deep venous thrombosis compared to the non-obese patients.¹⁴

The effect of obesity on ankle fractures has been rarely examined. Bostman²³ found a higher mean BMI amongst patients who had lost reduction or had failure of ankle fracture fixation. Increased BMI has also been linked to an increase in severity of fracture. Spaine and Bollen²⁵ reported a significantly higher BMI in patients with displaced ankle fractures compared to those with non-displaced fractures.

The limitations of the current study include an analysis of only two patient groups. Further stratification into smaller BMI intervals may illustrate a trend towards differing outcomes. Since there is a subjective component to functional outcomes, obese patients may also have different expectations and desires, thus masking a less than ideal outcome.

We conclude that while obesity is commonly associated with the potential for a poor outcome and increased complications, this is not seemingly the case with respect to unstable ankle fractures. The effect of obesity on fractures of the ankle is limited solely to an increase in severity of fracture. Since there are no increases in peri-operative complications that we could find, we suggest that obese patients be treated in line with standard protocols, with obvious consideration given for any associated medical co-morbidities.

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References

1. Daly PJ, Fitzgerald RH Jr, Melton LJ, Ilstrup DM. Epidemiology of ankle fractures in Rochester, Minnesota. *Acta Orthop Scand* 1987;58:539-44.
2. Gandhi A, Liporace F, Azad V, Mattie KJ, Lin SS. Diabetic fracture healing. *Foot Ankle Clin* 2006;11:805-24.
3. Jones KB, Maier-Yelden KA, Marsh JL, et al. Ankle fractures in patients with diabetes mellitus. *J Bone Joint Surg [Br]* 2005;87-B:489-95.
4. Mokdad AH, Ford ES, Bowman BA, et al. Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA* 2003;289:76-9.
5. Wilson JA, Clark JJ. Obesity: impediment to postsurgical wound healing. *Adv Skin Wound Care* 2004;17:426-35.
6. Patel N, Bagan B, Vadera S, et al. Obesity and spine surgery: relation to perioperative complications. *J Neurosurg Spine* 2007;6:291-7.
7. Gillespie GN, Porteous AJ. Obesity and knee arthroplasty. *Knee* 2007;14:81-6.

8. Ibrahim T, Hobson S, Beiri A, Esler CN. No influence of body mass index on early outcome following total hip arthroplasty. *Int Orthop* 2005;29:359-61.
9. Yap CH, Zimmet A, Mohajeri M, Yui M. Effect of obesity on early morbidity and mortality following cardiac surgery. *Heart Lung Circ* 2007;16:31-6.
10. Brandt M, Harder K, Walluscheck KP, et al. Severe obesity does not adversely affect perioperative mortality and morbidity in coronary artery bypass surgery. *Eur J Cardiothorac Surg* 2001;19:662-6.
11. Dindo D, Muller MK, Weber M, Clavien PA. Obesity in general elective surgery. *Lancet* 2003;361:2032-5.
12. Winiarsky R, Barth P, Lotke P. Total knee arthroplasty in morbidly obese patients. *J Bone Joint Surg [Am]* 1998;80-A:1770-4.
13. Amin AK, Clayton RA, Patton JT. Total knee replacement in morbidly obese patients: results of a prospective matched study. *J Bone Joint Surg [Br]* 2006;88-B:1321-6.
14. Karunakar MA, Shah SN, Jerabek S. Body mass index as a predictor of complications after operative treatment of acetabular fractures. *J Bone Joint Surg [Am]* 2005;87-A:1498-502.
15. Abidi NA, Dhawan S, Gruen GS, Vogt MT, Conti SF. Wound-healing risk factors after open reduction and internal fixation of calcaneal fractures. *Foot Ankle Int* 1998;19:856-61.
16. Kitaoka HB, Alexander IJ, Adelaar RS, et al. Clinical rating systems for the ankle-hindfoot, midfoot, hallux and lesser toes. *Foot Ankle Int* 1994;15:349-53.
17. Swiontkowski MF, Engelberg R, Martin DP, Agel J. Short musculoskeletal function assessment questionnaire: validity, reliability and responsiveness. *J Bone Joint Surg [Am]* 1999;81-A:1245-60.
18. No authors listed. American Society of Anesthesiologists. www.asahq.org/clinical/physicalstatus.htm (date last accessed 19 June 2007).
19. No authors listed. Fracture and dislocation compendium. Orthopaedic Trauma Association Committee for Coding and Classification. *J Orthop Trauma* 1996;10:1-154.
20. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999-2000. *JAMA* 2002;288:1723-7.
21. Ogden CL, Carroll MD, Curtin LR, et al. Prevalence of overweight and obesity in the United States, 1999-2004. *JAMA* 2006;295:1549-55.
22. Bostman OM. Body mass index of patients with elbow and ankle fractures requiring surgical treatment. *J Trauma* 1994;37:62-5.
23. Bostman OM. Body-weight related to loss of reduction of fractures of the distal tibia and ankle. *J Bone Joint Surg [Br]* 1995;77-B:101-3.
24. Soballe K, Christensen F, Luxhoj T. Hip replacement in obese patients. *Acta Orthop Scand* 1987;58:223-5.
25. Spaine LA, Bollen SR. 'The bigger they come...' the relationship between body mass index and severity of ankle fractures. *Injury* 1996;27:687-9.
26. McLaughlin JR, Lee KR. The outcome of total hip replacement in obese and non-obese patients at 10- to 18-years. *J Bone Joint Surg [Br]* 2006;88-B:1286-92.