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Editorial Board Member of *World Journal of Orthopedics*, Biju Benjamin, MBBS, MCh, MS, Surgeon, Department of Orthopaedic surgery, Forth Valley Royal Hospital, Larbert FK5 4WR, Scotland, United Kingdom.
bijuben@yahoo.com

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MINIREVIEWS

Implications of obesity in patients with foot and ankle pathology

Hugo A Ubillus, Alan P Samsonov, Mohammad T Azam, Megan P Forney, Thelma R Jimenez Mosquea, Raymond J Walls

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Hugo A Ubillus, Alan P Samsonov, Mohammad T Azam, Thelma R Jimenez Mosquea, Raymond J Walls, Department of Orthopedic Surgery, NYU Langone Health, New York City, NY 10002, United States

Megan P Forney, Department of Surgery, University of Cincinnati, Cincinnati, OH 45267, United States

Corresponding author: Raymond J Walls, FRCS, MBChB, MD, Assistant Professor, Doctor, Staff Physician, Department of Orthopedic Surgery, NYU Langone Health, 171 Delancey Street, New York City, NY 10002, United States. raymond.walls@nyulangone.org

Abstract

Obesity is a growing problem defined as a body mass index of greater than 30 kg/m^2. It is predicted that by 2030, 48.9% of adults will be classified as obese which expands surgical risk factors to a broad population while increasing healthcare costs at the same time in different socioeconomic groups. This specific population has been widely studied in multiple surgical fields and published studies have shown the implications in each of these fields. The impact of obesity on orthopedic surgical outcomes has been previously reported in several total hip and knee arthroscopy studies, with evidence indicating that obesity is strongly associated with an increased risk of post operative complications together with higher revision rates. In line with increasing interest on the impact of obesity in orthopedics, there has been a similar output of publications in the foot and ankle literature. This review article evaluates several foot and ankle pathologies, their risk factors associated with obesity and subsequent management. It provides an updated, comprehensive analysis of the effects of obesity on foot and ankle surgical outcomes, with the ultimate aim of educating both surgeons and allied health professionals about the risks, benefits, and modifiable factors of operating on obese patients.

Key Words: Obesity; Foot and ankle surgery; Ankle fracture; Total ankle replacement; Achilles tendinopathy; Hallux valgus

Core Tip: Obesity is a growing population. The impact of this is also reflected in fields such as Orthopedic Surgery including foot and ankle. Mobility is determinant in every aspect of life and in the obese population it reflects a greater challenge when addressing pathologies affecting the foot and ankle. Multiple factors can affect the outcomes of surgical treatments in this population and we believe that a greater understanding is needed to be prepared to treat these patients while trying to reduce the further complications that they face.

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INTRODUCTION

Obesity is a growing problem; it is predicted that by 2030, 48.9% of adults in the United States will be classified as obese[1] (Table 1). Causes of obesity are multifactorial, ranging from increasingly sedentary lifestyles, lower socioeconomic groups, as well as several genetic factors[1]. Obesity also contributes to healthcare costs, with an estimated $150 billion spent on direct impact costs per year in the United States [2]. Obese individuals have been found to have medical costs that are approximately 30% greater than their normal weight peers[3]. Worldwide costs of obesity continue to increase with an estimated two trillion dollars per year, or approximately 2.5% of the global Gross Domestic Product in 2014, spent solely on obesity related costs[4].

Obesity is defined as a body mass index (BMI) greater than 30 kg/m^2[1]. The importance of this lies in the physiologic changes of obesity presented by patients, both metabolic and biomechanical. Metabolically, hypertrophic adipocytes and adipose tissue-resident immune cells release increased levels of adipokines and lipokines, creating a chronic inflammatory state that exacerbates cardiovascular disease and insulin resistance, both of which adversely affect bone metabolism[5]. It has been shown that obese subjects who have one or two additional risk factors, like smoking and sedentarism, their risk of developing diabetes increases by nine times[5].

Bone mineral density is compromised in obese people by two mechanisms[6]. Firstly, increased levels of chemerin, an adipokine, correlates with an increased osteoporotic fracture risk[7]. Secondly, increased receptor activator of nuclear factor-kB (RANK)/RANK Ligand activity results in increased bone resorption by inducing increased osteoclast activity[8].

Forward progression forces are essential for normal gait. In obese subjects, energy usages tend to be lower in the anteroposterior plane and higher in the mediolateral plane indicating lower energy efficiency[9,10]. Other factors associated with abnormal gait include quadriceps weakening, knee osteoarthritis, poor balance, increased risk of falls, and skin irritation from poor shoe fit secondary to increased foot width and acquired flatfoot deformity[11-13]. Tibiotalar joints experience forces up to 5 times the body weight during the stance phase which is greater in an obese person[14,15]. With this knowledge in mind, it is no coincidence that there is an increased incidence of foot pain and higher rates of tendinitis, plantar fasciitis, and osteoarthritis in obese individuals[16-19].

Pre-operative weight loss seems the obvious solution for improving surgical outcomes. However, weight loss is difficult to achieve and to maintain[20,21]. Patients with foot and ankle pathologies often report pain as a limiting factor for successful weight loss. These patients have a higher risk of unsuccessful conservative treatment in conditions including Achilles' tendinopathy, plantar fasciitis and posterior tibial tendon dysfunction[22]. This leads to the belief that surgery will eliminate pain and finally allow them to lose weight as reported by MacMahon *et al*[23] where > 66% of obese patients had higher expectations than their surgeons, prior to surgical intervention[23].

The impact of obesity in orthopedic surgical outcomes has been extensively reported in total hip and knee arthroplasty studies, with strong evidence that obesity is highly associated with increased perioperative complications and higher revision rates[22,24-26]. A frequent complication present in this type of patients are wound complications which occur 3 times more often in obese individuals as shown in the literature[24]. In recent years, there has been more literature evaluating the implications of obesity in foot and ankle surgery[27]. This review will provide an updated, comprehensive analysis of the effects of obesity on foot and ankle surgical outcomes, provide insight into outcomes obese patients may expect from their surgeries, and highlight risks, benefits, and modifiable factors when operating on this cohort.

Table 1 Summary of foot and ankle surgical implications in obese patients

No.	Key points
1	By 2030, 48.9% of adults will be classified as obese, expanding surgical risk factors to a broad population
2	A chronic pro-inflammatory state faced by these patients, adversely affects bone metabolism
3	Factors associated with abnormal gait include quadriceps weakening, knee osteoarthritis, poor balance and an increased risk of falls
4	In obese subjects who have one or two additional risk factors like smoking and sedentary, their risk of developing diabetes increases by nine times
5	In Achilles tendon repairs, there is a significant increased rate of surgical site infection at the time of surgery if a comorbidity is present compared to those without a comorbidity
6	Patients with diabetes and vascular complications have the highest surgical site infection rate followed by obesity
7	Percutaneous hallux valgus procedures have found no difference in complication or re operation rates between normal weight and obese adults after surgery
8	There is an increased incidence of foot pain including higher rates of tendinitis, plantar fasciitis, and osteoarthritis in obese individuals
9	Compared with normal weight women, obese women have a three-fold increased risk of sustaining an ankle fracture after a fall
10	Obese patients have a greater proportion of chondral lesions when compared with normal weight subjects, 58% *vs* 30% respectively

IMPLICATIONS IN FOOT AND ANKLE SURGERY

Ankle fractures

A positive relationship between obesity and ankle fractures has been found in both men and women[28-31]. Compared with normal weight women, obese women have a three-fold increased risk of sustaining an ankle fracture after a fall[29].

Obesity has a direct correlation to ankle fractures in part due to altered gait changes as outlined above [32,33]. Mechanical loading is also affected in the obese population. Goodloe *et al*[34] found that after ankle fractures, obese patients have a significantly greater risk of needing repair of the syndesmosis[34]. They demonstrated an increased risk of 4.2% for each point increase in BMI for malleolar fractures, 3% for bi-malleolar fractures, and 3.4% for tri-malleolar fractures[29]. They proposed a biomechanical explanation where increased weight generates greater torque contributing to an increased risk of a more complex injury.

A greater risk of surgical site infections (SSIs) after open reduction internal fixation (ORIF) is a concern in obese patients. Specifically, Richardson *et al*[35] reported the greatest risk factors for SSIs were a BMI over 40 kg/m^2 [odds ratio (OR): 2.23, $P < 0.0001$] and the presence of peripheral vascular disease (OR: 2.16, $P < 0.0001$)[35]. Stavem *et al*[36] reported increasing BMI was associated with increased rates of venous thromboembolism (VTE) within 6 mo of ORIF for closed ankle fractures [OR: 1.15 per kg/m^2, 95% confidence interval (CI): 1.07-1.24, $P < 0.001$]. These complications arise from the fact that obese patients are at a constant inflammatory and immunosuppressed state[37,38].

Osteochondral lesions

Osteochondral lesions (OCLs) of the talus occur in approximately 70% of patients with an ankle sprain or fracture[37]. Frequently, a BMI greater than 25 kg/m^2 is associated with negative clinical outcomes [39].

Mardani-Kivi *et al*[14] performed a study of 26 obese patients and 10 nonobese patients evaluating the success of arthroscopic treatment of anterior ankle impingement in these groups. Patients underwent American Orthopaedic Foot and Ankle Society (AOFAS) scores at 6- and 12-mo follow-up demonstrating no difference in clinical outcomes. However obese patients were found to have a greater proportion of chondral lesions, when compared with normal weight subjects (58% *vs* 30% respectively) [40].

Ankle arthroscopy is more technically demanding in obese patients with significantly longer operative times[41]. This itself may be a risk factor for wound complications post-operatively, however further study is required.

Usuelli *et al*[42] studied arthroscopic autologous matrix-induced chondrogenesis for talar OCLs and found that overweight patients were more likely to have larger lesions based on preoperative magnetic resonance imaging scans. Despite this, they had similar clinical improvements and functional outcomes compared with normal weight patients. Koh *et al*[41] retrospectively evaluated 252 patients who underwent arthroscopic treatment for OCLs of the talus and found that a BMI > 25 kg/m^2 was not associated with worse post-operative and clinical outcomes when compared to non-overweight patients [43]. In contrast, a prospective study by Chuckpaiwong *et al*[44] investigating the relationship between lesion size and microfracture for OCLs found that higher BMI was a significant predictor of a negative outcome[44]. Younger patients with a shorter duration of symptoms and a lower BMI had better outcomes than older patients with a higher BMI and a more chronic symptomatic course[44].

Total ankle replacement

Total ankle replacement (TAR) surgery is increasingly performed for end stage arthritis to reduce pain and improve function and mobility to these patients. Obesity is important when considering TAR. These patients induce greater stress on prosthetic joints which may cause premature failure and subsequent surgery[45]. Werner *et al*[46] analyzed 5361 TAR procedures for end-stage arthritis and found obese patients had significantly more major and minor complications at 90 d post-surgery including infection and VET[46]. Comorbidity were more prevalent in the obese cohort compared to the nonobese cohort (P < 0.0001)[46]. While these may explain the higher complication rate and revision in obese patients following total ankle arthroplasty, multivariate regression analysis was not performed to determine if any of them were confounding variables.

Implant failure at mid and long-term follow up has been reported by Schipper *et al*[47]. Their study showed that a BMI 30 kg/m^2 was associated with a higher probability of implant failure (OR: 2.8, 95%CI: 1.04-7.53, P = 0.04), revision, and a significant decrease of 5-year survivorship when compared to nonobese patients (adjusted hazard ratio 3.73, 95%CI: 1.05-10.43, P = 0.04)[47].

Gross *et al*[48] carried out a prospective study of 455 primary TARs with a minimum follow-up of 2 years and reported no difference in complication, infection, or failure rates between obese and non-obese groups. While obese patients had high post-operative satisfaction and statistically significant improved clinical outcomes, they were all lower than their normal weight counterparts[48].

Ankle arthrodesis

Ankle arthrodesis remains the primary surgical approach in end-stage arthritis for many patients[49]. Using the United States Medicare database, Kamalapathy *et al*[50] evaluated the relationship between obesity, postoperative complications and hospital utilization following ankle arthrodesis[50]. They identified 5540 patients with normal BMI, 1108 patients who were obese and 1108 patients who were morbidly obese. Morbid obesity was associated with a statistically significant increased risk for acute kidney injury, urinary tract infection, VTE, readmission, and minor complications. Morbidly obese patients' length of stay was on average 2 d longer, and total hospital charge also correlated with increasing BMI, averaging $34335 more for morbidly obese and $28942 for obese patients compared to their normal weight counterparts[50].

Likewise, Werner *et al*[46] analyzed 17688 patients who underwent ankle arthrodesis and found that obesity was associated with a significant increase of thromboembolic events, infection and revision surgery[46]. Similar to TAR, complications can be related to additional medical comorbidities, intra operative factors and larger tissue envelopes[46].

Adult acquired flatfoot deformity

Obesity is a known risk factor for developing adult acquired flatfoot deformity (AAFD). The main stabilizer of the longitudinal medial arch is the posterior tibial tendon which, in obese patients, sustains greater axial load leading to insufficiency and finally collapse.

Soukup *et al*[51] performed a retrospective study comparing the outcomes of normal weight, overweight, and obese patients following AAFD reconstruction to treat stage II adult acquired flatfoot [51]. They identified 44 normal weight, 39 overweight and 44 obese patients with a mean follow up of 2.9 years. Obese patients reported more severe symptoms pre-operatively, but had similar clinical and radiological outcomes in the short-term when compared to the other two groups. They suggest that obese patients are still candidates for reconstruction with comparable short-term outcomes, but recognized that longer follow up and larger patient cohorts are needed to evaluate mid-term and long-term outcomes[51].

Fuhrmann *et al*[52] performed a retrospective analysis looking at clinical and radiological outcomes of hindfoot arthrodesis in patients with and without a flatfoot deformity showing that increased weight and BMI were predictors of recurrent deformity[52]. They suggested that when performing Stage 2 flatfoot deformity correction in obese patients, tissue reconstruction and corrective osteotomies should be augmented with a subtalar fusion, to enhance hindfoot stability[52].

Achilles tendinopathy

Achilles tendinopathy is a common condition associated with age greater than 50 years, male sex, increased BMI and lower extremity deformities[53]. Macchi *et al*[54] performed a meta-analysis of 22 studies comprising 18814 patients, 4010 of whom were obese (BMI ≥ 30 kg/m^2). They found that obese patients had increased rates of Achilles tendinopathy but not increased rates of rupture[54].

Some of the most common complications of Achilles tendon surgery are wound dehiscence and wound infection[53-55]. Dombrowski *et al*[55] identified that in a population of 24269 primary Achilles tendon repairs, there was a significantly increased rate of SSI if a medical comorbidity was present at the time of surgery compared to those without a comorbidity (17.96% *vs* 5.96%, P < 0.0001)[55]. Patients with diabetes and vascular complications had the highest SSI rate (OR: 7.85, 95%CI: 6.25-9.86, P < 0.001), followed by obesity (OR: 3.2, 95%CI: 2.9–3.6, P < 0.001)[55,56]. Bruggeman *et al*[53] also showed that patients with one or more risk factors had a greater rate of wound complications than patients without risk factors (P < 0.0001)[53].

Hallux surgery

Dufour *et al*[18] examined the association between obesity and foot problems in older adults and found that both men and women had an increased risk of morbidity with increasing BMI. Interestingly, severely obese women were less likely to develop hallux valgus (HV)[18]. Frey and Zamora[57] also identified that normal weight people had an increased likelihood of HV[57]. We suspect that shoe wear options in patients with large feet may have a wide toe-box and thus help prevent the development of HV.

Chen *et al*[58] found a 7-fold increase of re-operation in obese patients due to rates of non-union[58]. They proposed that fat-derived adipokines resulted in poor bone healing[58]. While obese patients had a poorer preoperative AOFAS Hallux Metatarsophalangeal-Interphalangeal scores, they were able to achieve functional outcome scores comparable to those of patients of normal weight, suggesting that obese patients can experience a greater improvement in function after HV surgery[58].

Percutaneous HV procedures have found no difference in complication or reoperation rates between normal weight and obese adults after surgery[59]. This may be due to the fact that surgeries on the forefoot are typically shorter, usually performed under regional anesthesia, and can allow for partial weight bearing operatively.

At present, it is unclear if BMI has an adverse effect in HV surgery. Although some studies suggest higher reoperation rates, and others state no correlation[60], most authors agree that while it is important to warn obese patients of the significantly higher risk of repeated surgery, these patients should not be excluded from undergoing HV surgery[58], and in most scenarios BMI should not influence prognosis[61].

LIMITATIONS

Obesity cannot be seen as an isolated risk factor for surgical procedures. Various clinical diseases arise from obesity and a better stratification of individuals should be contemplated when designing clinical studies to reach more significant clinical results according to each risk factor that englobes obesity. Large prospective studies are an urge in the field to identify associated risk factors and accurately stratify patients. This would enable choosing management adequately, including appropriate selection for surgery, in order to optimise the clinical outcomes.

CONCLUSION

Obesity significantly increases the risk of post-operative complications for many foot and ankle surgical procedures. However, these patients should not be excluded from undergoing surgery as improved functional outcomes can be achieved, relieving suffering for many patients. A multi-disciplinary pre-operative approach including different specialties should be considered to address the possible clinical implications such as wound infections, cardiovascular events and delayed functional recovery after these procedures. This way, risks can be reduced by preparing patients in the best way before a surgical procedure.

Future steps are necessary regarding better quality of evidence studies to examine how obesity and associated complications may contribute to unwanted surgical outcomes and how these risks can be managed.

FOOTNOTES

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ORCID number: Hugo A Ubillus 0000-0002-4369-0289; Alan P Samsonov 0000-0002-0770-8138; Mohammad T Azam 0000-0003-0184-1330; Megan P Forney 0000-0003-0251-6302; Thelma R Jimenez Mosquea 0000-0002-0799-6723; Raymond J Walls

0000-0002-8606-7411.

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