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ORIGINAL PAPER

The impact of body mass index on metatarsalgia surgical outcomes

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Abstract

Introduction Several studies have suggested that an increased body mass index (BMI) is a negative factor for forefoot plantar pain but its influence in the surgical correction of metatarsalgia is unknown. The purpose of the present study is to evaluate the influence of the BMI on the surgical outcomes of metatarsalgia. It has been hypothesized that the higher the BMI, the worse the functional outcomes after metatarsalgia surgical treatment at one year follow-up.

Material and methods A prospective cohort study that included all patients operated on for third rocker metatarsalgia was conducted. Weil's osteotomy was performed on all the patients operated on. The patients' pre-operative height, weight, and BMI were recorded. The patients were subsequently divided into three groups based on their BMI. There was group 1 or the normal group (18.5 > BMI ≤ 25 kg/m2), group 2 or the overweight group (25 > BMI ≤ 30 kg/m2), and group 3 or the obese group (BMI > 30 kg/m2). Pre-operative, post-operative, and differential AOFAS were used to evaluate and compare the groups. The post-operative VAS was also measured to assess pain. The correlation between the BMI and those variables was also analyzed.

Results After the exclusion criteria were applied, 107 patients were finally assessed. There were 22 patients (20.6%) in group 1, 52 patients (48.6%) in group 2, and 33 patients (30.8%) in group 3. No correlation was observed between the BMI and AOFAS ($p > 0.05$). Neither were any differences found when the three groups were compared ($p > 0.05$). Moreover, no correlation between the BMI and the VAS score was observed ($p = 0.690$).

Conclusion Obesity does not negatively influence functional outcomes after surgery for metatarsalgia in short to medium term. Regardless of their BMI, patients with propulsive metatarsalgia improve in functionality after surgical treatment.

Keywords BMI · Obesity · Metatarsalgia surgical outcomes · Forefoot disorders

Introduction

Obesity is a major public health concern with over 1 billion people worldwide considered overweight. Some 300 million of them are considered obese [1, 2]. Obesity has been defined as an increase in body weight as a result of an excessive accumulation of body fat and is commonly measured using the body mass index (BMI) [2, 3]. It has been related to an increased risk of complications after orthopaedic surgery procedures [4, 5]. In terms of surgical outcomes, obesity has been associated with worse functional outcomes in rotator cuff surgery or hip and knee arthroplasty [5–8]. However, other studies have shown the opposite [9, 10].

Increased body weight has been suggested as a worsening factor in metatarsalgia as it is linked to an instability of the medial column that could translate into transfer metatarsalgia [11–14]. It also increases peak plantar pressures during walking phases [14]. Therefore, one could think that an increased BMI would worsen forefoot surgery results. Thus, patients suffering from obesity obtain worse outcomes after surgical correction of metatarsalgia. However, there is no study that specifically assesses the influence of obesity on metatarsalgia surgery outcomes.

The aim of the present study is to evaluate the influence of the BMI on the functional outcome of metatarsalgia surgical treatment. It has been hypothesized that the higher the BMI the patients have, the worse the functional outcomes after metatarsalgia surgical treatment at one year follow-up.

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Material and methods

A prospective cohort study that included all the patients operated on for third rocker metatarsalgia was conducted. The patients were treated in a single centre by the same surgical team from November 2011 to November 2013. Patients over 18 years old with third rocker metatarsalgia in which conservative treatment (insoles) had failed were included in the study. Patients with a rheumatic disorder, Morton's neuroma, and 2nd rocker metatarsalgia were excluded from this study. Patients who underwent revision surgery for recurrent symptomatic metatarsalgia were also excluded. Hallux surgery or lesser toes surgery were not considered as an exclusion criteria. A total of 119 patients made up the present study. After the exclusion criteria were applied, 107 patients were finally assessed (89.9%). All patients gave informed consent prior to participating in this investigation.

The patients' preoperative heights, weights, and BMI were taken and recorded. Subsequently, the patients were divided in three groups according to their BMI. They were group 1 or the normal group ($18.5 < BMI \geq 25$ kg/m$^{2)}$, group 2 or the overweight group ($25 < BMI \geq 30$ kg/m^2), and group 3 or the obese group (BMI > 30 kg/m^2).

Surgical technique

A pre-operative weight-bearing dorsoplantar radiograph was taken of all the patients. The metatarsals were corrected by means of Weil's osteotomy [15]. In each patient, the number of metatarsals that required the Weil osteotomy was individualized in order to achieve lengths that are considered ideal to reproduce Maestro's parabola [12]. A standard procedure was followed in all cases. A transverse dorsal incision was made over the metatarsal heads. Sharp dissection was used to expose the distal aspect of the shaft, making sure to protect the extensor tendons. Once the joint was made visible, the capsule was opened and the metatarsal head was exposed. A fine oscillating saw was used to perform an osteotomy parallel to the weight-bearing surface. The plantar fragment was moved proximally as measured on the preoperative radiograph planning. The resultant bone overhang was used to assess the amount of proximal displacement. The osteotomy was fixed with a headless cannulated compression screw. The remaining bone overhang was then removed and the wound was closed in layers (Fig. 1).

Outcome measures

The patients were prospectively followed for one year. The specific test for metatarsophalangeal-interphalangeal (MP-IP) of the lesser toes provided by the American Orthopedic Foot & Ankle Society (AOFAS) was used [16]. It was collected at the preoperative visit and at one year post-operatively. The questionnaire consists of nine items that are distributed over three categories. They are pain (40 points), function (50 points), and alignment (10 points), scoring a total of 100 points together. A score of 100 points is possible in a patient with no pain, full MP-IP range of motion, no MP or IP instability, good alignment, no limitation of daily or recreational activities, and no footwear limitations.

The Visual Analog Scale (VAS) was used at 1 year post-operatively to assess pain. Patients scoring 0 meant no pain and a score of 10 points meant excruciating pain. This scale has been shown to have good validity and internal consistency when used as a measurement for foot pain [17].

Statistical analysis

To assess the relationship between the BMI and functional outcomes, a statistical analysis was performed. Descriptive statistics were used to summarize demographics, the AOFAS and Visual Analog Scale. A chi-square analysis was used to compare categorical variables and the ANOVA with a Scheffé post hoc was used to compare quantitative variables. A Pearson correlation test was also performed. All statistical analyses were performed using the SPSS version 18.0 software package (SPSS, Inc., Chicago, Illinois, USA.) The alpha level was set at 0.05.

Results

There were nine men (8.4%) and 98 women (91.6%). The mean age was 65 years old (SD 11.4) and the mean BMI was 28.2 kg/m^2 (SD 4.5). There were 22 patients (20.6%) in group 1, 52 patients (48.6%) in group 2, and 33 patients (30.8%) in group 3. All groups were similar in terms of age, gender, and diabetes and tobacco distribution ($p > 0.05$). Table 1 provides the demographic characteristics of the groups.

The mean pre-operative MP-IP AOFAS of the sample was 51.73 points (SD 12.93), and the mean post-operative MP-IP AOFAS was 80.4 points (SD 15.7). No correlation was observed between the BMI and MP-IP AOFAS ($p > 0.05$), as can be seen in Table 2. No differences between them were found either when the three groups were compared. ($p > 0.05$). Table 3 provides the comparison between the three groups.

The mean post-operative VAS of the sample was de 2.19 (SD 3.07). No correlation between the BMI and the VAS score was observed ($p = 0.690$). Patients in group 1 obtained a mean post-operative VAS of 2.63 points. Group 2 and group 3 obtained 2.20 and 1.87, respectively. These differences were not significant ($p = 0.21$).

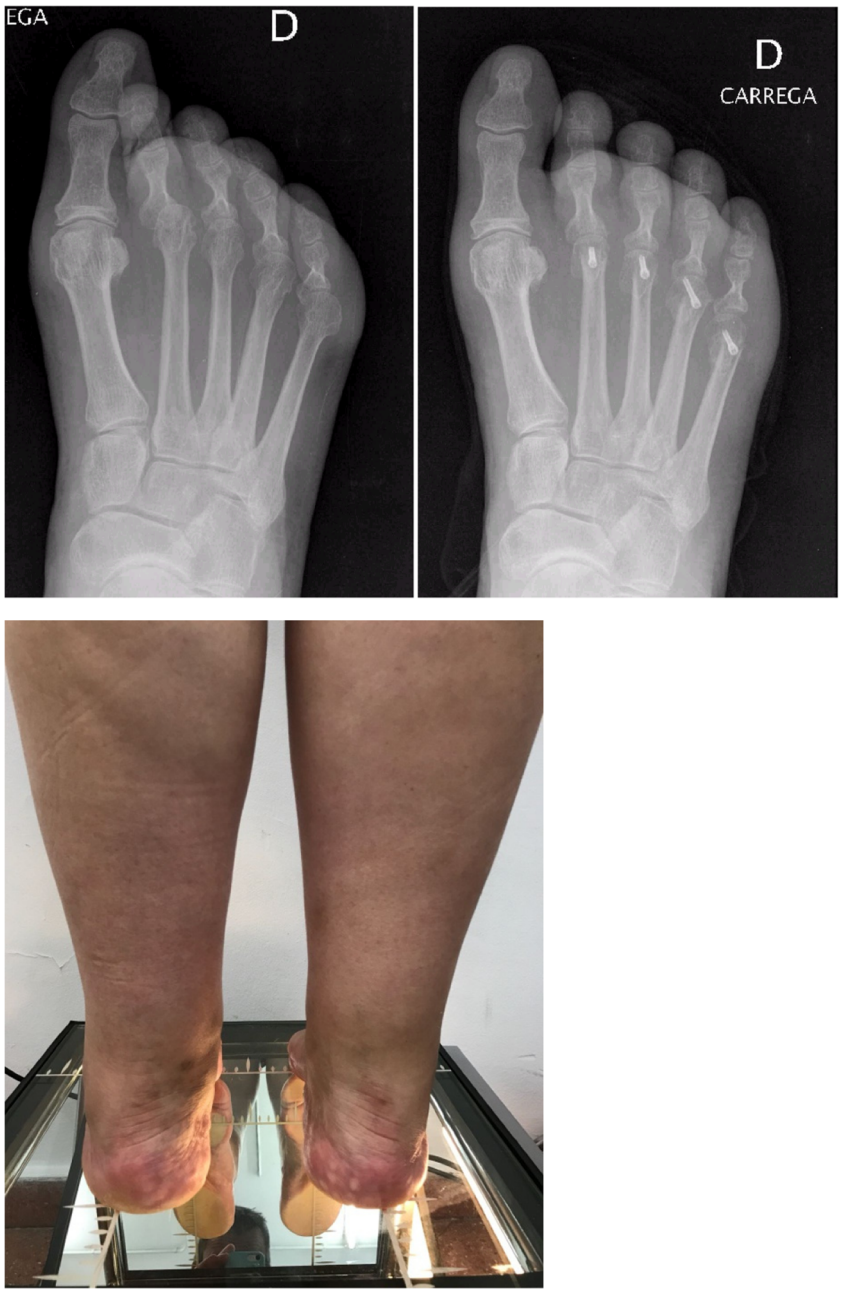

Fig. 1 Standing X-ray and 1 year post-operative X-ray. Clinical aspect

Table 1 Demographic data

	Group 1 (normal)	Group 2 (overweight)	Group 3 (obese)	*p* value
n	22	52	33	0.076
Age, mean (SD)	62 (21.5)	66.5 (14.5)	68.5 (16.3)	0.128
Gender (male/female)	2/20	9/43	3/30	0.452
Side (right/left)	11/11	22/30	19/33	0.578
BMI, mean (SD)	22.7 (1.77)	27.3 (1.27)	33.2 (2.95)	< 0.001
Smokers, *n* (%)	3 (13.6%)	2 (3.8%)	2 (6%)	0.295
Diabetes mellitus, *n* (%)	1 (4.5%)	3 (5.8%)	3 (5.8%)	0.762

Table 2 Correlation between AOFAS and BMI

	Mean	Standard deviation	*r*	*p* value
AOFAS pre-operative	51.73	12.93	−0.053	0.586
AOFAS post-operative	80.4	15.7	0.115	0.289
AOFAS differential	21.99	26.18	−0.123	0.250

Discussion

The BMI does not have any impact on metatarsalgia surgical outcomes in terms of function and pain in the present sample. Therefore, the initial hypothesis is rejected.

Obesity is a frequent entity with a growing incidence in our society [18]. It has been hypothesized that obesity alters the function and structure of the foot through different mechanisms. They include an alteration of the biomechanics of the sole of the foot and in the fat pad, a decrease in muscle strength, and/or changes in the gait cycle [11, 13, 14, 19]. In metatarsalgia due to a biomechanical alteration, there is an abnormal distribution of plantar pressures in the forefoot during the gait swing phase [20]. The objective of Weil's oblique distal osteotomy is to more uniformly redistribute pressures at the forefoot through proximal displacement of the metatarsal [15].

Different authors have observed a relationship between increased body weight and increased plantar pressure peaks in the forefoot as well as an increase in the contact areas of the foot [3, 11, 14, 21]. Arnold et al. concluded that there is a significant relationship between weight gain and an increase in pressure peaks in the heel and head of the second to fifth metatarsals [22]. On the other hand, Roy et al. found a relationship between load peaks in the lateral column of the foot as the age and weight of the patients increase [21]. Given that metatarsalgia results in an abnormal distribution of the plantar pressures in the forefoot during the gait swing phase, these studies suggest that an increase in body weight influences the evolution of metatarsalgia [21, 22]. Nonetheless, there is scarce literature to determine how the BMI influences the outcome of forefoot surgery.

In the literature, some studies show that obesity negatively impacts the post-operative period of arthroscopic surgery on the rotator cuff by extending the surgical time, the hospital stay, and giving worse functional results [6, 7]. Although the surgical time and hospital stay have not been analyzed in the present study, no differences in functional outcomes were seen. Therefore, obese and non-obese patients have a similar MP-IP AOFAS after surgery for metatarsalgia. Noteworthy is the work of Chen et al. having to do with forefoot surgery [23]. It evaluates the effect of obesity on the results of hallux valgus surgery. The authors of that study concluded that obese and non-obese patients have comparable results in terms of function and pain at two years of hallux valgus surgery. Milczarek et al. did not find any functional differences after evaluating patients at two years of Scarf surgery either [24]. Similar results have been obtained in the present study as there are no differences in function between the three groups (normal, overweight, and obese) of patients after metatarsalgia surgery. Relative to pain, patients obtained a mean VAS in all groups of around 2. This homogeneity of post-operative pain is also observed in other studies like that of Chen et al., a VAS score of about 1 point at 2 years postoperatively [23]. There is also Milczarek et al. with VAS score of around 3 [24]. There is also one study that assesses the influence of obesity on forefoot surgery outcomes. The authors did not specifically study metatarsalgia, however they found similar results as those presented here [25].

As for the improvement with respect to the pre-operative period, Chen et al. indicated that obese patients present with the greatest functional gain [23]. These same results have been obtained in studies focusing on knee and hip arthroplasty [4, 5]. The present study reveals a similar trend as the overweight patients are also the ones that obtain the best improvement in MP-IP AOFAS.

An increase in body weight has been related to an increase in pressure peaks in the sole of the foot and biomechanical alterations of it and a correlation of pain in patients with metatarsalgia and obesity [14, 21, 22]. However, it is clear from the present work that there is no relationship between an increased BMI and the functional outcomes after surgical treatment of metatarsalgia. One possible explanation is that Weil's oblique distal osteotomy more evenly distributes forefoot pressures through proximal metatarsal displacement [15]. This correct distribution of the pressures is achieved regardless of the patient's weight and makes for a satisfactory post-operative result at one year of surgery.

Even though obesity can impair bone healing, any non-union was found in the present study [8].

There are several limitations to the present study. One is that the follow-up may be too short to assess the outcome of the surgery for metatarsalgia. Moreover, the evolution of the BMI during the follow-up has not been evaluated. Thus, no

Table 3 AOFAS and BMI groups comparison

	Group 1 (normal)	Group 2 (overweight)	Group 3 (obese)	*p* value
AOFAS pre-operative	49.18 (12.97)	52.46 (13)	49.97 (14)	0.542
AOFAS post-operative	66.46 (27.46)	76.92 (25.91)	71.21 (31.5)	0.313
AOFAS differential	17.27 (25.48)	24.46 (25.76)	21.24 (27.6)	0.552

information is available on how these variations in weight might influence the outcome. There are some factors that can affect surgical outcomes such as diabetes or smoking that have not been assessed in the present study and it should be considered as one limitation. Another limitation is the small number of male patients in the sample, even though forefoot disorders are more common in female patients. Finally, the presence of concomitant surgeries (first ray or hammertoe/claw toe) could set up a bias in the evaluation of the results even though the association of these surgeries is frequent in our environment.

With all the foregoing, we conclude that an increased BMI does not negatively influence functional outcomes after surgery for metatarsalgia in the short to medium term. Patients with propulsive metatarsalgia improve in functionality after surgical treatment, regardless of their BMI.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Statement of informed consent All patients gave informed consent prior to participating in this investigation.

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