DOI: https://doi.org/10.30795/jfootankle.2021.v15.1596

Original Article

Access to the talar dome through the posteromedial approach: an anatomical study

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Abstract

Objective: To determine the posteromedial area of the talus that can be reached without malleolar osteotomy through the posteromedial approach.

Methods: Fifteen human cadaveric ankles were dissected in standard fashion to expose the posteromedial talar dome. Seven of the approaches (46.7%) were done on the left ankle. We did not observe any significant difference between sides (chi-square test, p=0.715).

Results: On average, 2.09 cm^2 (range, 1.72-2.69) of the posteromedial talus dome or 15.27% (range, 12-20) of the total talus dome can be accessed without osteotomy.

Conclusion: Osteochondral lesions within the area accessible through the posteromedial approach (mean 2 cm^2), as seen on magnetic resonance imaging, may be treated without a medial malleolus osteotomy.

Level of Evidence IV; Descriptive Study.

Keywords: Talus/injuries; Talus/surgery; Osteochondritis; Osteotomy.

Introduction

Osteochondral lesions (OCLs) of the talar dome have different characteristics. Lateral lesions are mainly located on the anterior half of the talus, while medial lesions are usually located on the posterior half.

According to Flick and Gould[(1)], a history of trauma was observed in approximately 98% of patients with lateral dome OCLs and in 70% of those with medial dome OCLs.

The term transchondral fracture of the dome of the talus was described by Berndt and Harty[(2)] to reflect this possible traumatic origin. These authors were able to reproduce the lesion at two sites in a cadaver study. Inversion, plantarflexion, and lateral rotation of the tibia at the talus resulted in damage to the medial surface, while inversion of the foot combined with dorsiflexion of the ankle resulted in damage to the lateral part of the talar dome.

There are conflicting findings in the literature regarding the association between type of ankle fracture and the incidence of OCLs. Nosewicz et al.[(3)] found no significant association with fracture types; on the other hand, Hintermann et al.[(4)] reported that the frequency and severity of lesions increased significantly from type B to type C fractures, using the classification proposed by Danis-Weber and Müller[(5)]. Regier et al.[(6)] reported substantially higher risks of developing OCLs in patients with trimalleolar fractures or dislocated ankle fractures compared to patients with type B unimalleolar fractures.

Burns and Rosenbach[(7)], in a cadaver study of ankle joints, found that the maximum pressure on the lateral edge of the talus occurred during valgus and pronation, while trauma sustained during supination stressed the medial half of the ankle joint. Verhagen et al.[(8)] reported a 61% incidence of medial-dome OCLs after ankle trauma. The high incidence in this region can be explained because many OCLs can be attributed to an inversion mechanism and can, therefore, result in impaction of the medial talar dome.

Elias et al.[(9)] and Asaumi et al.[(10)] confirmed this in magnetic resonance imaging (MRI) studies; among 424 patients in the first study and 100 patients in the latter, 63% and 61%, respectively, showed involvement of the medial region. In a series of

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Conflicts of interest: none. **Source of funding:** none. **Date received:** November 2, 2021. **Date accepted:** November 23, 2021. **Online:** December 20, 2021.

How to cite this article: Molina WF, Heitzmann LG, Martins GB, Pimenta LSM, Fiorot GR, Fragalli IA. Access to the talar dome through the posteromedial approach: an anatomical study. J Foot Ankle. 2021;15(3):247-51.

4 cases describing an en bloc chondral autograft technique by Souza et al.[11], all lesions were located in Raikin's zones 4 and 7 (Figure 1).

Most lateral OCLs can be reached through a standard anterolateral approach; however, the surgical approach to medial lesions usually requires a medial malleolar osteotomy, especially for those involving a larger area and a more posterior region[12].

Medial malleolar osteotomy is associated with some degree of morbidity and further impairment of an already compromised joint, and several factors involved can have an adverse impact on patient recovery: pain and tenderness at the osteotomy site are common; prolonged immobilization may be required, which makes early mobilization of the joint impossible; and several potential technical difficulties are involved. Oblique osteotomy can reach the area of the tibial pilon, while chevron-type osteotomy may not allow adequate access; meticulous preoperative planning is required to avoid causing additional injury to an already damaged area[13,14]. These challenges notwithstanding, it bears stressing that poor outcomes generally result from the underlying condition, although, as noted above, osteotomy can cause additional morbidity.

Access through a posteromedial (PM) approach without osteotomy can allow visualization of approximately 33% of the PM talar dome in the anteroposterior plane, and about 30% in the mediolateral plane[12].

The aim of this study was to determine the area of the PM region of the talus that can be reached via the PM approach without malleolar osteotomy.

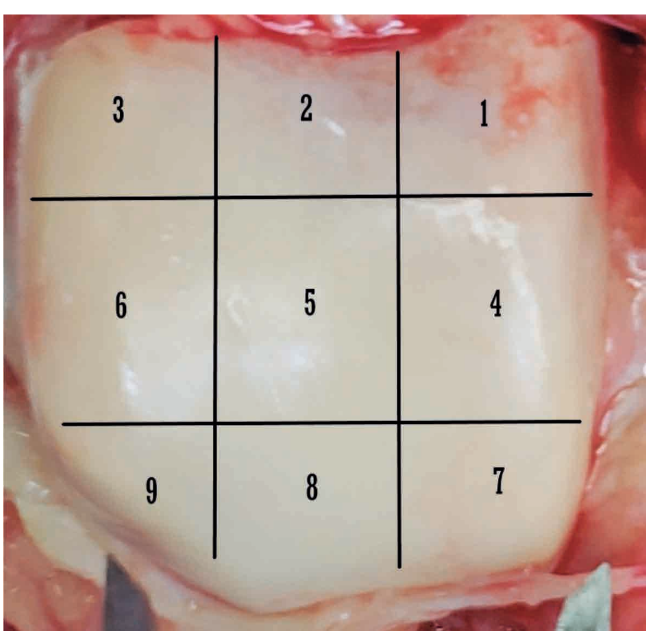

Figure 1. Raikin's nine zones of the talar dome, with 1, 2, and 3 corresponding to the anterior area and 1, 4, and 7 to the medial area.

Methods

This study was approved by the local research ethics committee and was conducted in accordance with the principles of the 1964 Declaration of Helsinki. Fifteen ankle joints from 15 fresh cadavers, all in good condition, with no evidence of trauma or scarring, were dissected. The cadavers were placed in prone position.

PM access was performed with a 6 cm longitudinal incision over the tibial neurovascular bundle. The incision was started 4 cm proximal to the tip of the medial malleolus and extended 2 cm distally. Dissection over the neurovascular bundle must be performed cautiously; the flexor hallucis longus tendon is displaced laterally and the bundle is retracted medially. The arthrotomy is then performed longitudinally, just posterior to the medial malleolus, exposing the PM articular surface of the talus (Figures 2 and 3).

The ankle was then placed in maximal extension to enlarge the view of the talar joint. The exposed height and base were then measured with digital calipers (Mitutoyo® ABSOLUTE, resolution 0.01 mm). Subsequently, we dislocated the tibiotalar joint and measured the total articular surface of the talus with the aid of a measuring tape (heights) and caliper (bases); we then applied the formula of a scalene trapezoid to calculate its area in cm^2 (Figures 4 and 5).

Figure 2. Access window over the neurovascular bundle.

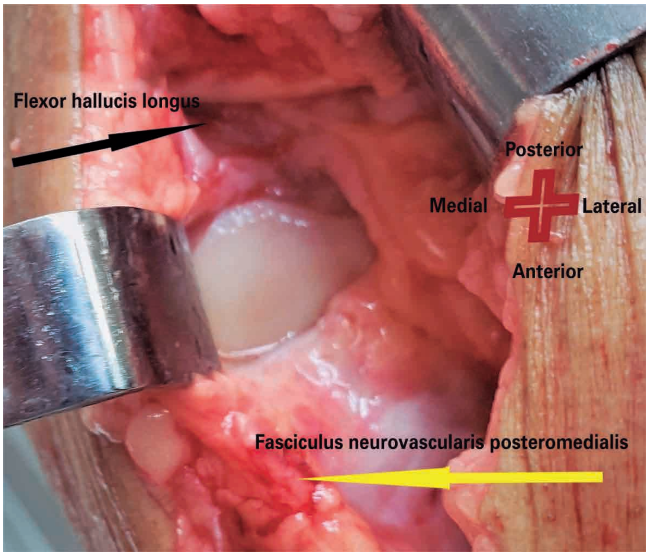

Figure 3. Exposed area of the posteromedial talar surface after arthrotomy with direct visualization. The black arrow indicates the flexor hallucis longus tendon, and the yellow arrow, the neurovascular bundle containing the posterior tibial artery and vein and tibial nerve.

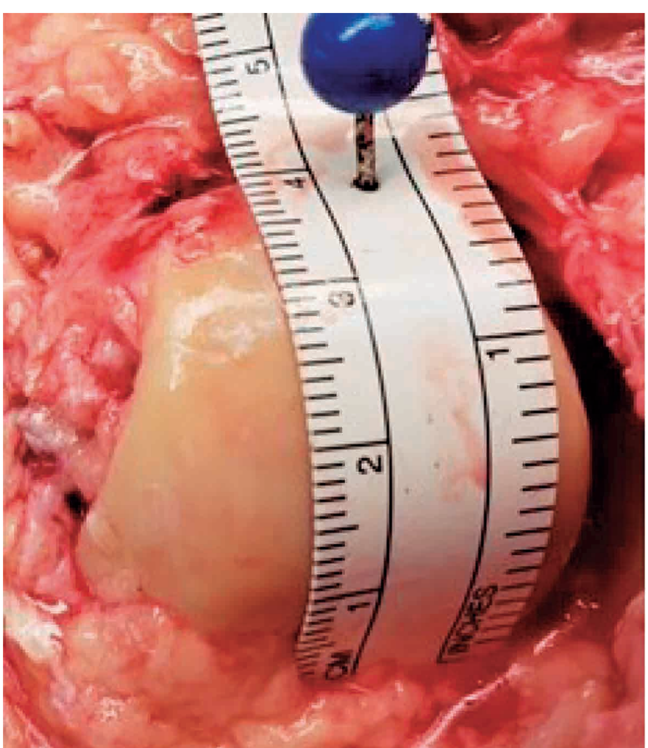

Figure 4. Articular surface of the talus, measured with the aid of a measuring tape.

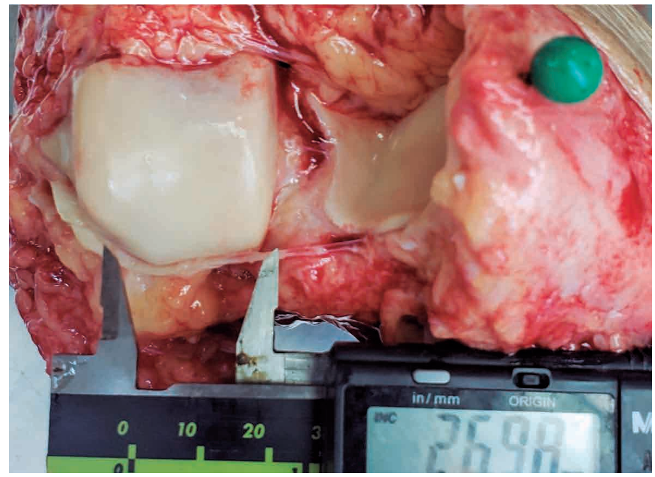

Figure 5. Articular surface of the talus, measured with the aid of a caliper.

For statistical analysis, all variables were first analyzed descriptively. For quantitative variables, this analysis was performed using minimum and maximum values, means, standard deviations, and medians as appropriate. Qualitative variables were described as absolute and relative frequencies.

The Shapiro-Wilk test was used to test for normality of data distribution[15].

When the assumption of normality was confirmed, Student's *t*-test was used to compare means between groups[15]; when the assumption of normality was rejected, the nonparametric Mann-Whitney *U* test was used instead[15].

The chi-square method was used to test for homogeneity of proportions[15].

Spearman's coefficient was used to test for correlation between variables[15]. All calculations were performed in SPSS 17.0 for Windows®, and the significance level was set at 5%.

Results

Fifteen cadavers were examined. Age at the time of death ranged from 24 to 77 years (mean, 51.73 years; standard deviation, 16.20 years; median, 55 years). Eleven (73.3%) were male, and four (26.7%) were female. BMI ranged from 18.67 to 35.14 kg/m^2 (mean, 25.20 kg/m^2; standard deviation, 4.39 kg/m^2; median, 25.59 kg/m^2). Eight (53.3%) were white and seven (46.7%) were black.

PM access was performed on the left side in seven cadavers (46.7%). There was no significant difference between sides (chi-square test, p=0.715).

Area values are described (as percent area and cm^2) in table 1. Figure 6 shows Raikin's zones of the talar dome and the areas visualized under PM access.

Spearman's coefficients showed no significant correlation of age or BMI with differences between measurements.

Table 1. Descriptive statistics of the posteromedial access parameters of interest (degree of exposure of the talar dome in cm, cm^2, and percentage). Standard deviation (SD).

Variable	n	Mean	SD	Minimum	Maximum
Coronal plane	15	1.12	0.09	0.98	1.30
Sagittal plane	15	1.86	0.22	1.47	2.21
Area (cm^2)	15	2.09	0.30	1.72	2.69
Percent exposed area	15	15.27	2.40	12.47	20.38

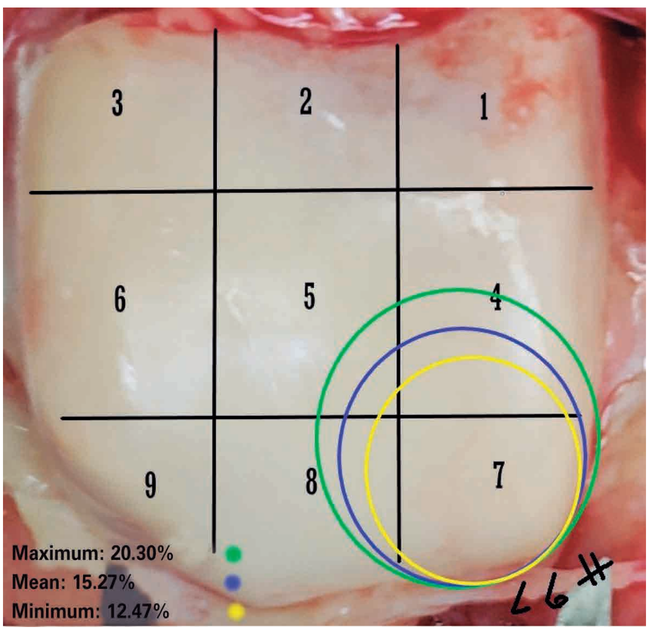

Figure 6. Exposed area of the talar surface. Yellow circle shows the minimum exposure, blue circle shows the average exposure, and green circle shows the maximum exposure achieved, within their respective Raikin's zones.

Discussion

Medial malleolar osteotomies are not without complications. These can be divided into three major types: intraoperative (injuries to adjacent structures, more specifically in the posteromedial region, such as the posterior tibial tendon and artery and the tibial nerve, or chondral lesions of the tibia at the time of osteotomy); intermediate (nonunion and malunion); and late complications, which induce or worsen chondral lesions or cause osteoarthritis[16].

The extent of the OCL itself, as well as inadequate repositioning of the osteotomized segment forming empty spaces or a stepped defect on the joint, can lead to late complications. Gaurapp et al.[17] reported a 50% rate of osteoarthritis after treating OCLs with medial malleolar osteotomy. Baltzer and Arnold[18] observed a decrease in tibiotalar plantarflexion and a 5% nonunion rate after medial malleolar osteotomy, with no such complications after anterior arthrotomy without osteotomy.

In a study of 62 patients who underwent chevron-type osteotomy of the medial malleolus, with a mean postoperative follow-up of 34.5 months, Lamb et al.[19] found that 6% were symptomatic at the osteotomy site. Furthermore, quantitative T2-mapping MRI analysis showed that relaxation times in the deep half of repair tissues at the osteotomy interface were restored to normal values in relation to those in the tibial cartilage, while those in the superficial half were prolonged, indicating a more fibrocartilaginous repair.

In a case series published by Jarde et al.[20], in which 13 patients underwent malleolar osteotomy for the treatment of OCLs with a minimum follow-up of 2 years, no case had any complications attributable to osteotomy.

Leumann et al.[16] reported that 59% of patients had to undergo arthroscopy of the ankle joint to remove osteotomy hardware and anteromedial capsular adhesions.

If an OCL is within the area accessible via a PM approach as seen on MRI, it is treatable without medial malleolar osteotomy. Muir et al.[12] evaluated methods of access to OCLs of the talus (a combination of approaches with and without malleolar osteotomies) in 9 cadaver ankles. They achieved access perpendicular to, on average, 35% of the talar dome when using the PM approach without osteotomy. Their findings showed that more than 75% of the entire dome of the talus can be accessed without osteotomy. Young et al.[21], in a study with five cadaver ankles, managed to expose 33% of the anteroposterior length and 30% of the mediolateral length of the dome through the PM approach.

These results are slightly better than those found in our study. We were able to expose an average area of 2.09 cm^2 of the PM region and an average of 15.27% of the total area of the talar dome, as shown in Figure 6. It is noteworthy that both studies were performed on cadaver ankles, in which the gastrocnemius-soleus complex was lacking, which can result in excessive ankle dorsiflexion and exposure of a larger area. Muir tried to minimize this bias by limiting dorsiflexion to 20° in each of the examined specimens. Furthermore, since this study was performed on intact fresh cadavers and not isolated anatomical specimens, we were able to perform a wider and more aggressive dissection than is sometimes possible *in vivo*. It would therefore be interesting to carry out clinical trials, preferably randomized, to reduce the biased inherent to anatomical studies and translate our results to clinical practice.

In studies by Asuami et al.[10], 22% of lesions were in the PM region (zone 7). Raikin et al. apud Asaumi et al.[10] reported 6.8% of lesions in this area; in both studies, zone 4 was most affected, accounting for 33% and 53% of lesions, respectively.

Sagittal radiographs with the tibiotalar joint in maximum dorsiflexion are extremely important preoperatively, as they allow the operator to determine whether exposure of the OCL in the talar dome through the PM approach will be possible. If the lesion is in Raikin's zone 4, it is important to keep osteotomy as a surgical option, as the OCL may not be adequately exposed.

We believe that access to the medial talar dome without osteotomy causes less morbidity and is associated with more favorable outcomes. Clinical trials comparing the two approaches are needed to test this hypothesis. Nevertheless, it is essential that the surgeon be prepared to use both techniques as appropriate according to the location of the lesion.

Conclusion

If an OCL is within the approximately 2-cm^2 area accessible via a PM approach as seen on preoperative imaging, it should be treatable without medial malleolar osteotomy.

Authors' contributions: Each author contributed individually and significantly to the development of this article: WFM *(https://orcid.org/0000-0002-1007-9539) Conceived and planned the activity that led to the study, wrote the article, participated in the review process; LGH *(https://orcid.org/0000-0003-4345-7222) Data collection, bibliographic review; GBM *(https://orcid.org/0000-0003-0735-8999) Formatting of the article, bibliographic review; LSMP *(https://orcid.org/0000-0002-7087-5852) interpreted the results of the study, participated in the review process; GRF *(https://orcid.org/0000-0002-0225-2004) performed the surgeries; data collection, statistical analysis; IAF *(https://orcid.org/0000-0003-0655-3258) Conceived and planned the activity that led to the study, wrote the article, participated in the review process All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID) iD.

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