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The lateral transligamentous approach to the talar dome

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ABSTRACT

Introduction: Anatomic reduction of talar body fractures is critical in restoring congruency to the talocrural joint. Previous studies have indicated 43% talar body access with a single incision and without malleolar osteotomy. The aim of this study was to investigate the percentage talar body exposure when using the lateral transligamentous approach.
Methods: The lateral transligamentous approach to the talus was undertaken in 10 fresh frozen cadaveric specimens by surgeons inexperienced in the approach following demonstration of the technique. An incision was made on the anterolateral aspect of the ankle augmented by the removal of the anterior talofibular ligament (ATFL) and the calcaneofibular ligament (CFL) from their fibular insertions. A bone lever was then placed behind the lateral aspect of the talus and levered forward with the foot in equinus and inversion. A mark was made on the talar dome where an instrument could be placed 90 degrees to the talar surface. The talus was subsequently disarticulated and high-resolution images were taken of the talar dome surface. The images were overlain with a reproducible nine-grid division. Accessibility to each zone within the grid was documented using the mark made on the talar surface. ImageJ software was used to calculate the surface area exposed with each approach.
Results: The mean percentage area of talar dome available through the transligamentous approach was 77.3% (95% confidence interval 73.3, 81.3). In all specimens the complete lateral talar process was accessible, along with the lateral and dorsomedial aspect of the talar neck. This approach gives complete access to Zones 1, 2, 3, 5 & 6 with partial access to Zones 4, 8 & 9.
Conclusion: The lateral transligamentous approach to the talus provides significantly greater access to the talar dome as compared to standard approaches. The residual surface area that is inaccessible with this approach is predominantly within Zones 4,7 and 8, the posteromedial corner.
Level of Clinical Evidence: V.

1. Introduction

The goal of surgical treatment of talar body fractures is a precise anatomical reduction in order to restore congruity of the tibiotalar and talocalcaneal joints [1]. This is however, hampered by the extent to which the operating surgeon can visualise and instrument their open reduction and fixation. Equally, addressing an osteochondral lesion (OCL) using an open approach, whereby an instrument must be manoeuvred orthogonally to the talar dome, gaining access to the centro-medial and centro-lateral locations [2] in which they commonly occur is technically challenging.

Planning approaches to the talus requires knowledge of its blood supply. Mortensen's original description states that the tarsal canal artery supplies the central and lateral two-thirds of the talar body [3]. Miller et al. has more recently demonstrated that there is both antegrade and retrograde flow to the talus at the tarsal canal and posterior tubercle respectively. A substantial proportion enters via the posterior tibial artery from the tarsal artery with lesser contributions from the anterior tibial artery and the artery of the sinus tarsi [4]. This results in a relatively safe zone on the anterolateral aspect of the ankle in respect to the talar body blood supply. Medial approaches are still commonly used despite

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their increased risk to the blood supply of the talar dome due to their relatively greater access to the talus.

Using a modified anterolateral approach and elevating the anterior talofibular ligament (ATFL) and the calcaneofibular ligament (CFL) from its origin on the fibula, we describe a soft tissue approach incorporating ligament reconstruction that may mitigate the necessity for fibular osteotomy, dual incisions and the potential for the necrosis of the interposing skin flap. The potential implication of our approach is that it lies beyond the aforementioned vascular entry points and may lessen a secondary iatrogenic insult to the talus in these precarious injuries. Our aim in this study, was to assess the degree of access to the talar body using the lateral transligamentous (LTL) approach.

2. Patients/ materials and methods

This study was undertaken at Keele University under the auspices of the Human Tissue Authority license held by the Keele Anatomy and Surgical Training Centre at the University of Keele Medical School. Cadaveric images used were taken with permission. We examined 10 fresh frozen cadaveric lower limbs that had been amputated at the level of the mid tibia. No specimens had any signs of pre-mortem surgical intervention or scars about the ankle and were morphologically normal. No specimen had mobility outside what would be acceptable as a normal range. Following a formal presentation of the approach, 6 consultant foot and ankle surgeons not previously experienced in the exposure, completed the surgical dissection. All surgeons were supervised during the completion of the exposure. A further 4 were approached by the supervising surgeons.

2.1. Dissection & surgical technique

The LTL approach to the talus incorporated the following steps; an incision was made on the anterolateral aspect of the ankle, anterior to the fibula, extending toward the 3rd metatarsal base. The superficial peroneal nerve was anterior to the incision and was retracted. The extensor retinaculum was incised. The extensor digitorum longus was retracted anteriorly to allow access to the capsule covering the lateral aspect of the talus. The capsule was incised. Both the ATFL and the CFL were both taken off their fibular insertion. A bone lever was then placed behind the lateral aspect of the talus and levered forward with the foot in equinus and inversion.

2.2. Analysis

The area of the talus which was accessible with a surgical blade perpendicular to the surface was documented by making a groove in the articular cartilage. The talus was disarticulated and high-resolution images were taken of the talar dome. Using the techniques described by Malagelada et al., ImageJ software was used to calculate the surface area exposed with each specimen using the LTL approach [5]. The talar dome in each specimen was divided using a nine-grid scheme as previous described by Elias et al. and exposure to each zone was documented [2].

3. Results

There were 10 unpaired fresh frozen specimens available for dissection. The demographics of the specimens included 8 female

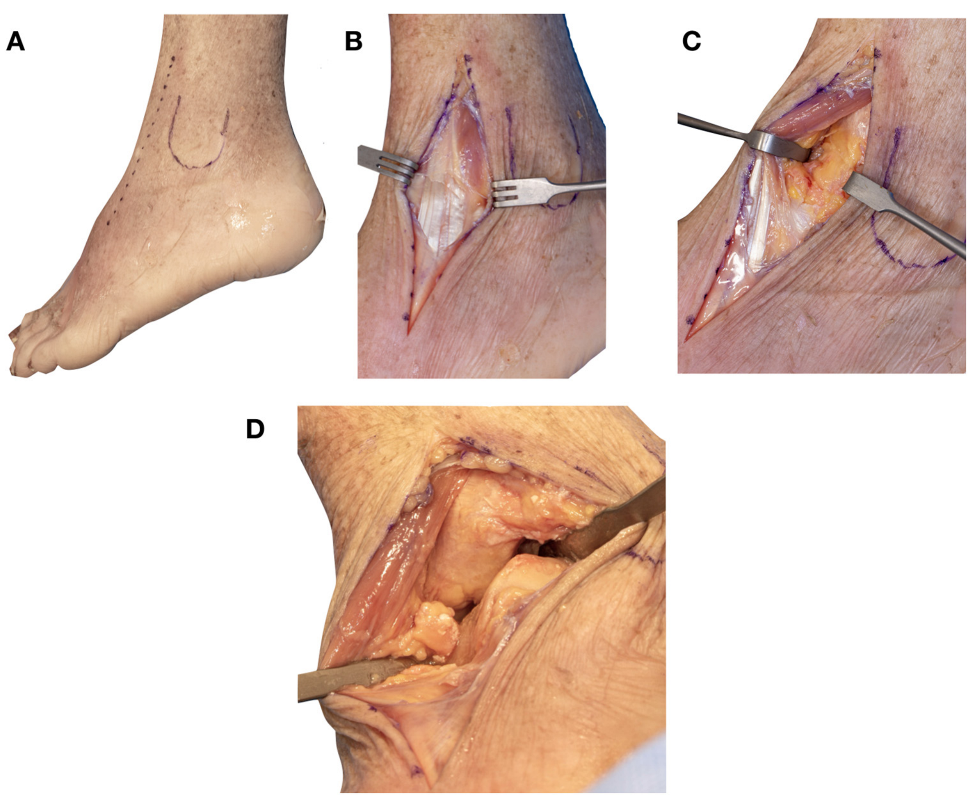

Fig. 1. Surgical technique for the lateral transligamentous approach.
A. Skin incision.
B. Extensor digitorum longus prior to anterior retraction.
C. Ankle arthrotomy revealing ATFL & CFL.
D. ATFL & CFL removed from the fibula insertion.

Table 1
The areas of access to the talar dome as per Elias grid [2]. (Access complete in grid segment given 10% per specimen, partial access given 5% per specimen). Table represented as opacity in Fig. 3A.

Grid number	Percentage	Grid number	Percentage	Grid number	Percentage
1	100%	2	100%	3	100%
4	60%	5	100%	6	100%
7	0%	8	45%	9	80%

and 2 males, with a mean age of 75.7 (range 54–91). The mean percentage area of talar dome available through the trans-ligamentous approach was 77.3 % (95% confidence interval 73.3, 81.3). The areas of access to the talar dome is shown in Fig. 1 & Table 1. In all specimens the complete lateral talar process was accessible, along with the lateral and dorsomedial aspect of the talar neck.

4. Discussion

Our study has demonstrated that by using the LTL approach the residual area of the talar dome that is inaccessible to an instrument orthogonal to its surface is 22.7%. The transligamentous approach allowed a substantially larger access to the talar dome than what is reported in the literature with other approaches used in isolation [5]. Whilst soft tissue approaches that involve the release of supporting ligaments are described elsewhere [6,7] this is the first cadaveric study to show that the majority of the talar dome is accessible with a single incision and the release of both ATFL & CFL. Thus, less than one quarter of its surface, predominantly in the posteromedial region of the talus would require a secondary incision, multiple incisions or osteotomy.

Elias described the talus in a 9 zone grid in terms of medial, lateral and central and from anterior to posterior (Fig. 2) [2]. It is a simplistic tool to communicate the location of an OCL lesion. Other studies have utilised this grid when undertaking research on talar neck and body access and as such we have applied this technique in our study to standardise the terminology used when describing the precise location on the talar dome [8–10]. In our study, there was complete access (100%) to zones 1, 2, 3, 5 & 6 (Fig. 1 & Table 1) with the LTL approach. We contrast this to the work of Garras et al. and Mayne et al. who report 43.3% and 43.2% respectively, talar dome access with an anterolateral approach and ATFL dissection [7,11]. Muir et al. demonstrated perpendicular access to the talar dome was 47% using an anteromedial approach, 54% with an antero-lateral approach (43% in the sagittal plane), 36% with a posterolateral approach and 35% with a posteromedial approach. With all 4 soft tissue approaches combined they demonstrated the ability to access 76% of the talar dome (range 72–82%) however this required 4 incisions with the central talus being inaccessible [6]. A Chaput osteotomy, provides a modest increase in access to the lateral talar dome 11,12]. The LTL approach obviates the need for this fibular osteotomy to gain access to the posterolateral aspect of talar dome. Compared to these studies whereby 37–39% [6,13] of the total talar surface is not accessible with standard soft tissue approaches, our approach demonstrates that with the addition of elevating ATFL and CFL, only 22% of the talar dome is inaccessible (Fig. 3).

The study was conducted using multiple surgeons unfamiliar with the technique. The approach was considered reproducible and simple, with minimal difference in the level of exposure between individuals. We therefore feel this is an approach with the potential to be used in non-expert hands. The LTL approach subsequently requires repair of the elevated ligaments such as using a Broström-Gould technique [14], and therefore surgeons utilising this approach would need to be familiar with such techniques.

Fig. 2. Deep dissection showing the PTFL preventing full translation of ankle after ATFL and CFL have been incised.

Another potential benefit of utilising the LTL approach is that the main blood supply from the posterior tibial artery is preserved. Miller et al. in their gadolinium enhanced study of the talus demonstrated a dense arterial anastomosis providing both retrograde and antegrade blood flow. Anterolateral and postero-lateral quadrants (bisecting the images on MRI into axial, sagittal and coronal planes yielding 4 regions) are supplied by the entry point of the vasculature at the tarsal canal and at the posterior tubercle. This approach avoids injury to both of these regions. [4] There is currently no study discussing the impact of the surgical incision on the blood supply to the talus.

A talar body fracture differs from a talar neck fracture in that it is intra-articular and communicates with the talocrural and

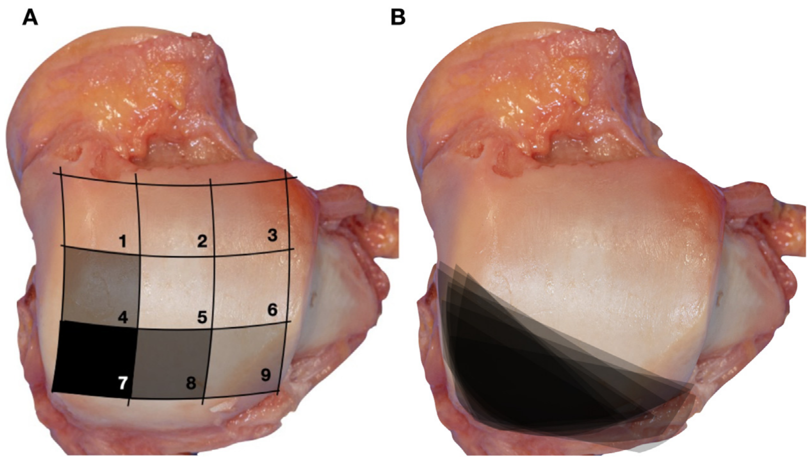

Fig. 3. Disarticulated talus showing perpendicular access to the talar dome.
A. The 9 zone grid of the talus described by Elias et al. 2007, describing medial, lateral, central zones from anterior to posterior. The shading of the zone reflects the degree of inaccessibility to that zone via the LTL approach. Zones 1, 2, 3, 5 & 6 are 100% accessible.
B. Overlay of the LTL approach completed for all 10 specimens and the perpendicular access achievable with an instrument. The area shaded in black (Zone 7) is inaccessible. The gradation of shading in Zone 9, 8 and 4 respectively reflects the increasingly limited accessibility.

subtalar articulations [15,16]. Consequently, a malreduction impacts on the congruency of multiple joints giving rise to a greater surface area over which post traumatic arthritis may occur. Gauging current literature, talar body fractures likely represent an injury of the hindfoot whereby efforts to ameliorate post traumatic changes are futile 16]. A fracture dislocation of the talar body has a high frequency of complications associated with it 16]. Vallier et al. described a retrospective cohort of 57 patients of which 36 underwent a dual approach, 13 had a single medial approach, 7 had single lateral approach, 19 had a concomitant osteotomy (16 medial malleolus and 3 through the fibula). Of the 26 with a complete compliment of radiographic surveillance 21 were deemed to have achieved anatomic reduction. Of those 26 described 10 went on to develop osteonecrosis. This implies that there was overlap in the group of those who achieved anatomic reduction and still developed osteonecrosis. The approach utlised for internal fixation in these patients is not explicitly described.

The rate of osteonecrosis of the talus following talar body fracture ranges from 20% [17] up to 80% [16,18]. However, the literature describes multiple incisions, limited visualization of fracture reduction and risks to the talar blood supply. The complications of osteonecrosis, osteoarthritis and deformity are intimately linked, thus utilizing an approach that gives you greatest exposure whilst limiting the risk to the blood supply may prove beneficial in the future in reducing avascular necrosis. Osteotomies to expand the access windows can be fraught with poor outcomes. A medial malleolar osteotomy performed incorrectly can result in limited exposure or violate the weight-bearing cartilage on the tibial plafond [20].The oblique osteotomy on the medial side is difficult to reduce and can lead to non-union. Fixation of an osteotomy that does not restore anatomic congruence due to improper screw placement leaves an articular step off and may predispose to arthritis [19,20]. Arthritic change has been reported in up to 50% following the undertaking of a medial malleolus osteotomy in mid to long term follow up [21–23]. Lateral talar dome access can be achieved via a fibular window, segmental osteotomy of the fibula and division of the anterior inferior tibiofibular ligament [24] or a fibular door, osteotomy with division of the AITFL and the anterior talofibular ligament (ATFL). Both the fibula and the lateral tibial plafond can be osteotomised to preserve the syndesmosis. Similar to the iatrogenic removal of bone to develop the surgical field on the medial side, the aforementioned are quite extensive and require fixation just to achieve surgical access [25].

The transligamentous approach can be used in a smaller window without removal of the ligaments from their fibular origin if access to the talar neck only is required. The more dorsal access than the traditional approach allows easy visualization of the dorsum of talar neck as well as the lateral talar neck. If the ligaments are elevated from their fibular origin, reattachment and the skills to do so competently are required. Mabit and colleagues performed a systematic review of lateral ligament repair in chronic instability showing the evidence for the anatomic repair with reinforcement (Broström-Gould technique) revealed results of 82–85% good or very good [26]. So and colleagues performed a systematic review evaluating the recurrence rates and revision surgery rates in patients who had undergone a Broström-Gould repair [27]. 11 studies were included with 669 patients, with a mean follow-up of 8.4 years. The incidence rate of revision surgery in the included studies was 1.2%. The ligament repairs are therefore reliable and have good functional outcomes in the chronic instability patients, and it would seem likely that repair in the acute phase following elevation should be equivalent.

Surgical treatment of OCLs include microfracture, biologic and scaffold based therapies [28,29]. Microfracture, the gold standard of treatment for lesions smaller than 1.5 cm, may require a medial malleolar osteotomy to augment joint arthrotomy for access [30]. In autologous osteochondral transplantation, a chevron tibial osteotomy is performed to allow direct visualisation of the talus [29]. Scaffold based therapies such as Matrix-induced autologous chondrocyte implantation (MACI) or Autologous matrix-induced chondrogenesis (AMIC) can be undertaken via an open approach [29,31] or arthroscopically [32,33]. The former approach frequently mandates an osteotomy31] and wherein the surgeon's preference is for an open rather than arthroscopic approach, utilising the LTL technique may enhance talar dome access.

Our study has limitations. This is a cadaveric study with a limited sample size. It does not acknowledge the difference in embalming techniques nor the freeze thawing process which effects the compliance of the soft tissues of the specimens used [34,35]. It could be argued that the formaldehyde used to preserve our specimens provides stiffer tissues than found in living tissue thus limiting our capabilities with the LTL approach. This study gives a basis for future studies using this approach to further assess talar blood supply and functional outcomes.

5. Conclusion

The LTL approach to the talus is an adequate approach for addressing talar body fractures and osteochondral lesions wherein the OCL to fracture fragment(s) lie within the Zones 1, 2, 3, 5 & 6 of the talar dome. Moderate access is possible to Zones 4 (60%), Zones 8 (45%) and Zones 9 (80%). No access is possible to Zone 7 and this is when a combined approach or a medial malleolar osteotomy should be considered.

Conflict of interest

None.

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