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Histological evaluation of calcaneal tuberosity cartilage – A proposed donor site for osteochondral autologous transplant for talar dome osteochondral lesions

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ABSTRACT

Background: Osteochondral Autologous Transplant (OATs) as a treatment option for Osteochondral lesions (OCLs) of the talar dome frequently uses the distal femur as the donor site which is associated with donor site morbidity in up to 50%. Some studies have described the presence of hyaline cartilage in the posterior superior calcaneal tuberosity. The aim of this study was to evaluate the posterior superior calcaneal tuberosity to determine if it can be a suitable donor site for OATs of the talus

Methods: In this cadaveric study, we histologically evaluated 12 osteochondral plugs taken from the posterior superior calcaneal tuberosity and compared them to 12 osteochondral plugs taken from the talar dome.

Results: In the talar dome group, all samples had evidence of hyaline cartilage with varying degrees of GAG staining. The average hyaline cartilage thickness in the samples was 1.33 mm. There was no evidence of fibrocartilage, fibrous tissue or fatty tissue in this group. In contrast, the Calcaneal tuberosity samples had no evidence of hyaline cartilage. Fibrocartilage was noted in 3 samples only.

Conclusions: We believe that the structural differences between the talus and calcanium grafts render the posterior superior clancaneal tuberosity an unsuitable donor site for OATs in the treatment of OCL of the talus.

1. Introduction

The ankle joint is exposed to greater loads than any other joint in the body and any incongruence in the articulation may lead to degenerative change [1]. Osteochondral lesions (OCLs) of the talar dome are relatively frequent sequelae of ankle trauma with a reported incidence of 6.5% following ankle sprain [2]. Up to 70% of ankle fractures can be associated with articular cartilage injury [3].

Debridement and bone marrow stimulation (microfracture) is the treatment of choice for those lesions less than 15 mm in diameter that have failed non-operative management [4]. The critical size above which microfracture has a poor outcome is difficult to determine with some authors indicating poor outcome in lesions greater than 15 mm^2, but alternative techniques such as osteochondral autologous transplant surgery (OATS) has been advocated for these larger lesions and also following failed microfracture surgery [4–7]. The purpose of OATS is to reproduce the structural and biomechanical properties of original articular hyaline cartilage as closely as possible and normally healthy donor osteochondral grafts are usually taken from the ipsilateral knee. However, donor site morbidity in a previously asymptomatic knee is of concern with the OATS procedure with knee pain being

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reported in up to 36% of such individuals [7–14]. Additionally, the histological features of knee hyaline cartilage (with respect to thickness, orientation of the collagen and depth of the tidemark) are known to be very different from that in the talus [15]. Therefore, it would be beneficial to identify an alternative donor site which is less liable to give iatrogenic symptoms and where there is comparable articular cartilage to the talus.

The posterior superior calcaneal tuberosity increases the lever arm of the Achilles and therefore resists compressive as well as shear forces. Several studies have identified fibrocartilage covering the tuberosity on the anterior wall of the retrocalcaneal bursa [16,17]. However, others have reported that the tuberosity is covered with a hyaline-like cartilage raising an interesting possibility that this could be used as a potential donor site for OATS [18,19].

Given the potential clinical benefit of a local donor site for OATS procedures of talar OCLs, we conducted a histological evaluation of the posterior superior calcaneal tuberosity comparing cartilage with that from the talar dome. We hypothesised that this area could be a suitable harvest site for OATS of the talar dome with hyaline cartilage similar to that of the talus.

2. Materials and methods

This is a lab based cadaveric study conducted on below knee amputated fresh frozen cadaveric leg specimens. Local institutional ethical board approval was granted. Specimens were thawed overnight and the samples were harvested within 24 h. There were seven male and five female specimens with an average age of 60.3 years (41–80 years).

Osteochondral grafts were taken from consistent sites on both the posterior superior aspect of the calcaneal tuberosity and from the antero-medial talar dome.

The postero-superior aspect of the calcaneal tuberosity, typically defined as the anterior wall of the retrocalcaneal bursa, was located following a medial para-tendinous approach to the Achilles tendon just proximal to its insertion (Fig. 1). Osteochondral harvesting was performed using OATS harvesting equipment with a standard corer harvesting 6.5 mm diameter grafts (Smith & Nephew, Andover, MA).

The talar samples were taken from the antero-medial talar dome via a longitudinal antero-medial arthrotomy.

All specimens were assessed histologically for the presence of either hyaline cartilage or fibrocartilage. If hyaline cartilage was present, a measurement of its thickness/depth to the tidemark region was be made.

Samples were placed in 10% formalin and underwent standardised histological preparation. Samples were decalcified in 10% formic acid and ethylenediaminetetraacetic acid (EDTA). The specimens were then dehydrated, processed and embedded into paraffin wax using Tissue-Tek VIP tissue processor (Sakura Finetek, Torrance, CA, USA). Sections were then cut so that the cartilage surface was parallel to the blade. Longitudinal sections were taken at 5 μm thickness and stained for Safranin O and Hematoxylin and Eosin stains.

Low magnification images of all the stained sections were captured using the Leica DFC 450C camera (Leica Microsystems, Wetzlar, Germany) attached to the DM4000 microscope (Leica Microsystems, Wetzlar, Germany) at ×63 magnification (Figs. 2 and 3). Images were captured using the JVC KY-F1030 camera (Victor Company of Japan, Yokohama, Japan) attached to a Leica MZ6 stereomicroscope (Leica Microsystems, Wetzlar, Germany) at ×3 magnification.

Average cartilage thickness measurements were carried out on Safranin O images using Image Pro Plus v.6 software (Media Cybernetics, Rockville, MD, USA). The distance was measured between a line traced along the length of the cartilage surface and another along the interface between the cartilage and subchondral bone (Fig. 4). The average distance between the two lines was then calculated. Observational assessments of the slides included

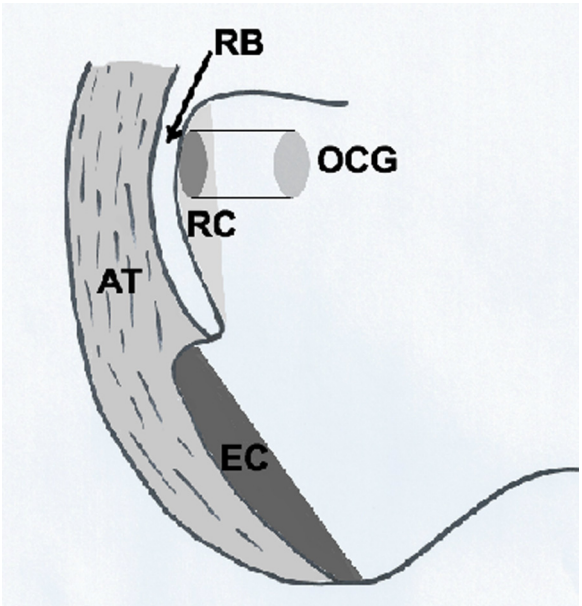

Fig. 1. Diagram of posterior superior calcaneus showing area of entheseal fibrocartilage (EC) and the insertion of the Achilles tendon (AT) and retrocalcaneal firbrocartilage (RC) on the anterior wall of the retrocalcaneal bursa (RB) and the position for harvesting of the osteochondral graft (OCG).

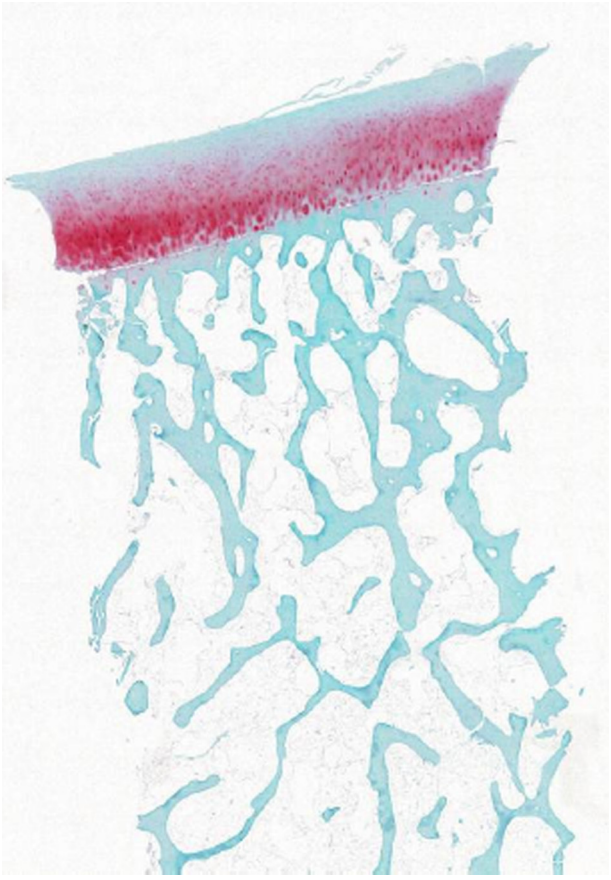

Fig. 2. Sample of talar osteochondral graft (×63 magnification).