A Natural Human Tibiofemoral Joint Model to Investigate the Wear of Decellularised Osteochondral Grafts

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Introduction

- The knee is the most common site for osteoarthritis, affecting >4.7 million people in the UK alone [1, 2]. Whilst total knee replacement surgery is a highly successful procedure in patients >65 years old [3], for younger more active individuals, total knee replacement is associated with higher revision rates and reduced patient satisfaction [4].
- Osteochondral grafts are an alternative treatment for the repair of focal chondral lesions and restoration of the articulating surfaces of the joint. Autografts are the current gold standard approach however, there are several factors that limit the clinical use of osteochondral autografts including, a difficulty in matching the graft and host geometry, poor integration of the graft and host tissue and donor site morbidity; all of which can influence surgical outcomes [5].
- Decellularised osteochondral xenografts offer an alternative to autografts. They are readily available and have a similar structure to native cartilage, their use removes donor site morbidity and they are non-immunogenic. However, for the grafts to be successful, they must be able to restore the articulating surfaces of the joint and replicate the biomechanics and biotribology of the cartilage.

Aim

The aim of this study was to compare the stability and wear, damage, and deformation of decellularised porcine xenografts to autografts in a cadaveric human tibiofemoral joint model under walking gait.

Methods

- Three human knee joints mean age 57 years (range 48-65) were studied experimentally in a ProSim single-station, six-axis knee simulator (Simulation Solutions, Stockport, UK).
- Specimen specific walking gait profiles of the intact joint were derived based on ISO14243-1 [6]. The ligaments and soft tissue surrounding the joint were then fully dissected to allow visualization of the articulating surfaces and for ease of graft implantation
- A Negative control study was performed by initially subjecting the intact knee to walking gait for 3 hours without grafts.
- A single graft (8.5 mm diameter x 8mm length) was harvested from the trochlear groove and implanted into one condyle, a porcine decellularised graft was implanted in the contralateral compartment (Figure 1). The compartment in which the graft was implanted was chosen at random.
- The wear, damage and deformation of the cartilage surfaces were assessed at 3, 8, 24 and 48 hour time points using a modified ICRS grading scale involving dividing into 9 regions and scoring each region from 0 (no wear, damage or deformation) to 4 (damage through to subchondral bone).
- Graft stability was assessed by taking silicone replicas of the cartilage surface and measuring the step height between the graft and the surrounding cartilage surface using an optical profiler.

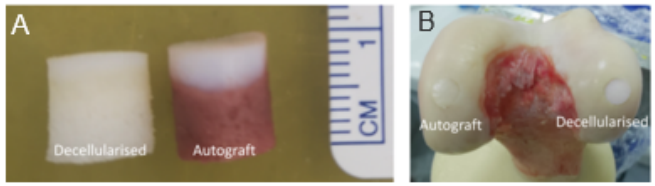

Figure 1: (A) Side by side comparison of a porcine decellularised graft (from a porcine condyle) (left) and an autograft harvested from the trochlear groove (right). (B) Grafts implanted in the centre of the gait cycle contact point on the femur. Autograft implanted into the centre point of the left femoral condyle and a decellularised graft into the right condyle.

Results

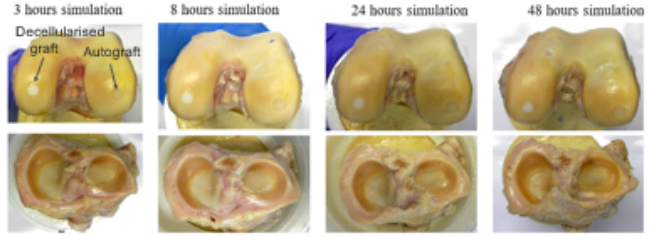

Figure 2: Images of one specimen over the duration of the study.

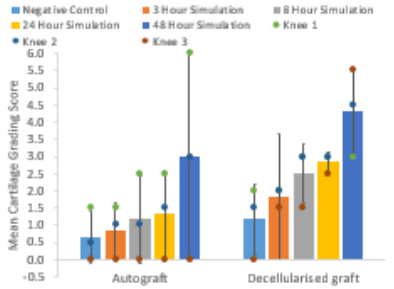

Figure 3: Mean ± SD cartilage grading score on femur following 48 hours simulation (N=3). Data presented as a change in the cartilage grading score from pre-test values. Points show individual samples.

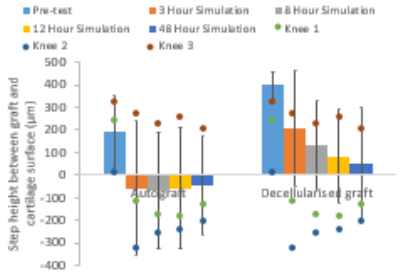

Figure 4: Mean step height between the graft and the surrounding cartilage surface ± SD, negative values indicate subsidence (N=3). Individual samples shown as points.

Discussion

- Decellularised porcine grafts and autografts were implanted in the condyles of a human tibiofemoral joint model and subjected to a walking gait for 48 hours.
- A decrease in step height between the graft and the surrounding cartilage surface was evident for both the decellularised and autografts.
- Over the duration of the study an increase in ICRS score for both graft types occurred, indicating there was a degree of wear, damage and deformation of both the cartilage adjacent and opposing the grafts.
- This is the first *in vitro* study to investigate decellularised grafts implanted in a human tibiofemoral joint model. Porcine decellularised grafts behaved similarly to osteochondral autografts in terms of their stability, and the wear, damage and deformation of the surrounding and opposing cartilage surfaces when implanted in the femoral condyles of a human cadaveric knee model subjected to a walking gait cycle.

References:
[1] Felson DT, et al. Ann Intern Med. 2000;133(8):635–46. [2] UK AR. Osteoarthritis in General Practice. 2013; [3] Laskin RS. Clin Orthop Relat Res. 2001;(388):95–102. [4] Kurtz S, et al. J Bone Jt Surg Am. 2007;89(4):780–5. [5] Reddy S, et al. Am J Sports Med. 2007;35(1):80–5. [6] Liu, et al. Plos one. 2020;e0230765.

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