BIOMECHANICAL ASSESSMENT OF BONE GRAFT STABILITY USING A FEMORAL OVINE MODEL

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Introduction

Bone grafts are clinically used for a range of reconstructive orthopedic surgical applications such as bone repair, osteochondral grafting, and ligament reconstruction procedures [1]. Graft stability is vital to enable effective tissue regeneration between the host and graft bone [2]. Graft stability can be used to partly evaluate the risk of graft subsidence, measured by the force required to displace grafts below congruency, known as a push-out test [3]. The aim of this study was to assess the mechanical stability of various bone-only graft types at different stages after implantation compared to native bone.

Method

Push-out tests were performed on the bone-only portion of skeletally mature, distal ovine femurs. From 9 femurs, a total of 33 sites were tested. These had been implanted with either *ex vivo* porcine xenografts or ovine allografts (taken from an *in vivo* study 12 weeks after implantation) (N=6 and N=6 respectively), *in vitro* autografts (harvested from the medial side of the femur and implanted in the lateral side of the same specimen) (N=9), or nothing (native bone acting as a control) (N=12). The autografts were 10 mm long and 6.5 mm in diameter and implanted with an Acufex™ Mosaicplasty surgical toolkit (Smith and Nephew, MA, USA). The specimens were prepared for testing by segmenting the femurs at 10 mm from the test surface to expose the grafts from below. The grafts were uniaxially loaded at a rate of 1 mm/min, using a materials testing machine (3365 with a 5 kN load cell, Instron, UK) until a displacement of 10 mm below congruency or a maximum load of 2.5kN (Fig. 1).

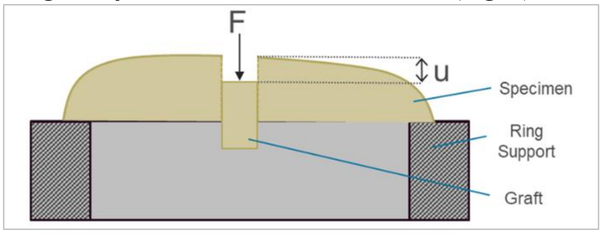

Figure 1: Push-Out Test Configuration

Resistance to motion was derived for each specimen and the statistical significance compared between groups using a Kruskal Wallis analysis. For each specimen, the bone density, measured as the ratio of the bone volume to total volume, and segment thickness at each test site was also measured from CT scans to ascertain their influence on results.

Results

The maximum force was largest for the *ex vivo* grafts (mean value F = 1.50 ± 0.18 kN for the porcine xenografts; F = 2.11 ± 0.17 kN for the ovine allografts), then the native tissue (F = 1.19 ± 0.39 kN), and lastly the *in vitro* autografts (F = 0.34 ± 0.11 kN) (Fig. 2). The segment thickness and bone density, which had some experimental variability (10.91 ± 2.45 mm and 47.7 ± 10.2 %), did not appear to affect the maximum forces observed.

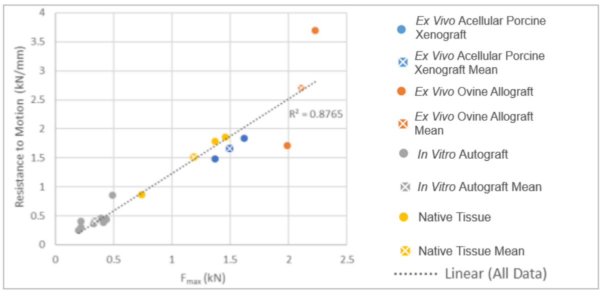

Figure 2: Relationship of Specimen Frictional Force and Resistance to Motion [Trendline based on all data excluding calculated means]

The Kruskal Wallis analysis showed the resistance to motion of the *in vitro* ovine autograft group was significantly statistically lower than the other groups ($p<0.5$) (Fig. 3).

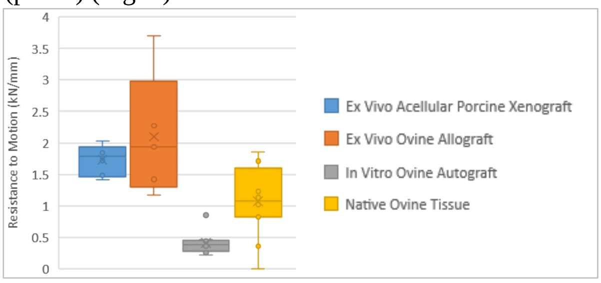

Figure 3: Box Plot of Resistance to Motion

Discussion

The outcomes demonstrate that osseointegration in the *ex vivo* grafts result in an increase in the force required to displace bone-only femoral grafts, while immediately post-implantation (the autograft group), grafts are susceptible to subsidence at low loads. Future testing using osteochondral grafts will assess the contribution of bone and cartilage components to graft stability.

References

1. Khan et al, 13(1):77-86, 2005.
2. Bowland et al, J Biomech, 77:91–98, 2018.
3. Bowland et al, J Biomech, 234(2):163–170, 2020.