Mechanobiological Study of the Enthesis of the Rotator Cuff and its Response to Injury

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Introduction

The shoulder joint is at high risk for rotator cuff injuries due to its anatomy, being mainly stabilized by its surrounding muscles and the ability to move in a wide range of motion. Rupture of the rotator cuff occurs with a prevalence of 20% and leads to pain and loss of function.[1] Predominantly ruptures occur at the side of the enthesis, which is a 4 zone interface between the tendon and the bone. Surgery is indicated because of the structures poor physiological healing ability. After surgery no natural healing of the enthesis occurs for the 4-zone interface to arrange again. The forming of scar tissue contributes to the high re-rupture rate of up to 94%.[2] Complete re-ruptures are around 20%. Hence, it is important to gain an understanding of what leads to this high re-rupture rate and how it can be prevented.

The aim of this master thesis was to investigate the mechanical loading on the enthesis, while utilizing a self-made bioreactor.

Materials and Methods

Sheep shoulders were obtained from a local abattoir. The infraspinatus enthesis was then dissected and cultured to load it in a self-made bioreactor. In this experiment, this bioreactor is used stimulate the enthesis to both low-load conditions (1800 cycles; 0.5 Hz, 1% strain, 7 days a week) and a high load condition (1800 cycles; 0.5 Hz; 7% strain, 7 days a week).

After harvesting the outcome measure including the cell activity, the Glycosaminoglyan (GAG) content, the DNA content and the metabolic activity were analysed. The cell viability was measured using a home made python script.

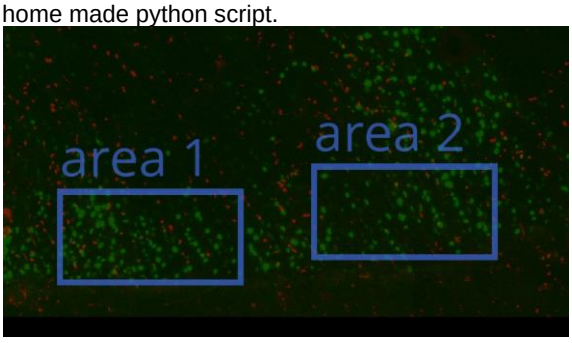

Fig. 1: Representative image of cell viability assessment of a low load condition. The enthesis were stained to visualize the live cells (green) and dead cells (red) with a Laser Scanning Microscope (LSM)

Results

In terms of the GAG/dry weight, after 7 days a significant difference in the tendon between the free float and the low load (free float: 0.014 ± 0.003µg, low load: 0.047 ± 0.055µg, p = 0.0331) was observed. In terms of the cell viability the low load condition indicated a trend of higher cell viability compared to free float and high load (Figure 2). For the metabolic activity no significant difference was found.

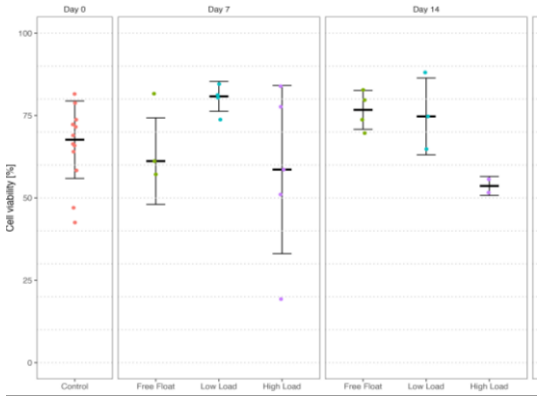

Fig. 2: Cell viability in % with the corresponding Median ± SD for day 0 (control in red), day 7, and day 14 for free float (green), low load (blue), and high load (purple)

Discussion

A higher total GAG content could regulate fibril arrangement and indicate a higher total collagen content. Both would be expected to positively influence the mechanical properties. Further long-term experiments must be conducted to gain more conclusive outcomes about the GAG, metabolic acvitiy and cell viability.

References

[1] B. K. Connizzo and A. J. Grodzinsky, 'Release of Pro-Inflammatory Cytokines from Muscle and Bone Causes Tenocyte Death in a Novel Rotator Cuff In Vitro Explant Culture Model', Connect. Tissue Res., vol. 59, no. 5, pp. 423–436, Sep. 2018

[2] C. K. Hee et al., 'Augmentation of a rotator cuff suture repair using rhPDGF-BB and a type I bovine collagen matrix in an ovine model', Am. J. Sports Med., vol. 39, no. 8, pp. 1630–1639, 2011

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