# SUPERFICIAL MENISCAL STRAIN AND FORCES ACTING IN THE MENISCAL ATTACHMENTS UNDER AXIAL LOADS

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## Introduction

Knowledge of the forces acting on the meniscal attachments in combination with the superficial strain distribution of the meniscus is important to develop functional meniscal replacements. Therefore, the aim of this study was to investigate the interaction of an intact and partially resected meniscus with its adjacent attachments under bodyweight (BW).

## Methods

Six porcine medial menisci with their anterior (AHA) and posterior horn attachments (PHA) and related bony cylinders of their insertions were placed in a custom-made apparatus (Fig. 1A). The bony cylinders were adapted to radial force sensors (RFS150, Honigmann GmbH), allowing force measurement in the insertional direction and perpendicular to it. After printing a dot pattern on its distal surface (Fig. 1B), the meniscus was placed on a glass plate allowing optical strain distribution measurement.

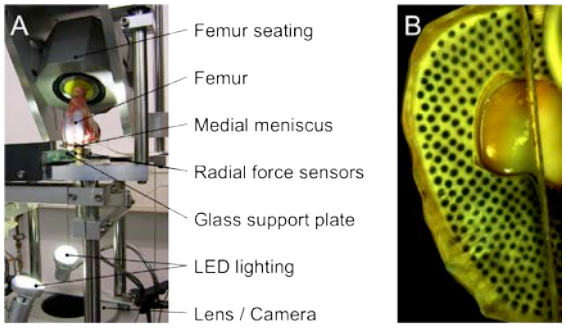


*Figure 1: (A) Customized loading setup; (B) Medial meniscus with 50% partial resection in the posterior horn, view from distal.*

The respective femur was flexed to 30° knee flexion, and then used to apply an axial compression force of 2xBW (650N), which corresponds to axial forces acting in quadrupeds during walking [Taylor, 2006], via a materials testing machine. Testing was performed with an intact, bucket-handle tear, partial resection with 50% and 75% of the meniscal depth only in the posterior horn (PH) and a complete 75% resection from the anterior to the posterior meniscal horn. Superficial strain was detected using a customized algorithm (LabVIEW). Results data were statistically analysed using a Mann-Whitney u-test (Matlab2012b) and p=0.05 was considered statistically significant.

## Results

No differences (p>0.31) in force measurements were seen at the AH between the intact and all resection states (Tab. 1). Forces in the PH decreased with increasing resection and were statistically different between the intact and 75% resection states (p<0.04). Median circumferential strain increased from 0.7% (intact) to 1.4% (75% PH), while the radial strain varied between -5% and 1%.

| | AHA | | PHA | |
|---|---|---|---|---|
| **Intact** | 44 | (35 - 91) | 69 | (56 - 91) |
| **Tear** | 51 | (39 - 81) | 62 | (53 - 84) |
| **50%** | 63 | (46 - 76) | 68 | (54 - 95) |
| **75% PH** | 53 | (45 - 86) | 44 | (32 - 84)* |
| **75%** | 40 | (40 - 66) | 35 | (27 - 64)* |

*Tab. 1: Forces in N acting on the anterior (AHA) and posterior horn attachments (PHA) at 2xBW in the intact, torn, 50%, 75%PH and 75% resection state (n=6; Median (Min – Max) *p<0.05).*

## Discussion

This study investigated the interaction of superficial meniscal strain and the forces in the adjacent attachments for the first time. The attachment forces in the intact state correspond with published values [Stärke, 2009]. An increasing meniscal resection led to decreasing attachment forces in the adjacent horn close to the resection, and furthermore, to increasing circumferential strains. The results of this study suggest, that with increasing meniscal resection the compound of the circumferential meniscal fibres is gradually discontinued, leading to lower forces in the attachments, but potentially higher stresses in the remaining fibres. Additionally, higher circumferential strains might lead to meniscal protrusion and thus to less effective reduction of the pressure on the articular cartilage. Implants for partial meniscal replacement should therefore effectively reinforce the remaining meniscal tissue to prevent it from protrusion.

## References

Stärke *et al*, J Orthop Res, 27:1619-1924,2009.
Taylor *et al*, J Biomech, 39:791-798, 2006.