Hydrogels stay in the disc even with dynamic loading simulating daily activities after needle injection. An in vitro experiment [abstract only]

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A) Photo of custom-built setup with external fixation device, pelvis fixation, mobile frame (flexion only), and load cells integrated in rods supporting the frame.
B) Force measured in compression load cells relative to baseline after 35 min relaxation time (left). Individual contributions of passive structures derived from load increments between resection steps (right).

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HYDROGELS STAY IN THE DISC EVEN WITH DYNAMIC LOADING SIMULATING DAILY ACTIVITIES AFTER NEEDLE INJECTION. AN IN VITRO EXPERIMENT

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Introduction: Most nucleus implants are likely to be extruded under dynamic loading. Therefore, preclinical testing is essential in developing new regenerative approaches for the intervertebral disc. Bovine tail disc are often used as a model but, unfortunately, they do not mimic human disc degeneration. Disc degeneration can be provoked by enzymatic digestion which decreases disc height (DH) and increases range of motion (ROM). This model allows biomechanical testing of the disc restoration as well as the risk of extrusion while applying dynamic loading. The aim of the present study was to combine a papain organ culture with dynamic testing that simulates daily activities as previously shown for human specimens as well as two exemplary biomaterials were tested with the new method.
Materials and Methods: 16 fresh bovine motion segments (CY3/4), assigned to two groups (n=8), were prepared, embedded, and artificially degenerated with 65 U/ml papain using an organ culture approach (7 days, 6% O2, 37°C). At day 7, complex physiological loading was applied to diminish disc swelling. In both groups, 0.7 ml of either Albugel or NPgel were injected with a 27G needle. The performance of the hydrogel was tested with a dynamic spine tester that simulated 10k cycles of four different daily activities (Fig.1A, n=6). ROM, DH, and extrusion risk were determined in the native state before enzyme treatment, after complex loading, and after injection of the hydrogel into the "degenerated" discs, and again after cyclic testing. Additional specimens (n=2 per group) were used for Safranin-O/Fast-Green staining directly after the hydrogel injection. Statistics: Median values, Wilcoxon, Mann-Whitney-U ($p \leq 0.05$).
Results: From day 0 to day 7, digestion with papain led to a decrease of the DH and an increase of the ROM in all groups ($p<0.001$). Injection of either hydrogel increased DH and decreased ROM ($p<0.001$) – even exceeding the native state. During cyclic testing, both hydrogels stayed inside the disc, i.e., no extrusion occurred. However, DH decreased for Albugel (2.3 mm) and NPgel (2.6 mm) without significant differences between the hydrogels (p=0.818). ROM increased by 35.3% and 41.9%, respectively (p=0.746). Histological examination demonstrated the close interface between hydrogel and disc tissue (exemplary in Fig.1B) as well as the filling of the papain digested void.
Conclusion: Our tests with 10k cycles could show a low extrusion risk and provide an important basis for further investigations. The adapted testing protocol allowed simulation of complex everyday activities, such as tying shoes, sweeping the floor, lifting boxes, which are known to be associated with lumbar disc herniation. In combination with papain-digested bovine specimens, this was thought to mimic a worst-case scenario for an extrusion experiment with biomaterials. Next steps could now determine cellular interactions (gene expression, matrix composition, immunostaining, etc.) of the hydrogels and make use of this new organ culture approach. Acknowledgements: iPSpine (825925)

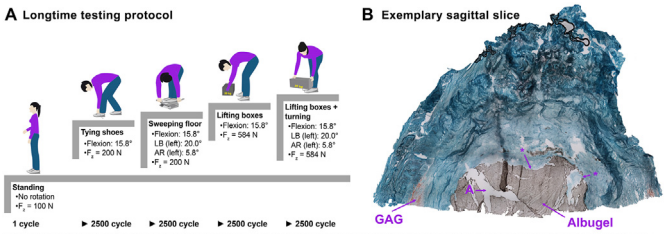

Fig1: A) New dynamic testing protocol adapted for the loading regime of bovine tails. B) Sagittal slice of an exemplary bovine tail disc artificially degenerated by papain with injected Albugel, Staining with Safranin-O/Fast-Green, GAG stained in red, bluish green stains collagen, asterisks (*) indicate hydrogel-nucleus-tissue-interface. Background area labelleled with A.

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THE ROLE OF PARASPINAL MUSCLE FUNCTION IN DYNAMIC SPINAL BALANCE IN PATIENTS WITH LUMBAR SPINAL STENOSIS, OLDER CONTROLS AND YOUNG CONTROLS: A PILOT STUDY

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Introduction: Symptomatic lumbar spinal stenosis (sLSS) can cause a highly disabling condition (1) and is the most common reason for spinal surgery in patients older than 65 years of age (2). Previous research has shown that paraspinal muscle quality in patients with sLSS is compromised and could be one of the factors influencing sagittal spinal balance (3,4). The Biering-Sorensen test is a valid instrument for the assessment of isometric endurance and fatigue of the hip/back extensor muscles (5). The purpose of this study was to determine if i) dynamic spinal alignment in patients with sLSS, old controls and young controls depends on age, paraspinal muscle endurance and the disease of sLSS and ii) if dynamic spinal alignment is affected by paraspinal muscle fatigue.
Materials and Methods: Ten patients with sLSS (5M/5F; age, 71±10 years; body mass index (BMI), 29±5 kg/m2), 10 elderly healthy persons (5M/5F; 65±5 years; 25±6 kg/m2), and 9 young healthy persons (5M/4F; 25±2 years; 22±2 kg/m2) were included in this observational pilot study. Spinal balance parameters were calculated using 18 reflective markers placed on spinous processes and a 3rd order polynomial (6). Spinal balance was assessed during right midstance before and after a modified Biering-Sorensen test (7). Spine inclination (SI) was calculated as the angle between the line connecting C7 and S1 and a global vertical. Paraspinal muscle endurance was assessed as the duration of the Biering-Sorensen test. Forward stepwise linear regression analysis was performed with dynamic spinal alignment as dependent and age, paraspinal muscle endurance, and sLSS as independent parameters.
Results: Stepwise linear regression revealed that age explains 59.8% of the variance of SI during midstance ($R=0.774$, $P<0.001$). When adding paraspinal muscle endurance, 66.1% of the total variance was explained ($R=0.813$, $P=0.038$). sLSS was not entered into our model. While paraspinal muscle endurance differed between groups (mean (SD), patients with sLSS: 82s (80s); old controls: 222s (98s); young controls: 322s (56s)), comparison of spinal alignment parameters before and after the Biering-Sorensen test showed minor differences. SI was slightly elevated in the fatigued state (patients with sLSS: +1.4° (1.2°); old controls: +0.6° (1.0°); young controls: +0.2° (1.1°)). Due to the missed criterion for clinical relevance (changes ≥5°), no further statistical analyses were pursued.
Conclusion: In our pilot study, SI was explained by age and paraspinal muscle endurance but not sLSS and correlated with paraspinal muscle endurance. The modified Biering-Sorensen test does not appear to affect dynamic spinal alignment to a clinically relevant extent in any group. Further research is warranted to elucidate if other parameters explain SI.