**Methods:** Six fresh frozen lumbar spine specimens (L2-5, age 62.2 ±12.7) were loaded in a spine tester with pure moments of 7.5 Nm in lateral bending, flexion/extension and axial rotation. The tested states of the specimens were: intact (a), instrumentation of L3-4 with Elaspine (Spinelab AG, Winterthur, Switzerland) (b), nucleotomy L3-4 (c) and instrumentation of L3-4 with Elaspine after nucleotomy (d). The segmental RoM in each of the three motion planes was evaluated.
**Results:** The instrumentation of the intact segment (b) significantly reduced the RoM ($p<0.002$) in flexion, extension and lateral bending to 37.7, 44.6 and 53% of the intact state, respectively. In axial rotation the instrumentation resulted in a non significant RoM reduction to 95% of the intact state. The nucleotomy (c) caused a significant instability compared to the intact state in all motion planes (128-143% of intact, $p<0.05$). Compared to the intact segment, instrumentation of the defect (d) significantly ($p>0.05$) reduced the RoM to 69.8, 62.3 and 79.1% in flexion, extension and lateral bending, respectively. In axial rotation the instrumented segment showed a significantly higher RoM than the intact segment (137.6% of the intact state ($p<0.01$)).
**Conclusion:** The tested non-fusion implant reduced the RoM in all motion planes except in axial rotation. Compared to data published about the Dynesys system [1], the Elaspine implant allowed more motion in flexion/extension and lateral bending while still limiting the RoM compared to the intact state. However, in axial rotation both implants did not reduce the increased RoM caused by a nucleotomy back to the range of the intact motion segment.
**References:** 1. Schmoelz, W., et al., *Dynamic stabilization of the lumbar spine and its effects on adjacent segments: an in vitro experiment.* J Spinal Disord Tech, 2003. **16**(4): p. 418-23.

### P 6

### Reproducibility of rasterstereography for kyphotic and lordotic angles and for trunk length and trunk inclination – A reliability study

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**Introduction:** Rasterstereography has been in clinical use since 1989 for patients with scoliosis and other spinal deformities and it significantly reduces the need for otherwise indispensable radiographs. The validity of this device has previously been examined in other studies. The objective of the present study is to determine the reliability of rasterstereography three-dimensional back surface analysis and reconstruction of the spine in healthy test subjects.
**Material/Methods:** 51 healthy volunteers were examined rasterstereographically by three investigators. Each investigator made a series of three measurements of each participant in which eight spine parameters including trunk length, trunk inclination, kyphotic angles and lordodic angles were measured. Cronbach's alpha was calculated. The influence of high or low body mass index on the accuracy of the technique was evaluated as well.
**Results:** Intertester- and intratester-reliability of rasterstereography in a healthy volunteer group is very good. Cronbach's alpha for the intratester-reliability of the kyphotic angle for the three investigators has values between 0.921 and 0.992 Cronbach's alpha. The intertester-reliability for the same parameter is 0.979 (95% CI). In this study group a meaningful association between Body Mass Index and reliability of the device was not found.
**Conclusions:** The reliability revealed very good results, both for Intratester and for Intertester reliability. The technique is well suited for analysis of the back in standing position. The Body Mass Index has no influence on the reproducibility.

Fig. 1

| Parameters / Investigator | One | Two | Three |
|---|---|---|---|
| Kyphotic angle ICT-ITL (max.) | 0.992 | 0.984 | 0.921 |
| Kyphotic angle VP-ITL | 0.980 | 0.975 | 0.897 |
| Kyphotic angle VP-T12 | 0.982 | 0.972 | 0.881 |
| Lordotic angle ITL-ILS (max.) | 0.972 | 0.915 | 0.884 |
| Lordotic angle ITL-DM | 0.959 | 0.848 | 0.825 |
| Lordotic angle T12-DM | 0.955 | 0.853 | 0.838 |
| Trunk length | 0.964 | 0.904 | 0.959 |
| Trunk inclination | 0.985 | 0.964 | 0.950 |

Tabelle 1

Fig. 2

| Parameter / Statistics | Cronbachs Alpha | 95%-CI maximum level | 95%-CI minimum level |
|---|---|---|---|
| Kyphotic angle ICT-ITL (max.) | 0.979 | 0.987 | 0.967 |
| Kyphotic angle VP-ITL | 0.974 | 0.985 | 0.959 |
| Kyphotic angle VP-T12 | 0.973 | 0.984 | 0.957 |
| Lordotic angle ITL-ILS (max.) | 0.961 | 0.976 | 0.937 |
| Lordotic angle ITL-DM | 0.907 | 0.944 | 0.851 |
| Lordotic angle T12-DM | 0.920 | 0.951 | 0.872 |
| Trunk length | 0.960 | 0.976 | 0.937 |
| Trunk inclination | 0.970 | 0.982 | 0.952 |

Table 2

### P 7

### Kinematic Evaluation of Cerkinetic™: A New Cervical TDR with Novel Geometry of Bearing Core Mechanism

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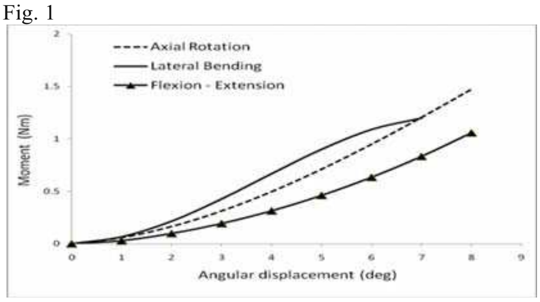
**Introduction:** Anterior cervical discectomy and fusion (ACDF) may result in progressive degeneration of adjacent level discs and facets in the cervical spine. Total Disc Replacement (TDR) was introduced in order to overcome these ACDF's physio-pathologic consequences, as well as to preserve inter-somatic motion. However, various studies report that these abnormal accelerated degenerative processes still occur after TDRs despite their motion capacity. TDR's Kinematic properties should emulate the natural disc motion qualities as closely as possible in order to avoid motion patterns which are extraneous per nature to the cervical spine dynamic scheme.
**Purpose:** the prime objective of this project was to quantify the motion attenuation properties of the Cerkinetic™ - a novel cervical TDR of OrthoKinematica Ltd. expressed as stiffness (Nm/deg). Namely, ultimate moment (Nm) corresponding to angular displacement (deg). A secondary objective was to describe the correlation between geometrical configuration and the motional outcome enabling the Cerkinetic™ to reproduce the natural disc kinematics, including properties conferred by the visco-elastic physics of the natural disc in a Metal on Metal (MOM) cervical TDR.

**Method:** Six Cerkinetic™ implants were tested for static angular displacement and the required applied moments in a preload mode of 150N to 10° in torsion, 8° in flexion/extension and 8° in lateral bending using INSTRON 8874 testing device. Static Axial test protocol followed the ASTM F2346-05. The lateral bending and flexion/extension torsion test protocol was designed to adapt to the guidelines delineated by ASTM Standard F2346-05 Standard Test Methods for Static and Dynamic Characterization of Spinal Artificial Discs. The procedures and their analysis criteria were applied to the two additional orthogonal axes of the 3D Cartesian system: Lateral Bending and Flexion/Extension. The geometrical configuration of the device's bearing core is designed to provide the non linear motional resistance to angular displacement - which is the characteristic pattern of the natural disc harbored within the cervical inter-somatic C3-C7.
**Results:** The mean moments versus angular displacements are summarized as follows (Fig. 1): Static Axial Torsion Ultimate Moment (Nm 1.92), Displacement (deg) 9.97; Static Flexion/Extension Ultimate Moment (Nm 1.01), Displacement (deg) 7.98; Static Lateral Bending Ultimate Moment (Nm 1.16), Displacement (deg) 8.00.
**Conclusion:** It is of crucial importance to provide an artificial TDR which can emulate kinematic features of the natural disc. Such emulation preserves: a) the properties conferred to the interspace by it visco-elastic nature; b) intervertebral height; c) foraminal patency; d) motion pattern of the specific treated inter-space; e) intervertebral and global cervical spine column dynamic scheme. Kinematic testing shows that all these properties have been reproduced in a MOM Prosthesis.

Fig. 1




**P 8**

**Biomechanical behavior of a cement augmented pedicle screw and its role in revision surgery – A cadaver Study**

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**Introduction:** Pedicle screws are used for fixation of spine implants for dorsal instrumentation. In some cases (osteoporotic bone, tumor) the use of pedicle screws alone is limited, since it is likely to come to a loosening. Aim of this study is the evaluation of the biomechanical behavior of a cannulated cement augmentable pedicle screw (Biomet®, omega 21®), which is to be used as salvage method in the above mentioned cases.
**Material/Methods:** 60 human cadaver vertebrae (VT) were randomized in four groups (Pullout, Unscrew, Bending, Torsion). Further 55 VT were divided resembling a revision case into the same groups, after solid screws (not cannulated) were pulled out of their pedicles. The pedicles of these VT were again occupied in a second experiment with either cannulated cement augmented or solid screws of larger diameter. Finally, in 5 VT expandable screws were inserted. All VT underwent a DEXA Scan before and a CT Scan before and after insertion of the screws. The four test procedures took place according to ASTM (American standard of testing machines) with an Instron 8874 machine. In case of normal distribution a t-test was performed. Between primary screw insertion and revision Wilcoxon paired test was performed.
**Results:** Bone mass density (BMD) correlates significantly with pullout strength and unscrew torque of the screws. Cannulated cement augmentable screws show a significantly better biomechanical behavior ($p<0,05$) both after primary implantation and after revision surgery in all test procedures. Pullout resistance in osteoporotic VT increases by 100%. Expandable screws do not improve pullout resistance. Unscrewing of the cement augmented cannulated screws is performed without complications.
**Conclusion:** Cement augmentable cannulated screws are a promising possibility for treatment of the osteoporotic spine and for revision cases. They are biomechanically superior from solid screws and can be removed without complications.

**P 9**

**In vitro Simulation of the Effect of Muscle Force on Spine Kinematics and Intradiscal Pressure**

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**Introduction:** New spinal implants should be tested for their suitability in preliminary clinical studies under physiologic loading. Furthermore, *in vitro* studies on the human lumbar spine have shown that simulating muscle forces has a strong influence on total range of motion (RoM), total neutral zone (NZ) and intradiscal pressure (IDP) [2, 3].
In the present study, a biomechanical model was developed to investigate the relative contribution of intrinsic muscle force on the physiologic kinematics and IDP of the human lumbar spine. Force of the five most significant muscle groups of the lumbar spine was applied to the specimens. Calf motion-segments were used as a substitute for human tissue since they display similar sensitivity to biomechanical parameters [4].
**Materials and Methods:** The testing device consisted of a force- and moment controlled serial industrial robot *KUKA KR1,* and seven force controlled servo-hydraulic actuators (Fig. 1).
The three motions (flexion/extension, lateral bending, axial rotation) of the specimens were initialized by applying pure moments (±10 Nm), which is the gold standard for *in vitro* testing of spine motion-segments [1].
The experimental investigation was conducted on three seven month old bovine mono-segments at the L4/L5 level. The five most significant muscle groups were simulated according to the biomechanical model of Wilke et al. [3]. The muscles were attached at the L4 vertebral-body, and a constant force of 80 N per muscle group applied during the simulation, both sequentially and in combination.
**Results:** The measurements showed a clear influence of each of the 5 muscle groups on RoM, NZ and IDP (Fig. 2). The total RoM in flexion and extension decreased significantly from 9.32 to 3.84 deg (-59 %, $p = 0.03$), the NZ from 1.45 to 0.63 deg (-57 %). The maximum IDP increased from 0.45 to 0.71 MPa (+63 %). In lateral bending the RoM decreased from 11.31 to 7.78 deg (-31 %) and the NZ from 1.65 to 1.36 deg (-18 %). The IDP increased from 0.59 to 0.70 MPa (+21 %). In axial rotation the RoM decreased from 1.95 to 0.80 deg (-59 %). and the NZ decreased significantly from 0.39 to 0.04 deg (-90 %, $p = 0.04$). The IDP increased significantly from 0.16 to 0.53 MPa (+238 %, $p < 0.001$).
**Discussion:** Muscle force had significant effect on the motion-parameters and IDP investigated in several of the directions of motion tested. A comparison with the study of Wilke et al. [3] shows that the simulation of the same muscle groups had a larger influence on human specimens than what we observed with bovine specimens. However, motion behaviour for both human and bovine specimens was influenced in a similar manner. The simulation showed that muscle forces contribute strongly to spine