Relevance of Using a Compressive Preload in the Cervical Spine: An Experimental and Numerical Simulating Investigation

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Study design: In Vitro human cadaveric and numerical simulating evaluation of a compressive preload in the cervical spine.

Objectives: To analyse the influence of a compressive follower preload on the biomechanical behaviour of the cervical spine.

Summary of background data: Simulating compressive action of muscles a follower load attends to reproduce a more physiological biomechanical behaviour of the cervical spine. Only few experimental studies reported its influence on kinematics and intra-discal pressure in the cervical spine.

Method: The present study was divided in two parts: part 1: In Vitro investigation; part 2: numerical simulating analysis.

Part 1: Twelve human cadaveric spines from C2 to T2 were evaluated intact and after application of a 50N follower load. All tests were performed under load control by applying pure moments loading of 2 N.m in flexion/extension (FE), axial rotation (AR) and lateral bending (LB). Three-dimensional displacements were measured using an optoelectronic system and intra-discal pressures were measured at 2 levels.

Part 2: Using a 3D finite element model, we evaluated the influence of a 50 N and 100 N compressive preload on intradiscal loads, facets forces and ranges of motion. Different positions of the follower load along the antero-posterior axis (± 5 mm) were also simulated.

Results:

Part 1: Mean variation of cervical lordosis was 5 ± 3°. The ROM slightly increased in FE whereas it consistently decreased in AR and LB. Coupled lateral bending during AR was also reduced. Increase of hysteresis was observed on load-displacement curves only for AR and LB. Intradiscal pressures increased but the aspect of load-pressure curves was altered in AR and LB.

Part 2: Using the FE model, only minimal changes in ROM were noted following the simulation of a 50 N compressive load for the three loading conditions. Compared to intact condition, less than 10% variation was observed with regard to the different magnitude and positioning simulated. Intra-discal loads and facets forces were systematically increased by applying compressive preload.

Conclusions: Although the follower load represents an attractive option to apply compressive preload during experimental tests, we found that this method could affect the native biomechanical behaviour of spine specimen depending on which movement was considered. Only minimal effects were observed in FE whereas significant changes in kinematics and intradiscal pressures were observed for AR and LB.
[Fig 1 In Vitro protocol]
Fig 2 load-displacement curves