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FINITE ELEMENT (FE) CALCULATION OF THE SPINAL LOAD-SHARING VIA SEQUENTIAL DISSECTION OF THE SPINAL PARTS

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Summary: Study of mechanical behavior of the spine is essential to understand Low Back Pain (LBP). Determining spinal load-sharing enables us understand how applied loads distribute among discs, ligaments and facet joints. Previous investigations are focused mostly on in-vitro experiments which are unable to quantify spinal load-sharing due to the indeterminacy of the system. One well-known method of determining spinal load-sharing is applying moment until achieving a unique rotation. The moment is applied to the intact functional spinal unit and rotation is measured. Then, one spinal structure is removed (e.g. supraspinous ligament) and a moment is applied until the same rotation is achieved. Difference between the applied moments in these two consecutive steps gives the load supported by the removed structure i.e. its load-sharing. This method does not give the force developed in the removed structure and it is also doubtful that similar result will be obtained if the order of the removed parts is changed. In this study it is aimed to compare the load-sharing resulted from sequential removal of the spinal parts while changing the removal order.
A three-dimensional nonlinear finite element (FE) model of the L4-L5 lumbar functional unit was developed and subjected to a moment of 10 Nm applied in various anatomical planes. Spinal parts were then removed sequentially following two scenarios and the moment was applied again. In the first scenario (P-A-1), removal started from posterior towards anterior structures; supraspinous (SSL), interspinous (ISL), ligamentum flavum (LF), intertransverse (ITL), capsular (CL), facet joint (FJ), posterior (PLL) and anterior longitudinal (ALL) ligaments. Reverse order was used in the second scenario (A-P-2) while the disc was left to the end in both scenarios. Results revealed that the removal order does affect load-sharing results. When the model rotates in sagittal plane similar structures were recruited to resist load in both scenarios but with different load-sharing. Although in lateral and transverse plane rotations, posterior parts resisted load in one scenario, they were silent during the other scenario which affected load-sharing. This confirmed that the model kinematics and kinetics are dissection-order dependent due to the redundancy of the spinal system.