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Biomechanics of Atalantoaxial Complex for Various Posterior Fixation Techniques

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Abstract : The study aims to analyze and understand the biomechanical stability of the atlantoaxial complex under different posterior fixation techniques using the finite element method in the Indian context. The conventional cadaveric studies performed show heterogeneity in biomechanical properties. The finite element method being a versatile numerical tool, is being wisely used for biomechanics analysis of atlantoaxial complex. However, the biomechanics of posterior fixation techniques for an Indian subject is missing in the literature. It is essential to study in this context as the bone density and geometry of vertebrae vary from region to region, thereby requiring different screw lengths and it can affect the range of motion(ROM), stresses generated. The current study uses CT images for developing a 3D finite element model with C1-C2 geometry without ligaments. Instrumentation is added to this geometry to develop four models for four fixation techniques, namely C1-C2 TA, C1LM-C2PS, C1LM-C2Pars, C1LM-C2TL. To simulate Flexion, extension, lateral bending, axial rotation, 1.5 Nm is applied to C1 while the bottom nodes of C2 are fixed. Then Range of Motion (ROM) is compared with the unstable model(without ligaments). All the fixation techniques showed more than 97 percent reduction in the Range of Motion. The von-mises stresses developed in the screw constructs are obtained. From the studies, it is observed that Transarticular technique is most stable in Lateral Bending, C1LM-C2 Translaminar is found most stable in Flexion/extension. The Von-Mises stresses developed minimum in Trasarticular technique in lateral bending and axial rotation, whereas stress developed in C2 pars construct minimum in Flexion/ Extension. On average, the TA technique is stable in all motions and also stresses in constructs are less in TA. Tarnsarticular technique is found to be the best fixation technique for Indian subjects among the 4 methods.

Keywords : biomechanics, cervical spine, finite element model, posterior fixation
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