SEMIRIGID SPINAL FIXATION TECHNIQUES COULD HELP PREVENT PROXIMAL JUNCTIONAL KYPHOSIS – A FINITE ELEMENT STUDY

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Introduction

Proximal junctional kyphosis (PJK) is a relatively common mechanical complication following long instrumented posterior spinal fusions, with an incidence rate ranging from 17% to 39% within two years after the surgery [1]. Previous biomechanical studies suggest that one of the leading causes is the sudden mobility change between the instrumented and healthy spinal segments [2]. The current study investigates the biomechanical impact of two semirigid fixation techniques (SFTs) by comparing their effects on spinal mobility and pedicle screw loading with conventional rigid fixation.

Methods

Four T7-L5 finite element (FE) models were developed: 1) intact spine; 2) ⌀5.5mm titanium rods between T8 and L5 (TRF); 3) five ⌀1.9mm titanium rods between T8 and T9 connected with ⌀5.5mm titanium rods between T9 and L5 (MRF); 4) ⌀5.5mm PEEK rods between T8 and T9 connected with ⌀5.5mm titanium rods between T9 and L5 (PRF) (Fig. 1a-d). A modified multidirectional hybrid test protocol was employed with two successive loading steps [3]. First, a pure bending moment of 5 Nm was applied to simulate flexion, extension, lateral bending and axial rotation, and the intervertebral rotation (IVR) angles were recorded [4]. Second, the motion of the TRF technique was applied to the instrumented FE models to evaluate the von Mises stress values in the pedicle screws at the upper instrumented vertebra (UIV).

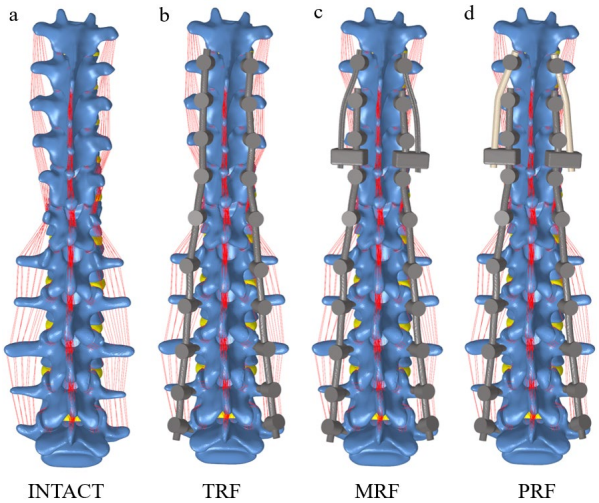

Figure 1: The analyzed spinal fixation techniques. (a) The intact T7-L5 model, (b) the TRF model, (c) the MRF model, and (d) the PRF model.

Results

In the load-controlled step, relative to TRF, at the uppermost instrumented segment, the IVR values increased by 46.8% and 99.2% for flexion, by 43.2% and 87.7% for extension, by 90.1% and 137% for lateral bending, and by 407.1% and 585.2% for axial rotation, in MRF and PRF, respectively. In the motion-controlled step, the maximum pedicle screw stress values at the UIV level were highest for TRF with 37.26 MPa, 42.13 MPa, 44.4 MPa, and 44.59 MPa for flexion, extension, lateral bending, and axial rotation, respectively. Compared to TRF, in the case of MRF and PRF, the screw stress values were reduced by 17.3% and 27.7% for flexion, by 26.6% and 36.7% for extension, by 6.8% and 34.3% for lateral bending, and by 49.1% and 59.8% for axial rotation (Fig. 2).

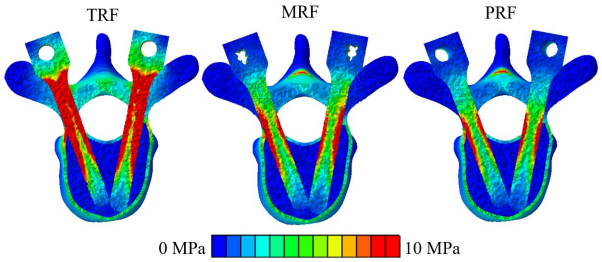

Figure 2: Von Mises stress distributions of the TRF, the MRF and the PRF fixation techniques at the UIV level against left axial rotation

Discussion

FE analysis has shown that the semirigid fixations increase the mobility at the upper instrumented segment, providing a more gradual transition in motion between the instrumented and the healthy spinal segments. In addition, SFTs decrease the pedicle screw loads at the UIV level and hence could help reduce the risk for PJK. However, further investigations are recommended to evaluate the long-term clinical usefulness.

References

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