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BIOMECHANICAL ANALYSIS OF SURGICAL TREATMENT OF THE CERVICAL SPINE - ARTHRODESIS

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ABSTRACT

One of the main problems associated to the cervical spine is degenerative disc disease. The most popular treatment for this pathology has been decompression via anterior intersomatic arthrodesis. However, functional limitations, loss of mobility, additional strain now allocated to the vertebrae directly above and below the now fixed vertebrae, plus aggravation of any disc degeneration caused by this extra strain are still cause for concern. These factors justify the study of how the cervical spine behaves once subjected to cervical fusion, so as to search for new and safer solutions. Other studies have been executed to access the cervical spines' performance when the vertebrae are fused, however there is still a lack of information as to the strains and loads the other vertebrae and discs adjacent to the fused segment behave. Thereby, this study focuses on cervical arthrodesis and evaluates how load transfer to the adjacent vertebrae would be affected, ascertaining the potential risks of failure of these vertebrae when compared to those in the native (healthy) state. Numerical models were developed of the C4-C6 segment and subjected to loading case of that of a human head. Strain values were assessed for the native case and for an implanted case with the Fidji PEEK cage (Zimmer, Inc).

Keywords: biomechanics, finite element model, arthrodesis, stress/strain analysis.

INTRODUCTION

The prevalence of degenerative disc disease (DDD) is roughly described in proportion to age such that 40% of people aged 40 years have DDD, increasing to 80% among those aged 80 years or older [1]. During the last 50 years, the most popular treatment for this pathology has been decompression via surgical procedure performed by anterior intersomatic arthrodesis (vertebral fusion).

Due to the fact that the fusion of vertebrae is directly linked to movement restriction, the body has a tendency to compensate de loss of mobility by straining the components adjacent to the fused segment; however this may lead to further complications and degeneration of other discs and vertebrae. By studying stress and strain values, not only in the fused segment but also in the adjacent components it may be possible to ascertain how the fused segment influences further degeneration of intervertebral discs and vertebrae. Several studies such as the one performed by Teo *et. al.* [2] are based on numerical models of a segment of either a native cervical spine, or a fused one. However studies based on fused segments don't often cover results on adjacent discs and vertebrae, nor do these studies usually compare native intact healthy models with fused models. This study, quantifies values of strain and stress of both native and fused segments of the cervical spine.

Finite element models were the developed from CT images obtained from a healthy male patient. Vertebrae and intervertebral discs 3D numerical models were generated using the

semi-automated segmentation tools available in the Simpleware package (ScanIP, ScanCAD, ScanFE). A native model was generated by applying HU distribution for bone material properties obtained through equations based on bone apparent density. A second native model was generated by assuming constant elasticity properties of cortical and trabecular bone, so as to numerically compare any default error associated to this assumption. Another objective of this study was to numerically quantify the structural alterations caused to the bone right after cervical arthrodesis, so before fusion and any bone growth has occurred, as well as quantifying the case when fusion has occurred.

The C4-C6 spinal segment was focused on in this study, since C5-C6 intervertebral area is the most common section to suffer degeneration. Thus implants were positioned in the C5-C6 intervertebral space. The results obtained for each model enabled the evaluation, and therefore the comparison, of the alterations in load transfer from one model too another.

RESULTS AND CONCLUSIONS

The obtained stress and strain values for the native model and fused model was taken from the peripheral intervertebral disc area on the cortical bone for each of the vertebrae. Typical results are presented in figure 1. These values can be important to define ranges of mechanical failure for cortical bone and ascertain where critical cases that may lead to further degeneration.

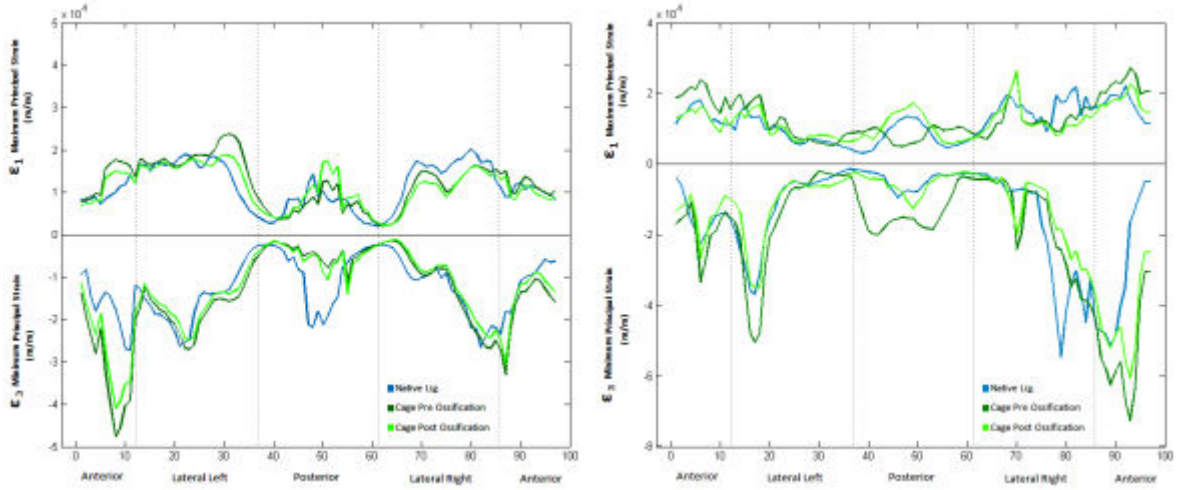

Fig. 1 - Cage and Native Model Strain Comparison - Cortical Bone, on the left C4, on the right Upper C5.

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