CTM BRACE EFFECT ON INTERVERTEBRAL DISC VERSUS BONE PROPERTIES IN SCOLIOSIS

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INTRODUCTION

The effect of orthotic treatment on scoliotic spine has been widely studied, but limited to the geometrical changes that occur on the bone structures. Using MRI measurements of intervertebral discs behavior and vertebral bone densitometry, correlations were found in vivo on scoliotic patients between nucleus zone displacement within intervertebral discs and mechanical center migration within vertebral bodies. The aim of this study was to investigate the Cheneau-Toulouse-Munster (CTM) brace effect on the intervertebral discs behavior using MRI, in relation to the vertebral bone properties of scoliotic patients.

METHODS

The clinical protocol had been performed in vivo on eleven girls (12.5±2 years old) having lumbar or combined idiopathic scoliosis in the evolution period (Cobb angle of 22.4°, no wedged apical vertebral). This protocol was composed of a standard CT scan acquisition of the apical vertebral followed by two MRI acquisitions of the thoracolumbar spine (turbo spin echo T2-weighted sequence) with and without brace. Standard frontal radiographs were also taken with and without brace the same week, and without brace one year later.

The cortical bone outline of the vertebral body was detected on the CT-scan images (Figure 1) using threshold process. The cancellous bone outline was deduced assuming a cortical thickness of 1mm. A regular 2D mesh was created into each outline allowing an automatic mapping of CT scan numbers. A regular 3D mesh into brick elements was built from successive extrusions allowing the analysis of the mechanical properties distribution in the vertebral body. The cancellous bone density, deduced from the CT numbers using predictive relationships, were assigned to the 3D vertebral body meshing. Vertebral body centroids and inertia centers were computed using unit and measured densities respectively. The inertia center displacement relative to the centroid was quantified and called the mechanical migration.

The outline of the vertebral bodies and intervertebral nucleus zones (intervertebral high intensity portion) were drawn on the MR images (Figure 2) using threshold process. Both intervertebral and vertebral outline centroids were computed. The displacement of the middle of the segment joining both adjacent vertebral body centroids relative to the nucleus zones centroid was quantified and called the nucleus zone migration, for each of the acquisition with and without brace.

The radiographs were analyzed by the surgeon who measured the Cobb angles using classic method.

The statistical analysis consisted in Student t-test between no-brace and in-brace acquisitions, and Pearson product moment correlations (Kolmogorov-Smirnov normality tests succeed) between MRI, CT scan and radiographic measurements.

RESULTS

The immediate effect of the CTM brace on the nucleus zone migration was a decrease from 1.7±1.4mm and 16±7.7mm with no brace to 1.4±1.1mm and 1.5±1.7mm with the brace, in the coronal and sagittal planes respectively. No significant differences were found on the nucleus zone migration between the in brace and no brace acquisitions (p>0.8 in the coronal plane and p>0.1 in the sagittal plane).

At the curvature apex, the decrease of the nucleus zone migration due to the brace effect was 1.6±1.1mm and 0.7±0.3mm while the mechanical migration due to scoliosis was 0.5±0.2mm and 0.3±0.2mm, in the coronal and sagittal planes respectively.

The Cobb angle after one year wearing the brace was decreased of 6.1±7°. There were no significant correlations (p>0.05) between the effect of the brace on the nucleus zone migration, the mechanical migration due to scoliosis and the reduction of the Cobb angle after one year wearing the brace. But some tendencies were found in the coronal plane (Figure 3).

DISCUSSION

This study highlighted the effect of the CTM brace on a specific parameter, the nucleus zone migration within intervertebral discs that appears with the scoliotic deformation of the spine. While the brace decrease the spine curves in the coronal plane, the intervertebral wedging should be reduced. Then the nucleus, which was shifted away from the intervertebral pinched side, should go back to its initial position. The decrease of the nucleus zone migration obtained between the no brace and in brace MRI acquisitions, and the tendency between nucleus zone migration and Cobb angle reduction after one year wearing the brace, justified this hypothesis. The absence of significant correlations may be due to the small number of patients analyzed, and also to the small deformations measured on the patients.

The absence of statistical differences between no brace and in brace nucleus zone migrations suggested that the brace did not create any discontinuities in the displacement of the nucleus zones between adjacent intervertebral levels.

The geometrical measurement of the nucleus zone migration on T2-weighted MR images cannot make any distinction between fluid and structural movements within the disc. However, both phenomenons entail changes in the bone density distribution within the apical vertebrae, due to disc continuous stresses, with high-pressure zone where the growth is limited and low-pressure zone where the growth is physiologic. Because the brace corrected the nucleus zone migration within the discs, it should modify the bone density distribution within the apical vertebrae. This hypothesis should be verified by measuring the resulting changes in the vertebrae after one year wearing the brace. However, the tendency found between the nucleus zone migration due to the brace effect and the mechanical migration due to scoliosis, and also between the reduction of the Cobb angle and the mechanical migration, suggested that the brace treatment would be less effective if changes in the bone mechanical properties yet occurred. This last hypothesis should be verified on more patients, and should be of interest for predictive criteria of scoliosis.

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