Biomechanical Analysis of a Less Invasive Destabilization Procedure for Corrective Surgery in Adolescent Idiopathic Scoliosis

ABSTRACT INTRODUCTION:

Posterior-only techniques are becoming more popular in the orthopaedic community for the treatment of rigid Adolescent Idiopathic Scoliosis. Ponte Osteotomies, traditionally used to correct sagittal plane deformities, have recently been suggested for use in these cases of rigid adolescent idiopathic scoliosis. However, the amount of correction attainable has not been quantified. The purpose of this study was to quantify and compare the range of motion of multi-segment thoracic spines intact, and following three sequential Ponte osteotomies.

METHODS:

Five human cadaveric thoracic spine segments, spanning T1-T6, or T7-T12, were used to compare sequential Ponte osteotomies. The inferior and superior vertebrae of each segment were rigidly potted in epoxy resin, and mounted in fixtures using a laser guided alignment protocol. Specimens were tested in an MTS 858 Servo-Hydraulic load frame (MTS, Eden-prairie, MN) equipped with an 8 degree-of-freedom FlexTest software. (Figure 1) Cyclic, pure moment testing in: 1) flexion-extension, 2) lateral bending, and 3) axial rotation was applied at a rate of 0.5°/s, to a maximum of ±6 Nm.

Each specimen was tested intact, and after 1 level, 2 levels, and 3 levels of Ponte osteotomies. For each Ponte osteotomy included a bilateral total facetectomy, and resection of the following: entire portion of superior spinous process of vertebrae superior to the osteotomy site, interspinous ligament, and the ligamentum flavum. (Figure 2) The osteotomies were performed starting at the superior most level, and then in sequence inferiorly, until three sequential Ponte osteotomies were performed.

RESULTS SECTION:

In total, two T1-T6 segments and three T7-T12 segments were tested. Total range of motion for the three sequential vertebral motion segments measured (either T2-T5 or T8-T11) increased by as much as 1.6° in flexion, 1.5° in extension, 0.5° in lateral bending, and 2.8° in axial rotation with each single osteotomy. In order to account for differences in initial specimen stiffness, data was normalized by dividing the motion following each sequential Ponte osteotomy by the corresponding intact range of motion. By normalizing, the data is reported as a percent increase in flexibility. (Figure 3) Compared to intact, on average, flexion increased by 33% (p=0.17), 56% (p<0.03), and 69% (p<0.02), following three sequential Ponte osteotomies. Slightly smaller increases in extension were seen, increasing to as much as 56% following the third osteotomy. Ponte osteotomies did not change the motion in lateral bending. Axial rotation range of motion showed large increases in flexibility, with increases of 9% (p=0.02), 20% (p<0.01), and 34% (p<0.02) following the three sequential osteotomies.

DISCUSSION:

Sequential Ponte osteotomies increased range of motion in flexion, extension, and axial rotation; however, no changes in lateral bending were seen. Clinical literature suggests an estimated 5-10° of correction per level of Ponte osteotomy for kyphosis. Therefore, the additional 3° of flexibility we measured per-osteotomy in the sagittal plane are consistent with the clinical kyphosis correction data. Furthermore, when combined with nearly 3° increase per level in rotational flexibility, Ponte Osteotomies appear promising in correcting severe scoliosis deformities. Due to the limitations of using elderly cadaveric spine specimens, the data in our model provides low estimates of correction potential, which may be exceeded in surgery where larger forces and torques are applied to younger patients.

SIGNIFICANCE:

Ponte osteotomies show promise for correction of rigid adolescent idiopathic scoliosis. The technique may be appropriate when using surgical derotation, or to improve the lordosis at the apex of the curvature.

Each vertebra was labeled with 4 non-collinear LED markers and motion was recorded using an Optotrack 3020 Motion Capture System (Northern Digital Inc, Ontario, Canada). As the applied moments were intended to simulate surgical manipulations, they exceeded the typical cadaveric threshold of ±4 Nm, resulting in vertebral fractures in poor quality specimens. Analysis was based on specimens which successfully completed all three osteotomies and testing without fracture. Paired-samples t-tests were performed for the following pairs: intact – ponte-1, intact – ponte-2, and intact – ponte-3. Each paired-samples t-test was performed for measurements in each flexion, extension, lateral bending, and axial rotation. A separate test was performed for the raw measurement (degrees), as well as the normalized flexibility (ratio compared to intact).

† p < 0.05 versus intact axial rotation range of motion (Paired-Samples T-Test). * p < 0.05 versus intact flexion range of motion (Paired-Samples T-Test).