COMPRESSION OR DISTRACTION FORCES APPLIED ON A PEDICULAR FIXATION SYSTEM: AN EXPERIMENTAL STUDY

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SUMMARY

An experimental study was conducted with the objective of evaluating the effects of compression and distraction (approach and deviation) forces applied on implants placed at vertebral pedicles. The vertebral segments T8-T9, T10-T11, T12-L1, L2-L3 and L4-L5 of Landsark pigs were used in the study. Each vertebral segment was fixed with pedicular implants, with compression or distraction forces being applied with a displacement that ranged from 5.1 mm to 9.35 mm. Displacement caused by forces application was measured in four points of the vertebral segment: A (anterior portion of the vertebral segment), B (medial portion of the vertebral segment), C (posterior portion of the vertebral segment) and D (superior joint process). Compression forces caused the deviation of points located at regions A and B, and the approach of points at region D. Distraction forces caused the approach of points at regions A and B and deviation of the points at region D.

Keywords: Spine fusion; Spine fixation.

INTRODUCTION

Pedicular fixation systems have been widely used in the scope of spine surgery, and its application is usually related to stabilization or correction of vertebral segment deformities. During the application of that vertebral fixation modality, compression or distraction forces are applied on bars and screws of the fixation system. However, due to vertebral segment's morphology, the application of such forces is not homogeneously distributed on different parts of vertebral segment (anterior, medial, and posterior), being this the major purpose to conduct this study.

The objective of the study conducted was to check the effects of compression or distraction forces application (approaching or deviation) on a vertebral fixation system using a pediculum as anchorage point, as well as the effects caused by such forces application to different portions of vertebral segment.

MATERIALS AND METHODS

Vertebral spine segments of Landsark pigs weighting 98 kg were used. Vertebral segments T8-T9, T10-T11, T12-L1, L2-L3 and L4-L5 have been selected for study, so that 5 vertebral segments were employed. The vertebral segments selected for the study were appropriately prepared, being removed all muscle insertions and supra- and interspinous ligaments and preserving only joint capsules and intervertebral discs. Each vertebral segment was stabilized, using as anchorage point the four pedicula of vertebral segment. Over the bars linking implants inserted into vertebral pedicula, compression or distraction forces were applied. Compression or distraction was performed by means of a dislocation of a washer used for attaching implant bars. Each half spin of the washer corresponded to a dislocation of 0.85 mm, and the effective dislocation ranged from 5.1 mm to 9.35 mm, with measurements made at each 0.85 cm dislocation, which corresponded to washer's half-spin. Compression force was produced by approaching fixation system's bars, and distraction forces were produced by spreading the bars.

Four vertebral points were selected, named A, B, C and D. Point A corresponded to the most anterior region of

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the vertebral body; point B to the medial region of the vertebral body, located between points A and C. Point C corresponded to the posterior region of the vertebral body and was located at 5 mm anterior to transverse process. Point D was located on upper joint process. Those points were marked and, at each dislocation, the distance between similar points of 2 vertebras of the vertebral segment (A-A, B-B, C-C and D-D) was measured with electronic pachymeter (Figure 1).

Values achieved by approaching (compression) or spreading (distraction) of system's bars were individually analyzed and also by means of graphic view of the values set obtained in different vertebral segments, considering the displacement at the 4 selected points.

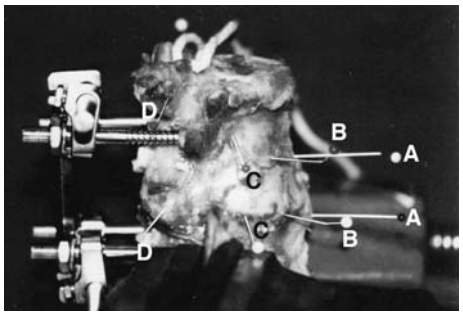


Figure 1 – *Photograph of a vertebral segment stabilized by a pedicular fixation system and with reference points. A (anterior portion of vertebral body), B (medial portion of vertebral body), C (posterior portion of vertebral body), and D (superior joint process).*

Vertebral Segment	Displacement (mm)			
	A	B	C	D
T8-T9	0.26	0.23	0.01	-1.04
T10-T11	0.44	0.59	-0.11	-2.67
T12-L1	1.08	1.13	0.19	-2.26
L2-L3	1.32	.096	-0.04	-2.78
L4-L5	1.13	0.59	-0.17	-2.32

Table 1 – *Values seen after final displacement of reference points after compression force (approaching) on pedicular implants. Positive values indicate the spreading of reference points and negative values indicate approaching.*

Vertebral Segment	Displacement (mm)			
	A	B	C	D
T8-T9	-1.31	-0.59	0.02	1.81
T10-T11	-1.09	-0.89	-0.03	1.02
T12-L1	-1.31	-0.91	0.15	2.94
L4-L5	-1.41	-0.82	0.04	1.36

Table 2 - *Values seen after final displacement of reference points after distraction force (spreading) on pedicular implants. Positive values indicate the spreading of reference points and negative values indicate approaching.*

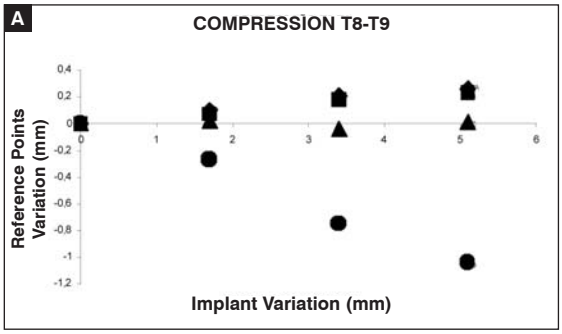
RESULTS

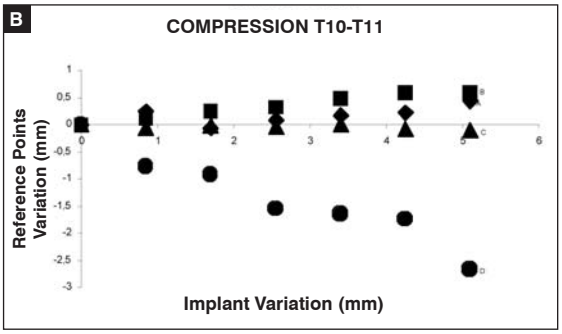
Values for final displacement, obtained after applying compression or distraction forces on different segments used in the study, are described on Tables 1 and 2. Positive values indicate the occurrence of reference points spreading, while negative values indicate reference points reduction or approaching.

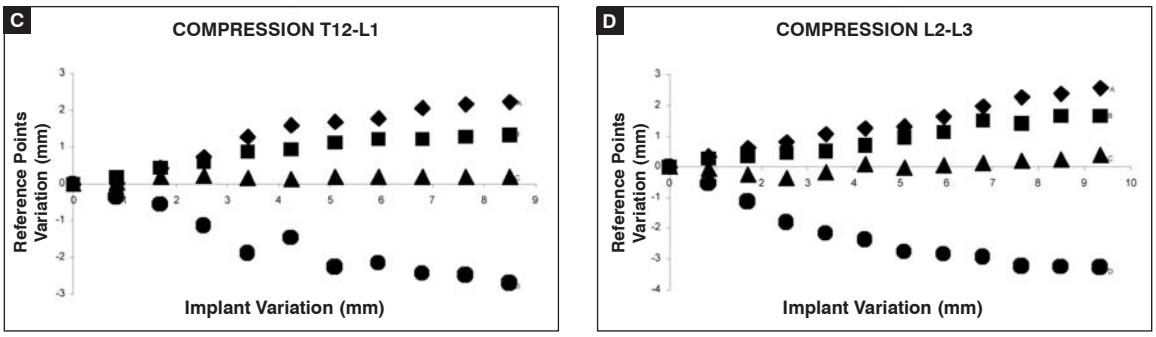
Compression force application, which corresponded to the approaching of implants placed into vertebral pedicula resulted in an increase of reference points located on anterior and medial portions of the vertebral body (reference points A and B), and reference points approaching located on the posterior portion (point D). On the posterior portion of the vertebral point (point C) a trend was noticed towards vertebral bodies approach in three studied segments, and spreading in the remaining two (Figures 2, 3, and 4).

Distraction force application, which corresponded to spread implants placed into vertebral pedicula resulted in approach of the reference points located at anterior and medial portions of vertebral bodies (reference points A and B), and spreading of reference points located at the posterior portion (point D). On the posterior portion of vertebral bodies (point C) reference points spreading was seen in most of studied vertebral segments, and approaching in one animal. Values for segment L2-L3 were not considered for distraction assays, due to technical problems precluding measurement.

Figure 2 shows the individual behavior of the 4 reference points studied in each vertebral segment (T8-T9, T10-T11, T12-L1, L2-L3 and L4-L5) and the distance variation among them after compression. Value distribution showed a progressive increase of reference points located at medial and anterior portions of the vertebral body, and the reduced distance of the posterior







reference point (point D) with compression (approaching of implants inserted into vertebral pedicula). The individual behavior of the 4 reference points studied in each vertebral segment (T8-T9, T10-T11, T12-L1 and L4-L5) and distance variations among them after distraction are plotted on Figure 3. Values distribution showed a progressive reduction of distance between anterior and medial reference points on vertebral body (points A and B), and an increased distance of the posterior reference point (point D) with distraction (spreading of implants inserted into vertebral pedicula).

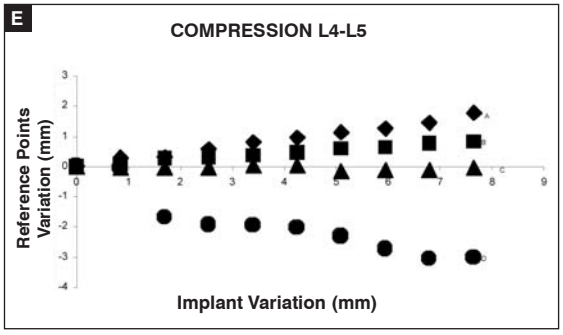


Figure 2 – *Behavior of distance between the four reference points used in the study (A, B, C and D) after compression (approaching) of system's components.*

DISCUSSION

In the last decades, implants in vertebral spine surgeries have been frequently used, and knowing biomechanical characteristics of lumbar spine, as well as implants used, is essentially important to meet treatment's objectives.

The major objective of the mechanical assay we conducted was to know better the mechanical phenomena occurring in different parts of vertebral segment by means of compression or distraction on implants applied on vertebral pedicula. Excluding surgeries for scoliosis correction, those forces are the most

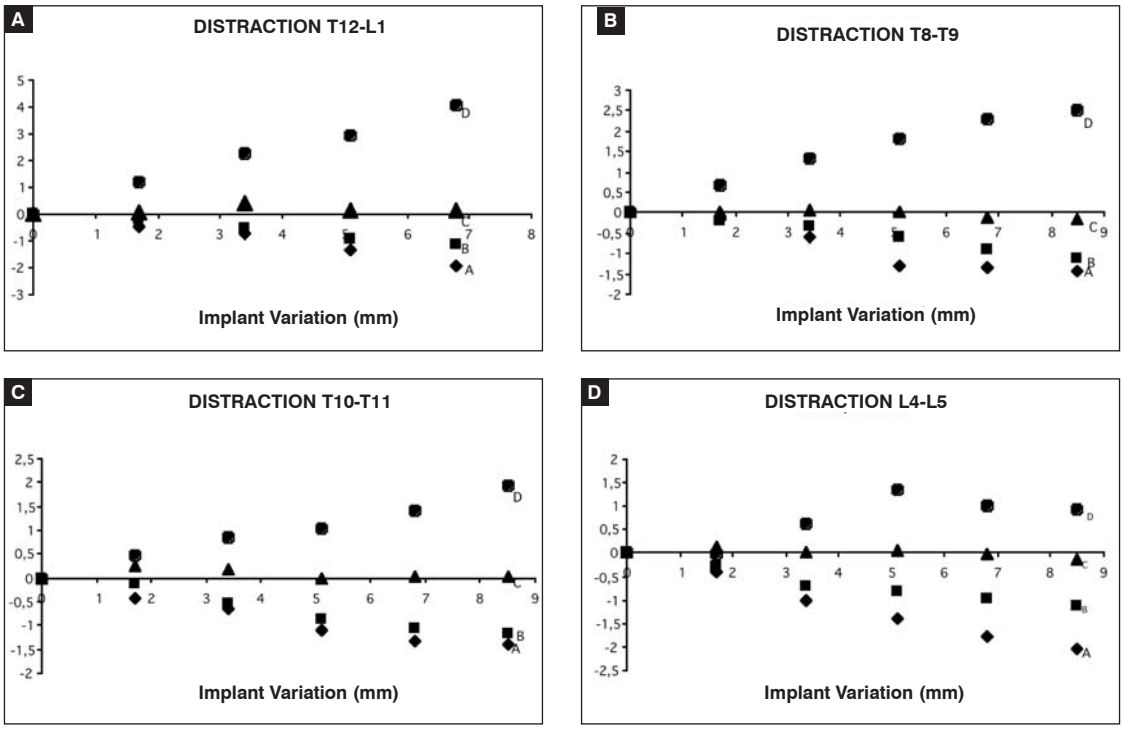


Figure 3 - *Behavior of distance between the four reference points used in the study (A, B, C and D) after distraction (spreading) of system's components.*

frequently used ones during surgical procedures on vertebral spine, and its effects to anterior or posterior portions of the vertebral segment imply in important clinical issues. As an example, we can mention the importance of applying a compression force on grafts used in inter-somatic arthrodesis of vertebral bodies, which contribute to its union and arthrodesis consolidation .[1]

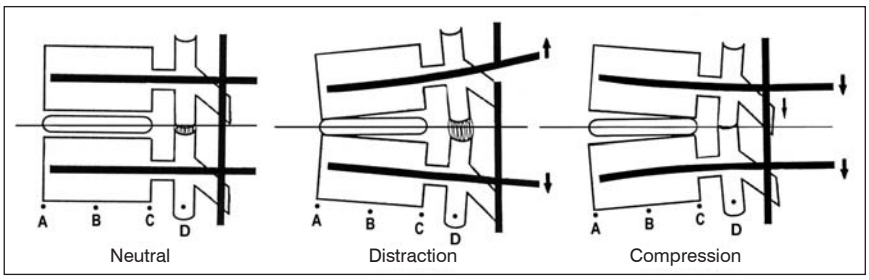


Figure 4 – *Illustration representing the effects of compression or distraction on reference points studied.*

The results seen in our mechanical assay evidence that the application of compression or distraction forces on pedicular implants produced opposite effects to the force applied on the anterior portion of a vertebral segment. Those results, yet preliminary, corroborate the reports on other similar studies[2] and are directly related to the vertebral rotation instantaneous center (VRIC), which is a geometrical concept that localizes a point in space on which the vertebra rotates. The rotation center would represent the relative movement between two positions of an object in motion.[3] On human lumbar vertebras, the VRIC is located posterior to fibrous annulet and near joint facets [3], and the analogy with the results observed in our assays indicates that this would probably be the VRIC site of the vertebras used.

VRIC presents modifications when vertebral segment's components are injured. The destruction of fibrous annulet displaces VRIC anteriorly.[3] Implants' ability to restrain movements of the vertebral segment is also related to VRIC,[4,5] and a complementation for our study would be the conduction of mechanical assays in vertebral segments where their components are injured, because this model would be closer to real clinical situations and would address different kinds of vertebral segment injuries. VRIC location on thoracic and lumbar vertebras is not similar due to particular anatomical and functional characteristics of those vertebras, and this fact would explain the difference in values between those vertebras, as observed in assays, evidencing that individual characteristics of vertebral segments should be considered.[6]

The application of compression-distraction forces does not produce similar effect on different portions of the vertebral segment, and that effect should be considered when using vertebral fixation systems, expecting the effect (compression and distraction) on vertebral segment is achieved.

CONCLUSION

The application of compression or distraction forces by means of approaching or spreading implants inserted into vertebral pedicula does not produce the same effect on different portions of the vertebral segment.

The application of components forces approaches components on anterior and medial portions of vertebral bodies and spreads posterior elements, with the opposite occurring when distraction forces are applied.

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