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MICROENDOSCOPIC VENTROSACRAL TRANSCORPOREAL OSTEOSYNTHESIS OF THE LUMBAR-SACRAL JUNCTION IN SPONDYLOLISTHESIS

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ABSTRACT:
Surgical management of spondylolisthesis remains widely disputable. The main surgical routs that are currently employed by surgeons are anterior or posterior approach and their combinations utilizing numerous instrumentation techniques. Most of these methods are traumatic and technically demanding. The authors describe alternative surgical technique for the management of low grade spondylolisthesis, utilizing ventrosacral approach to the L5-S1 junction and transcorporeal osteosynthesis of the lumbar-sacral spine with double compression screws. The preliminary results in the surgical management of 10 patients were favorable and are also presented in the paper .

Keywords:
spondylolisthesis, lumbar-sacral spine, ventrosacral approach, transcorporeal osteosynthesis, spinal fixation, surgical technique

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LOAD BEARING CAPACITY OF THE THORACIC SPINE AND THE NECESSITY OF FUSION FOLLOWING MODIFIED MICRODISCECTOMY: THEORETICAL EVALUATION AND EXPERIMENTAL *IN VITRO* BIOMECHANICAL STUDY

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Abstract:
Objectives: *to estimate the need for thoracic spine fusion after modified microdiscectomy on the basis of biomechanical spine concepts of Denis and Benzel, and to perform experimental in vitro cadaveric study to study the thoracic spine load bearing capacity, in flexion and axial loading, in intact state and after microdiscectomy.*
Methods: *seventy two functional spinal units (FSU) (from T4/5, T6/7, T8/9, T10/11 segments) from eighteen human cadavers were tested in three sequential stages. In stage 1 we tested intact specimens (control group) in compressive axial load and compressive-flexural bending load. Stage 2 and 3 included four-level simulated modified microdiscectomy performed on ten human cadavers (5 cadavers on each stage), with subsequent sectioning and testing with compressive axial load (stage 2) and compressive-flexural bending load (stage 3). All specimens were loaded until the registration of the limit of linear elastic behaviour on the load deformation curve.*
Results: *thoracic FSU's load bearing capacity at the proportional limit, under axial and flexion load, in intact state and after microdiscectomy, showed to be insignificant in all groups (P>0,05). Strength properties for the normal thoracic FSU's showed modest inter-region (T4/5, T6/7, T8/9 or T10/11 segments) difference, but still insignificant (P>0,05).*
Conclusions: *microdiscectomy in our modification causes minimal loss of in the thoracic FSU. Therefore, fusion or instrumentation procedures are not necessary.*

Keywords:
biomechanics, thoracic spine, microdiscectomy, load bearing capacity, thoracic disc herniation

INTRODUCTION

Various surgical procedures for the management of thoracic disk herniation (TDH) are inevitably include certain amount of osteoligamentous resection, leading to biomechanical and load bearing disarrangements followed by spinal deformity, secondary orthopedic and neurological complications [1, 3, 5, 8, 10-12]. An understanding of the biomechanical properties of the thoracic spine and its supporting structures is important for the surgeon to avoid the potentially destabilizing effect of surgery [1, 3, 6-8, 14-19]. Microsurgical discectomy via trans/extrapleural thoracotomy provide adequate visualization for the spinal cord decompression, but often requires spinal fusion [3, 5, 6, 13, 19]. Whereas, thoracoscopic discectomy is truly minimally invasive regarding spinal stability, but has limited space for manipulation and visualization and is overall technically demanding [5, 8, 10, 11]. In order to excel our clinical re-

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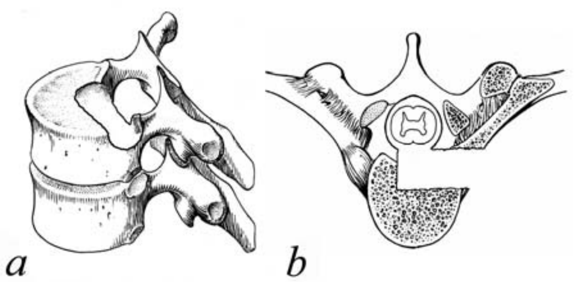

Fig. 1 a, b. Illustration of the MALEA microdiscectomy

sults, we combined the advantages of traditional extra/ transpleural thoracotomy and thoracoscopy, yielding Modified Anterolateral Extrapleural Approach (MALEA) to the thoracic spinal channel for the surgical treatment of TDH [11]. The employed approach is minimally invasive, implies the use of an endoscope and requires no fusion and bone grafting (Fig. 1).

Numerous studies showed that thoracic spine supported by the rib cage and trunk is relatively rigid and has limited range of motion (ROM), and even after microdiscectomy maintains stability [1-3, 6-8, 14-19]. And although fusion has been advocated after transthoracic discectomy [3, 5, 12], we have obtained good clinical results utilizing MALEA for the cord decompression without fusing the thoracic spine. Many studies investigated normal thoracic biomechanics and biomechanical consequences of surgery or trauma [2, 5, 7, 8, 16, 18-20], but few have assessed the effect of thoracic discectomy on the load bearing capacity of this spinal region and the necessity of fusion [3, 6, 15, 17].

Therefore, the purpose of this study is to estimate the need for thoracic spine fusion after discectomy via MALEA on the basis of biomechanical concepts of Denis [4] and Benzel [1], and to conduct experimental *in vitro* cadaveric study of the thoracic spine load bearing capacity, in flexion and axial loading, in intact state and after microdiscectomy utilizing MALEA [11].

SURGICAL TECHNIQUE

Operation is performed with the patient under gen-eral anesthesia. The patient is placed in the lateral position; the side to be placed facing up is dictated by the abnormality. The artery of Adamkiewicz, which enters on the left side in 80% of cases, is a concern, but we believe we should have access to the side of greater cord compression. MALEA starts with posterolateral thoracotomy, described by Moskovich [12] and later refined by McCormick [13]. The skin incision for upper and middle thoracic lesions is made over the rib of the involved level. In the upper thoracic spine (T3–4) a hockey stick–shaped incision is made along the medial and inferior border of the scapula, which is then freed of muscular attachments and rotated superiorly. A standard incision is made for lesions between T-5 and T-10. Beginning 4 cm lateral to the posterior midline, the incision is made along the rib at the involved segment (T-8 rib for a T7–8 intervertebral disc) and extended to the posterior axillary line. At the thoracolumbar junction, the incision is made two levels rostral to the involved segment (T-10 incision for a T-12 lesion). A subperiosteal dissection is used to free the intercostal muscles along an 8- to 10-cm length of rib. The exposed portion of the rib is transected, and the cut ends are waxed. Care is taken to keep proximal rib attached to the vertebral body (VB) and transverse process. Neurovascular bundle under the rib is identified and followed medially. The chest cavity is entered without resection of the rib fragment. By blunt dissection, the parietal pleura, is separated from the ribs above and below and from the spinal column. As a rule the segmental vessels crossing at midbody are preserved, as is the sympathetic chain. The operating microscope is now used. The radiate ligaments are incised, and the rib head is drilled away. Unlike traditional anterior approaches [5, 8, 10, 12, 13], costotransverse ligament and transverse process is intentionally remained intact, maintaining noninvasive pattern of the approach. The margins of the disc, the ventral margin of the foramen, and the pedicles above and below are all identified. With a high-speed drill the bony dissection is performed into the posterior 1/3 of the vertebral body adjacent to the disk, and a thin shell of the posterior cortex is kept intact to prevent epidural venous bleeding at this stage. Pedicle is remained intact. Once the disc is exposed in this manner, the lateral annulus is incised and removed using ronguers, thus creating a channel by which the dorsal annulus may be pulled away from the thecal sac using curettes. We remove the posterior one third of the disk and the posterior one third of the VB adjacent to the disk. Thus, adequate room is created to allow inspection of the anterior face of the spinal canal. The thin, bony shell of the posterior cortex is dislodged anteriorly into the defect so created. The posterior longitudinal ligament (PLL) is then in-cised and displaced anteriorly, both above and below the herniated disk. The endoscope is now used. The herniated disk and epidural sequestrated fragments are dislodged anteriorly and removed under control of endoscope (Fig. 2a). Once the thecal sac and nerve root are decompressed, hemostasis is obtained with tamponade and bipolar electrocautery. In MALEA, the removal of the bone is limited to the posterolateral portions of the VBs, thus no bone graft or instrumentation is required. The wound is closed by first reparing the periosteal bed of the rib with interrupted sutures. The transected rib is repaired by the approximation of the cut ends with sutures. The operative site is thoroughly irrigated, and the chest wound is closed in layers. Early ambulation and intensive spirometry are encouraged.

THEORETICAL EVALUATION

The thoracic spine consists of a unique osteoligamentous complex. The costovertebral joints connect the VB's to the rib cage and to adjacent VBs. Articulations of the transverse process with the rib and the rib head to the VB provide spinal stability. The associated ligaments involved with these articulations are the costotransverse, superior costotransverse, radiate, and intraarticular ligaments. This complex provides significant stability compared with the cervical or lumbar spine [1-3, 16, 17, 19].

In 1983 Denis introduced a three-column model for the assessment of spinal stability: the anterior column consists of the anterior longitudinal ligament (ALL) and the anterior half of the VB; the middle column is composed of the posterior half of the VB and the PLL, and the posterior column is composed of the posterior elements (facet joints and associated ligamentous structures) [4]. According to this concept the spinal stability is maintained if anterior and posterior columns are preserved. Although the three-column theory is

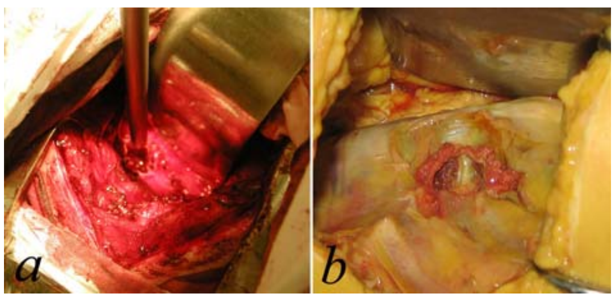

Fig. 2. Performance of the MALEA microdiscectomy. a – in vivo intraoperative picture shows inspection of the thecal sac and epidural space with endoscope, after the herniated disk is being removed; b – in vitro simulated MALEA microdiscectomy in cadaver session.

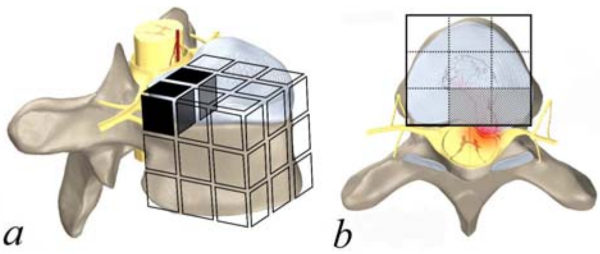

Fig. 3 a, b. Illustration of the MALEA using Benzel's model (shaded cubes show the extent of osteoligamentous resection).

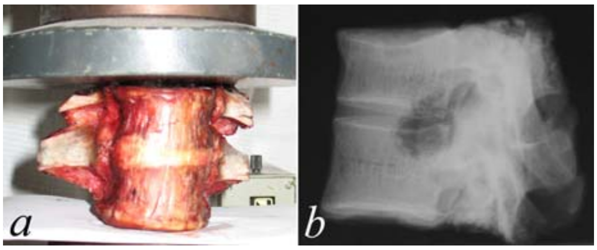

Fig. 5. Thoracic FSU's with simulated microdiscectomy. a – before testing, mounted in Electro Mechanical Testing Machine, Zwick 1464 (Germany); b – radiograph after load increment.

clinically attractive, it is not absolutely valid biomechanically. Studies of kinematics during spinal loading and fracture have shown significant variability in injuries produced with similar forces [2, 3, 6-8, 14-17]. Yoganandan proposed that instability should be considered as a continuum, in which partial injuries to different structures of the spine may allow pathologic amounts of motion, even if gross failure is not evident initially [20]. This concept was used in another model, proposed by Benzel [1, 19], where he visualized vertebral body, within anterior and middle columns, as a cube composed of 27 equal-sized cubical segments (3 x 3 x 3). This model does not evaluate the posterior column. However, Benzels model is useful in accessing the biomechanical effects of anterolateral surgical approaches through the vertebral body (Fig. 3). Disruption of the middle horizontal third, as viewed in the sagittal plane, results in destabilization and kyphosis with loss of the anterior and middle columns of Denis. One the other hand, removal of the middle coronal plane does not cause instability, with only partial disruption of anterior and middle columns. Resection of the ventral portion (the anterior nine cubes) may result in loss of stability; however, the loss of the middle and dorsal thirds in the coronal plane may not result in loss of spinal integrity if the ventral section of cubes is intact.

In the cervical and lumbar spine, the smallest functional unit consists of two VBs and the interconnecting soft tissue. In the thoracic spine, this functional unit is not as straightforward. There are connections between VBs and the rib cage through the costovertebral and costotransverse joints. The rib cage is the additional stabilizing component present in the thoracic spine. This sternal-rib complex has been described by Berg as the fourth column [2].

MALEA, as a modified variant of the transthoracic approach provides excellent exposure of the anterolateral thoracic spine and is particularly useful for centrally located calcified disc herniations or for multilevel exposure (Fig. 1 a,b,c). MALEA is accomplished without entrance into the pleural cavity; preserves the rib, pedicle, costotransverse ligament and transverse process; involves unilateral resection of the rib head, radiate ligament, costovertebral joint, the posterior one third of the disk and the posterior one third of the vertebral body and a part of the PLL adjacent to the disk. As

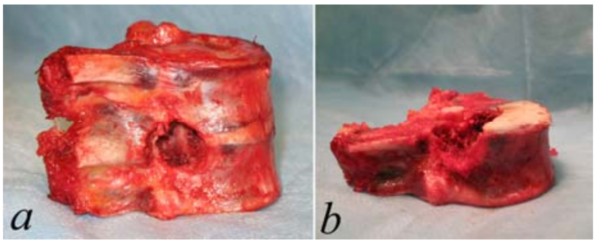

Fig. 4 a, b. Thoracic FSU's after MALEA microdiscectomy. The rib head and radiate ligaments are partially resected. Osteoligamentous resection is limited to the posterior 1/3 of the disc and adjacent vertebral bodies

a result, the middle column by Denis is interrupted, but anterior and posterior elements are preserved, as is the anterior and posterior load-bearing capability, thus fusion and bone grafting are not re-quired. Benzel's 27-cube model is particularly useful to determine the anterior load-bearing capacity under these circumstances (Fig. 2 a, b).

The ventral ligamentous structures such as the ALL and PLL and the annulus fibrosis provide significant stability to the spine. The ALL is a strong ligament attached to the VB edges at each segmental level of the spine. It provides a moment arm that resists extension by it's ventral position and a tension band–like effect, which is an especially important contributor to postoperative spinal stability [14-19]. ALL is always intact after MALEA. The PLL has far less biomechanical strength than its anterior counterpart in all areas of the spine. The position of the PLL provides a short moment arm and, in combination with its weak intrinsic mechanical properties, provides far less resistance to flexion than the dorsal elements [1, 14-19]. The contribution of the PLL is to resist flexion and distraction, albeit less than other ligaments [19]. PLL is partially is impaired after MALEA in which the intention is to decompress the spinal cord. The contribution of the annulus fibrosis to spinal stability parallels that of the immediately adjacent ALL and the PLL [19]. MALEA, although affects the dorsal one third of annulus, does not significantly disrupt the overall stability.

The bone removal during MALEA clearly affects stability. The degree of the spinal stability that remains is determined by the portion of the bone remaining in the ventral component of the VB and by the location and extent of the vertebrectomy. Resection of the dorsal portion (the posterior 9 cubes by Benzel) in the coronal plane, does not result in loss of stability if the ventral section of cubes is intact, the ALL remains intact, and dorsal column osseous and ligamentous integrity remains (Fig. 3). Further minimizing of bone removal within posterior 9 cubes, as performed with MALEA, contributes even more to spinal stability.

In MALEA, the above mentioned biomechanical concepts found excellent theoretical application. The purpose of our further investigation was to determine their accuracy in practical application, namely the conduction of experimental *in vitro* cadaveric study of the thoracic spine load bearing capacity, in flexion and axial loading, in intact state and after microdiscectomy utilizing MALEA.

EXPERIMENTAL EVALUATION

Study Design

This study is collaborative work of Neurosurgical department of Moscow Regional Scientific Research Clinical Institute (Moscow, Russia), Experimental Research Laboratory of Central Institute of Traumatology and Orthopedics (Moscow, Russia) and Smolensk Regional Institute of Pathology (the head – prof. A.E. Dorosevich, MD/PhD), conducted during nine month in 2006-2007. Total of eighteen human cadavers were used. Cadaveric thoracic spines were harvested en bloc and sectioned in to 4 functional spinal units (FSU), consisting of two vertebrae and interconnecting structures. The total of 72 FSU's from T4/5, T6/7, T8/9 and

T10/11 segments were tested in three sequential stages. In stage 1 we tested intact specimens (control group) in compressive axial load and compressive-flexural bending load. Stage 2 and 3 included four-level simulated microdiscectomy via MALEA performed on ten human cadavers (5 cadavers on each stage), with subsequent sectioning and testing with compressive axial load (stage 2) and compressive-flexural bending load (stage 3). The average age of cadavers was 60 and ranged from 45 to 75 years.

Specimen Preparation

In stage 1, eight unpreserved adult human cadaveric thoracic spines were harvested en bloc. Each thoracic spine were sectioned in to 4 FSU's, with total of 32 FSU's from T4/5, T6/7, T8/9 and T10/11 segments. Specimens were prepared by removing the rib cage and the surrounding muscles. The integrity of the ligaments, the joint articulations, the transverse processes, and the posterior 2-3 cm of the ribs including articulations were preserved. Each specimen was radiographically screened to exclude metastatic or metabolic deseases. The mean bone mineral density (BMD) of the specimens was 0,815 g/cm^2 and ranged from 0,530 to 1,100 g/cm^2. The specimens were wrapped in saline-soaked towels, sealed in double plastic bags and stored at -20^{o}C until tested. All specimens (FSU's) from each of the four thoracic spine levels tested were randomly divided in to 2 equal groups. One half of the FSU's underwent compressive axial load and another half underwent compressive-flexural bending load.

Stage 2, included left sided four-level (T4/5, T6/7, T8/9 and T10/11) microdiscectomy via MALEA performed on five fresh cadavers (Fig. 2b, 4), with subsequent sectioning for 20 FSU's and their testing with compressive axial load. The tools and techniques used for MALEA microdiscectomy were identical to *in vivo* surgical procedures. In all microdiscectomies, the spinal cord was completely decompressed. After microdiscectomies, five cadaveric thoracic spines were harvested en bloc. Each thoracic spine were sectioned in to 4 FSU's, corresponding to the level of manipulation, with total of 20 FSU's from T4/5, T6/7, T8/9 and T10/11 segments. Specimens were prepared by removing the rib cage and the surrounding muscles. The integrity of the ligaments, the joint articulations, the transverse processes, and the posterior 2-3 cm of the ribs including articulations were preserved. Each specimen was radiographically screened to exclude metastatic or metabolic deseases. The mean bone mineral density (BMD) of the specimens was 0,820 g/cm^2 and ranged from 0,490 to 1,150 g/cm^2. The specimens were wrapped in saline-soaked towels, sealed in double plastic bags and stored at -20^{o}C until tested with compressive axial load..

In stage 3, we performed five fresh cadaver sessions and microdiscectomies, attempting four thoracic levels in the manner described above. After microdiscectomies, we obtaited 20 FSU's from the corresponding levels (Fig.4). Specimens were prepared by the above mentioned methodology. Each specimen was radiographically screened to exclude metastatic or metabolic deseases. The mean bone mineral density (BMD) of the specimens was 0,755 g/cm^2 and ranged from 0,460 to 1,050 g/cm^2. The specimens were wrapped in saline-soaked towels, sealed in double plastic bags and stored at -20^{o}C until tested in compressive-flexural bending load.

Experimental Test Method

Biomechanical testing took place after each stage of the experiment. Before the testing the specimens were thawed to room temperature according to well-known methodology. They were mounted in Electro Mechanical Testing Machine, Zwick 1464 (Germany) (Fig. 5). For the compressive loading scenario, the specimens were placed in the neutral position, with the endplates of each vertebral body (VB) parallel to one another. The compressive load was applied by using a linear stepper motor and loads were applied with a rate of 200 N/sec from 0 N to 10000 N from caudal side of the specimens, using a compression speed of 1 mm/min. For the compressive-flexural bending testing we utilized the methodology described by Toh et al. [18], who created the load by applying a 20 mm anterior offset for the stepper motor. This resulted in applied bending moments from 0 to 3 Nm in increments of 1 N as well as the superimposed compressive load from 0 to 10000 N in 200 N/sec increments. The amount of pressure applied to the specimen was recorded by a strain gauge system that was calibrated from 0 to 1000 kilograms (from 0 to 10000 N).

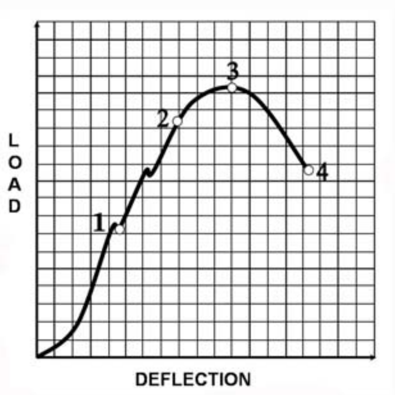

Fig. 6. Schematic load deflection curve illustrating alterations in FSU during compressive load. 1 – end plate fractures; 2 – proportional limit; 3 – yield point; 4 – total failure.

During data collection, we observed four distinct events in the load deformation data of the FSU (Fig. 6), occurring in consecutive order: 1. End plate fractures; 2. Proportional limit; 3. Yield point; 4. Total failure. End plate fractures have been observed to occur within the linear portion of the load deformation curve. The Proportional limit defines the limit of linear elastic behaviour beyond which load-deformation becomes non-linear and there is a reduced stiffness. It represents the point at which a material begins to fail, but is able to recover its preload form on release. The Yield point defines the ultimate or maximum load beyond which irreversible deformation occurs. Total failure defines the point at which the structural integrity is lost and the material collapses. In our experiment, all FSU's were loaded until the registration of Proportional limit on the load deformation curve.

During each load increment, radiographs were taken of the FSU sections under unloaded and loaded conditions. Before each radiograph the specimens were allowed to relax for 1 min.

Statistical Analysis

Comparisons of change in compressive axial load and compressive-flexural bending load in four thoracic FSU's, before and after microdiscectomy were performed using paired Student's t-test. Analysis of variance was used to compare differences among the levels studied. P-values less than 0,05 were considered statistically significant.

Results

Figure 7 shows thoracic FSU's strength characteristics at the proportional limit, under axial and flexion load, in intact state and after microdiscectomy.

In T4/5 FSU, the limit of linear elastic behaviour of the intact specimen estimated 2200-3000 N in axial compression (mean – 2600 N), and 2100-2800 N in flexural bending load (mean – 2450 N). The strength values after microdiscectomy were 1700-2400 N in axial compression (mean – 2050 N), and 1650-2300 N in flexural bending load (mean – 1975 N) (P>0,05).

In T6/7 FSU, the Proportional limit of the intact specimen estimated 2350-3100 N in axial compression (mean – 2725 N), and 2300-3000 N in flexural bending load (mean – 2650 N). The values after microdiscectomy were 1800-2550 N (mean – 2175 N), and 1750-2500 N (mean – 2150 N) respectively (P>0,05).

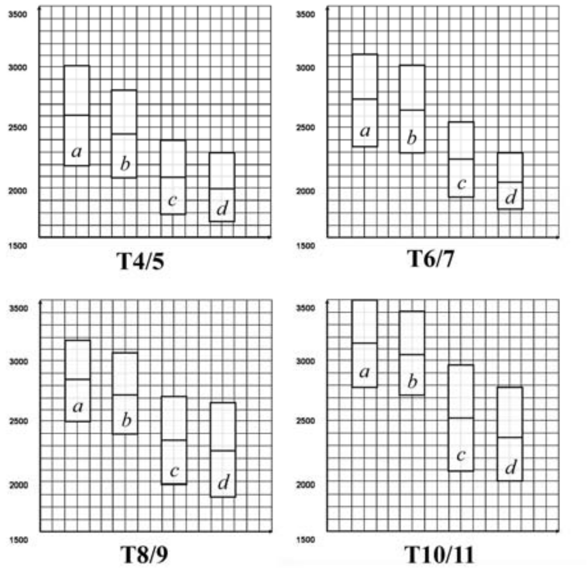

Fig. 7. Thoracic FSU's strength characteristics at the proportional limit. a – intact state under axial load; b – intact state under flexion load; c – after discectomy under axial load; d – after discectomy under flexion load. Bars show the low, average and high values for the specimens

Proportional limit of T8/9 FSU, in intact state were 2500-3300 N in axial compression (mean – 2900 N), and 2400-3100 N in flexural bending load (mean – 2750 N). The values after microdiscectomy were 2000-2700 N (mean – 2350 N), and 1900-2650 N (mean – 2275 N) respectively (P>0,05).

Strength properties for T10/11 FSU in intact state were 2800-3600 N in axial compression (mean – 3200 N), and 2750-3400 N in flexural bending load (mean – 3075 N), and after microdiscectomy estimated 2100-2950 N (mean – 2525 N), and 2000-2800 N (mean – 2400 N) respectively (P>0,05).

Consequently, after overall data pooling, demonstrated difference between intact and post-discectomy FSU's, showed to be insignificant in all groups (P>0,05), due to overlapping confidence intervals. Strength properties for the normal thoracic FSU's showed modest inter-region (T4/5, T6/7, T8/9 or T10/11 segments) difference, but still insignificant (P>0,05). These results lead us to a conclusion that microdiscectomy in our modification causes minimal loss of load bearing capacity in the thoracic FSU. Therefore, fusion or instrumentation procedures are not necessary after MALEA microdiscectomy. This statement was confirmed by the microdiscectomy procedures in patients with single/multilevel thoracic disc herniations (Fig. 8, 9).

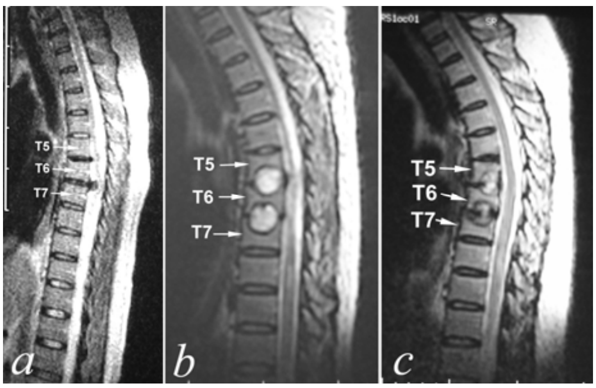

Fig. 8. Sagittal MRI of the thoracic spine. a – preoperative MRI shows two-level disc herniations at T5/6 and T6/7 compressing the spinal cord; b – postoperative MRI shows complete removal of the herniated discs at T5/6 and T6/7; c – 1 year after the operation. T5/6 and T6/7 lesions had been adequately removed, the vertebral body resection sites shows prominent osseous regeneration. No signs of segmental kyphosis at the operated level.

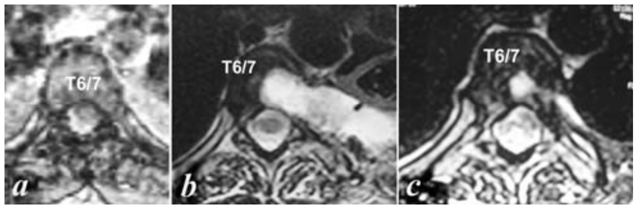

Fig. 9. Axial MRI of the thoracic spine. a – preoperative axial MRI at T6-7 shows massive disc herniation compressing the anterolateral surface of the spinal cord; b – postoperative MRI shows a channel created by excision of T6-7 disc and vertebral bodies; c – 1 year after the operation. T6-7 lesion was adequately removed. Postoperative resection channel shows prominent osseous regeneration.

DISCUSSION

In the present study we observed minimal loss of load bearing capacity of the thoracic FSU's following MALEA microdiscectomy. Our finding is consistent with other reports regarding this issue, both *in vitro* and *in vivo* [2, 5, 7, 8, 16, 18-20]. Broc et al. studied en bloc human cadaveric spines, before and after microdiscectomy, in three dimentional motion [3]. He showed that thoracic microdiscectomy had small effects on the immediate mechanics and kinematics of the thoracic spine and did not overtly destabilize the motion segments. Krauss et al. observed 18 patients who underwent transthoracic discectomy without fusion [10]. During follow-up of 6 years none of the patients reported the onset of a new axial spine pain postoperatively nor developed segmental kyphosis or scoliosis at the operated level. He concluded that interbody fusion may not be necessary for selected patients undergoing transthoracic discectomy.

Numerous biomechanical studies investigated the role of the posterior elements, costovertebral joints, rib cage, sternum and the disc in the stability of the thoracic spine [2, 6, 7, 8, 14-17]. Oda [14] and Tacheuchi [17], have performed sequential sectioning of the costovertebral joints and observed a large increase in the neutral zone, lateral bending, and axial rotation. The disruption of the rib cage resulted in further increase in lateral bending and axial rotation. Also they concluded that the intervertebral disc regulates the stability of the thoracic spine in flexion-extension, lateral bending, and axial rotation. Feiertag [6], after a series of experiments, found that the combination of bilateral rib head resection and radical discectomy provided significant increases in thoracic spine motion. However unilateral rib head resection, or a unilateral total facet excision, did not show a significant increase in motion if performed individually.

Furthermore, results of our study, in our opinion, overestimate biomechanical consequences of microdiscectomy because we used cadaveric FSU's lacking both musculature and the rib cage, which are important stabilizing elements. With the additional stabilization of the thoracic cage, the difference in load bearing capacity would be even less *in vivo*.

Statistical analysis in this study was evidently limited due to small number of specimens available (5-10 specimens in each testing group). This result in type II (beta) error, which is the statement that there is no statistical difference between group, when in fact there is a significant difference (incorrect acceptance of the null hypothesis). The only way to minimize type II error is to use larger study group, that is obvious limitation of human cadaveric experiments due to difficulty in obtaining enough specimens.

CONCLUSION

Thoracic microdiscectomy is a complex surgical procedure that should be performed with regard to thoracic spine unique anatomical and biomechanical properties. Interbody fusion may not be necessary if the extent of osteoligamentous resection is limited to the posterior 1/3 of the disc and adjacent vertebral bodies, and preserves the integrity of the rib and it's articulations with vertebral body and the sternum. Microdiscectomy in our modification, as follows from the conducted experimental *in vitro* cadaveric study, minimally affects thoracic spine load bearing capacity, both in flexion and axial loading. However, the precise evaluation of biomechanical consequences of thoracic discectomy requires the integration of information obtained from mechanical properties, loading and motion measured *in vivo*, supplemented by *in vitro* biomechanical analysis.

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ОПОРОСПОСОБНОСТЬ ГРУДНОГО ОТДЕЛА ПОЗВОНОЧНИКА И НЕОБХОДИМОСТЬ КОРПОРОДЕЗА ПОСЛЕ МОДИФИЦИРОВАННОЙ МИКРОДИСКЭКТОМИИ: ТЕОРЕТИЧЕСКОЕ ОБОСНОВАНИЕ И ЭКСПЕРИМЕНТАЛЬНОЕ БИОМЕХАНИЧЕСКОЕ ИССЛЕДОВАНИЕ

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РЕФЕРАТ

Цель: *изучение биомеханических последствий миодифицированной переднебоковой микродискэктомии в свете концепций Denis и Benzel, в теории и эксперименте, для понимания и предупреждения потенциально деструктивного и дестабилизирующего эффекта применяемого нами оперативного доступа.*

Материал и методы: *эксперимент включал проведение грудной микродискэктомии на 18 кадаверах и забор 72 позвоночных двигательных сегментов (ПДС) с четырех уровней - T4/5, T6/7, T8/9 or T10/11. В качестве контроля использовали интактные ПДС грудного отдела позвоночника взятых у кадаверов сходного возраста и пола. Биомеханические испытания прочностных характеристик проводили на испытательной машине Zwick 1464. ПДС подвергали вертикальной и флексионной нагрузке в возрастающем режиме до 10 тыс. Н со скоростью 200 Н в сек. ПДС нагружались до момента регистрации датчиком давления падения предела прочности, что соответствовало моменту перехода упругих деформаций в область пластических деформаций.*

Результаты: *разница в пределах прочности грудных ПДС в интактном состоянии и после микродискэктомии, (при вертикальнои и флексионной нагрузке), не имела статистической значимости (P>0,05).*

Выводы: *после модифицированной микродискэктомии, происходит не значительное снижение предела прочности грудного ПДС и следовательно, нет необходимости в дополнительной стабилизации оперированного сегмента позвоночника имплантатами или трансплантатами.*

Ключевые слова: *биомеханика, опороспособность, грудной отдел позвоночника, микродискэктомия, грыжа грудного межпозвонкового диска.*