Minimally Invasive Scoliosis Surgery

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ABSTRACT

Minimal Invasive Spine surgery extended to the field of spinal deformity correction. The main goal of minimally invasive surgeries are preventing blood loss and resulting minimal damage to the thoracic wall, better cosmetic appearance and shorter hospitalization time compared to conventional open surgical techniques. Scoliosis is the lateral curvature of the spine may be seen in every age of human. Decreasing high morbidity and risks in scoliosis surgery minimal invasive spine surgical procedures was objected in many articles. This paper intended to review the literature for briefing minimal invasive techniques and to discuss indications, contraindications and complications. The structural pattern of the deformed spine differs between adolescents and adults, which have a major role on treatment strategies. The clinical results of various surgical treatments of these age groups were also separately discussed in the present article.

KEY WORDS: MISS, scoliosis

INTRODUCTION

The morbidity of surgical approaches in Scoliosis are also decreasing with the technological advances for improving surgical procedures similar to every field of surgery. Incapacitating spinal deformities were previously inevitable or possible with challenges at high surgical risks. During the time, evolvings in the implant industry with supports of visual and navigation technologies easened further developments in minimal or less invasive spine deformity correction procedures (42). The concept of minimally invasive surgery is also getting changed from “limited surgical approaches” to endoscopic surgeries or percutaneous techniques in the present time.

The term of minimally invasiveness aims to define efforts in field of deformity surgery with minimizing local tissue morbidity and maximizing patient return to function. Scoliosis is an important structural deformity of the spine expressing in different ways in every age interval of a human (2). Traditional open posterior or anterior posterior combined procedures are properly effective with high morbidity especially in adult thoracolomber deformity. The present paper will be discussing surgical spinal deformity correction through the window of concepts of minimally invasive spine surgery during historical perspectives considering patient’s age and clinical results with reported complications. The novel area has also brought its own indications and algorithms.

Treatment plans and strategies have been changing according assessment of the severity of the disease and associated pathologies. All columns of the spine were more often consider for surgical intervention. MISS techniques are getting more important considering decreasing morbidity of combined surgical approaches. Meticulous plans and combined strategies were described for obtaining better treatment plans however complication rates are still high.

Scoliosis

Scoliosis is a musculoskeletal disorder in which there is a lateral curvature of the spine. Scoliosis is a progressive condition that affects the spines of many children, adolescents and adults. Classification of the disease may be made according its underlying medical pathology. Many conditions including neuropathic diseases such as cerebral...
curves and the deformity exist in 3 planes. The ability to control three spinal columns with modern pedicle screws made posterior approaches more popular. The decision of choosing the extension of surgical approaches has to be planned preoperatively. This advantage of pedicle screws does not extinguish the need of anterior release or bone resections and the anterior approach is still being applied in a great number of cases (26).

Indications of MISS

Indications have been proposed for surgery for adults with scoliosis, including curve progression, sagittal and/or coronal imbalance with unremitting back pain, curve flexibility, curve of greater than 50° when decompression is considered, documented history of progressive curve, radiculopathy on the side of the concavity of the curve due to foraminal stenosis, lumbar hyperlordosis, patients with a history of flat-back syndrome and back pain, fixed lateral listhesis within the degenerative curve when motion is present on side-bending films and when extensive decompression including facetectomy or the violation of the parts is planned (20).

Contraindications of MISS

Minimally invasive techniques for spinal deformity wouldn't be recommended in curves with a Cobb angle greater than 90°, sagittal imbalance greater than 10 cm, rigid kyphotic deformities with fused spinal segments and osteoporosis with T score of less than −2.0. According to severity of the deformity osteotomies should be considered in rigid and sharp curves. Spondylolisthesis is also an other contraindication especially high grade cases. Besides the curve flexibility extent and magnitude etc. medical co-morbidities need to be carefully evaluated. Rigid curves and spontaneous fused spinal segments are not candidates for minimally invasive techniques (3).

Spinal Endoscopy

Endoscopic techniques mylscopy and arthroscopic discectomies may be used as an additinal procedure for relaesing soft tissues, which may be associated with deformities like thetred cord or other intradural pathologies. However there aren't reported series investigating the role of these techniques in MISS. These procedures were briefly mentioned in the present text.

Myeloscopy is developed for improving the surgical visualisation rather than surgical intervention in a manner
of more minimally invasive way. Beside the popularity in arachnoidits and nerve root excursion in degenerative pathologies there are rare case reports analyzing their experience in using spinal endoscopy to treat various pathologies of the spinal canal in childhood (9). Based on the authors’ experience, intradural endoscopy is a useful surgical adjunct and one that helped to decrease morbidity through reduced laminectomy and myelotomy. According the authors’ conclusion with advances in technology, intradural endoscopy may begin to be used by more neurosurgeons for treating intradural originated pathologies.

**Percutaneous Arthroscopic Discectomy**

Ottolenghi (36) and Craig (10) described separately almost 60 years ago posterolateral biopsy of the spine. Hijikata et al. (21) performed a percutaneous discectomy by utilizing intradiscal arthroscopic techniques for lumbar disc herniations under local anesthesia. According this technique, discography was made initially using Evans blue dye. Specific instruments were designed working in a 5 mm cannula for inserting against the lateral annulus. A circular incision was made for accessing in the annulus, and the blue-stained nucleus pulposus was removed with pituitary forceps. An automated system was also involved to the technique (42).

Kambin and Gellman developed the technique using the Craig’s working cannula (24) performed a discectomy by inserting a small forceps into the disk space after an open laminectomy. They evaluated the effects and the changes on the surrounding anatomic tissues after evacuating the nucleus pulposus. Optic arthroscope for single working portal was modified (23) for observation of periannular structures, including the foramen and the spinal nerve. Arthroscopic discectomy enabled also removal of herniated discs via a posterolateral approach. Numerous studies on the efficacy of arthroscopic disc surgery have been published reporting an 88% excellent or good outcome rate with arthroscopic microdiscectomy (28) Biportal access via triangulation into the intravertebral disc with inline irrigation and suction was performed (24).

**Video-Thoracoscopy Assisted Surgical Technique (VATS)**

The video-thoracoscopy assisted surgical technique (VATS) and related devices were developed to decrease the morbidity related to anterior surgical procedures. The system was often used in patients with AIS. The reported criteria by different authors to select appropriate patients for undergoing the VATS procedure are also similar to the open anterior surgery. Isolated thorascoscopic instrumentation of the thoracic spine requires a limited curve pattern in which selection of such fusion levels between T4 and L1 would be appropriate (18).

Two types of applications with VATS can be identified; VATS as an initial procedure in rigid type curves or in young children or thorascoscopic instrumentation and correction of scoliosis using the VATS technique as an essential operation. The majority of studies using thorascopy in scoliosis have performed anterior release and discectomy. Treatment of AIS via anterior instrumentation has been shown to reduce the number of motion segments fused versus posterior instrumentation, and selective thoracic fusions improved spontaneous lumbar curve correction (26).

Vertebral stapling with VATS is another optional surgical technique designed for patients who have not reached skeletal maturity. Early published results show that the technique is feasible and relatively safe; however, the data is insufficient to permit conclusions as to whether the technique improves health outcomes (7). The technique involves endoscopic placement of titanium alloy staples along the convexity of the spinal curvature for attempting to retard growing of the spine and progression of the scoliosis as the patient matures (8).

Despite its potential advantage in standard thoracotomy regarding efficacy, some major concerns remained and it was examined clinically and biomechanically. Complete endplate removal with total discectomy enables a successful anterior fusion. Newton et al. realized biomechanically equivalent release of disc spaces when comparing open and thorascoscopic methods in animal models (32).

The extent of the instrumentation in VATS found comparable favorably with posterior procedures. Furthermore conserving the thoracic kyphosis provides better volume for lungs. The morbidity of a long instrumentation has been acknowledged by Newton et al, who found that close to 10% of their thorascoscopic instrumented patients had been fused at least 1 level too short (34). However, certain parameters like the balance of the patient, cosmesis, status of the unfused lumbar curve, and the number of levels saved with anterior surgery were not investigated adequately.

In different comparative studies comparing anterior and posterior surgeries blood loss was lesser in VATS patients and curve correction was found similar (27). On the other
hand the surgery time is longer in patients underwent VATS than posterior instrumented patients (44).

Qui et al. compared in a further study curve correction with operation duration. They found that curve pattern was comparable in postoperatively, but surgery time was significantly shorter in mini-thoracotomy group than VATS (40).

Co-morbidites of the anterior surgeries was the subject of the study reported by Faro et al. They investigated effect of VATS (23 patients) and thoracotomy (32 patients) on lung functions used in Adolescent Idiopathic Scoliosis (AIS). The thoracoscopy group caught up their pulmonary function with nearly preoperative FVC values (101%±11%) (15). The FVC values of the thoracotomy group recovered to 93% +/-10% of preoperative values.

Health quality scores of patients found higher in anterior instrumented patients than posterior instrumented counterparts in AIS. Lonner et al. found a score close to 5 in the VATS group (maximum score) in most domains tested as opposed to a score close to 4 for the posterior surgery group (27). Patients were also highly satisfied with the outcomes 2 years after surgery in the Newton et al. series and the SRS Outcomes Questionnaire resulted in average scores for this domain of 4.8+/-0.6. (33).

Endoscopic procederdes extended from thoracic region to lumbar area. Recently, retroperitoneal endoscopic surgery has been applied to various spinal disorders. Aunoble et al. reported clinical results of their series operated with anterior video assisted cage and plate fixation in L5- S1 level (5). Despite to variations of surgical approaches among surgeons to the retroperitoneal space the prevention of lumbar plexus nerve injuries is the major problem. Maro et al were analyzed the distribution of the lumbar plexus using cadavers. They located the genitofemoral nerve and its branches with variations. According to their study the nerve descends obliquely forward through the psoas major muscle, emerging on the abdominal surface between the cranial third of the L3 vertebra and the caudal third of the L4 vertebra. The authors defined a safe zone for sparing fibers of the psoas major muscle without demaging nerves, excluding the genitofemoral nerve, which is at L4/L5 and above (31).

In 1991, Obenchain (35) reported the first use of a laparoscopic approach to the lumbar spine for a discectomy. Regan et al. (41) described the technique and reported preliminary results for laparoscopic anterior lumbar fusion. Gaur was the first one to describe an endoscopic retroperitoneal approach for urological procedures, and Fessler first described this retroperitoneal endoscopic approach in the lumbar spine in 1992 and a lumbar fusion via this technique in 1997 (16).

Lumbar interbody fusion have been increasingly utilized in an attempt to lower the incidence of pseudoarthroses and to recreate the patient's normal sagittal alignment. Anterior approaches to lumbar interbody fusions are mostly preferred surgical routes. The majority of complications of anterior lumbar interbody fusion (ALIF) are associated with the surgical exposure. In 1998, McAfee et al. described a minimally invasive, endoscopic anterior retroperitoneal approach to the lumbar spine (29). This procedure was resulted with mostly transient groin pain and paresthesias at 30% incidence. The authors concluded that anterior endoscopic approach for exposure of the lumbar spine was useful without mobilization of the great vessels or sympathetic plexus (6).

The magnetic resonance neural imaging distribution of lumbar plexus was analyzed in patients with degenerative lumbar scoliosis and evaluated its value and the safety of XLIF (19). The results of the study indicated a ventral migration of lumbar plexus from L1-2 to L4-5 level. The Authors concluded that operation from the concave site of the deformity may reduce the risk of injury to the lumbar plexus.

Extensive lateral Interbody Fusion Techniques (XLIF)

Surgeons are offering their patients open surgery or MISS depending on their age and the severity of their deformity. Larger Cobb angles, greater sagittal imbalance, and higher reoperation rates were found in studies reporting the use of open fusion with osteotomy. Elderly patients requires different clinical approaches to their deformities. Current surgical treatment techniques include posterior only or combined anterior posterior surgeries. Reconstruction of the anterior column with interbody fusion techniques, followed by posterior interventions like arthrodesis, osteotomy or instrumentation. Despite of the effectivity of these techniques they have high morbidity and risks of complications. Development of MISS techniques provides impetus for treatment in this vulnerable patient population. XLIF technique is one of those recently developed one considering for these objectives. XLIF is a minimally
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The safety and effectiveness of transsacrals fixation/fusion in lumbosacral fusion without iliac fixation was investigated by Anand et al. They reported retrospectively good clinical results of their carefully selected patients with long-segment constructs (4). There were significant improvements in all HRQOL parameters. Eight of 46 patients had complications related to the transsacral fusion, including five pseudarthroses and three superficial wound dehiscences. Three patients required revision surgery with iliac fixation. They weren’t met bowel injuries, sacral hematomas, or sacral fractures.

COMPLICATIONS

The major objective of the MISS techniques is decreasing the complications types and ratios. The complications associated with wound size and additional procedures like costotransversectomy or rib resections were not met in patients underwent MISS. Other complications were similar to the present open techniques. Fortunately the amount and percentage was found lower (43). Even in robotic assisted pedicle screw placement was reported 11 malpositions in 960 screws (22).

Grewal et al. found a fewer number of infection-related complications in their VATS group which they attribute to smaller incisions (17). The rate of pseudarthroses was unacceptably high in the experience of Picetti et al (38).

CONCLUSION

MISS techniques are gaining popularity in the treatment of scoliosis in the last years due to advantages. These techniques require a steep learning curve and meticulous preoperative plan. Parallel to technical advances number of operated patients with MISS or combinations of MISS techniques will rise in the future. Further clinical studies are needed for evaluating clinical results.

REFERENCES


Minimally invasive decompression and XLIF techniques were first described by Diaz et al (13). Philips et al reported last year prospective, multicenter study to quantify outcomes after XLIF in DS patients (37). They have good and satisfactory clinical results with less complication rates after 2 years of follow up period with an average of 3 levels of fusion. Their radiographic results showed improvements from 20.9 degrees to 13.5 degrees in frontal plan curves and from 27.7 degrees to 37.6 degrees in sagittal plan curves.

They saw complications in twenty six of 107 patient cohort (24.3%): 16% minor, 12% major. The strongest predictor of complications was the total number of levels treated per patient. These results are acceptable comparing with the traditional surgical techniques which may reach to 66%. Charosky experienced at 37% of his patients complications and additionally nearly 20% further patients needed further operations (11). In Daub’s series the anterior approach was associated with a 10.9% incidence of iliac vein tears (12). Pumberger et al. analyzed postoperative neurological deficits in 235 patients after lateral interbody fusion. They reported 1.6% sensory deficits (39).

Minimally invasive decompression and XLIF techniques were compared and analyzed in a meta-analysis. The Authors found mean pre- and postoperative Cobb angles as 22.3° and 9.2°, respectively in XLIF group (14). In this study greater sagittal and coronal correction was noted in the XLIF versus decompression only MIS groups. However complication rates did not significantly differ between groups.

XLIF technique is not limited to lumbar area. Thoracic usage was adapted by Meredith et al. allowing access to the anterior aspect of the thoracic and thoracolumbar spine with specific reference (30). The authors studied early pulmonary complications, non-pulmonary complications, and ability of this technique for achieving successfully spinal decompression and fusion at the operative levels.

PERCUTANEUS TECHNIQUES

Algenstadt et al. was one of the initially begun to perform percutaneous scoliosis surgery. This is a limited study consisting only one case (2). Anand et al. reported results of 12 cases operated a combination of 3 MISS techniques (XLIF, Axial interbody lumbar cage, percutaneous posterior pedicle screws) on DS. They succeeded multi-segment correction in their limited series with less blood loss and and morbidity (3).

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