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Original Article

Preventing proximal junctional failure in long segmental instrumented cases of adult degenerative scoliosis using a multilevel stabilization screw technique

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Abstract

Background: The authors sought to demonstrate the safety and effectiveness of the multilevel stabilization screw (MLSS) technique in decreasing the incidence of proximal junctional failure in long segmental instrumented fusions for adult degenerative scoliosis.

Methods: Institutional review board approval was obtained and all patients with adult spinal deformity who underwent the MLSS technique were analyzed. A neuro-radiologist and spine-focused neurosurgeon not involved with the surgical treatment performed radiographic analysis. Proximal junctional angle was defined as the caudal endplate of the upper instrumented vertebra (UIV) to the cephalad endplate of two supradjacent vertebrae above the UIV. The UIV is defined as the most cephalad vertebra completed captured by the instrumentation. Abnormal proximal junctional kyphosis (PJK) was defined as proximal junctional sagittal Cobb angle >10 degrees and proximal junction sagittal Cobb angle at least 10 degrees greater than the preoperative measurement. The presence of both is criteria necessary to be considered abnormal.

Results: Twenty patients with degenerative scoliosis underwent the MLSS technique with the upper-instrumented vertebrae in the proximal thoracic spine. Fifteen patients met inclusion criteria with greater than 12 months radiographic and clinical follow up. Three patients were excluded due to lack of follow up imaging and two patients were excluded due to the inability to measure the UIV. Age range was 44–84 years with a mean of 66. Eleven of the 15 patients were over the age of 60 at the time of surgery. The male-to-female ratio was 4:11. Body mass index (BMI) range was 24–44 with a mean of 31.5 units. The follow up period ranged from 14 to 58 months with an average follow up of 30 months. The mean change in Cobb angle at the proximal junction was 4.00 degrees with a range from -0.92 to 9.13 degrees. There were no fractures or instrumentation failures at or near the proximal junction. There was no revision surgeries performed for proximal junctional failure. Retrospective clinical questionnaires revealed that surgical expectations were met in 15 of 19 patients surveyed, 79%. One patient was not reachable for a

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postoperative phone interview. In patients who were not satisfied with their overall experience, the change in Cobb angle ranged from -0.92 to 9.13 degrees with an average change of 3.90 degrees. Whereas patients reporting an overall positive experience had a change in Cobb angle range from -0.12 to 8.07 degrees with an average change of 4.05 degrees.

Conclusion: PJK and failure are well-recognized suboptimal outcomes of long-segmental fusions of the thoracolumbar spine that can lead to significant neurological morbidity and costly revision surgeries. With no known proximal junction failures to date, the MLSS technique has shown promising results in preventing adverse proximal junctional conditions and can be safely performed under fluoroscopy guidance. Future direction includes a comparative study establishing the relative risk of developing PJK with this novel technique versus a traditional long-segmental thoracolumbar fusion.

Key Words: Degenerative scoliosis, long-segmented thoracolumbar instrumentation, proximal junction kyphosis, proximal junctional failure

INTRODUCTION

Adult degenerative scoliosis is a spinal deformity in a skeletally mature individual with a coronal curve that measures >10 degrees using the Cobb method.[11] Prevalence has been reported from 1% to 10% with new-onset deformity observed in more than 30% of elderly patients with no history of spinal abnormalities.[11] Patients typically present in the sixth and seventh decade with symptoms of spinal stenosis, worsening back pain, radiculopathy, or a combination of these symptoms.[1]

Proximal junctional kyphosis (PJK) and failure has led to the 26–39% requirement for revision surgery within six postoperative months. Multiple risk factors including age greater than 55 and elevated body mass index (BMI) as well as biomechanical hypotheses such as altered integrity of ligamentous and muscular structures have been implicated in the need for second operations.[4,5,6,7,8,9,12]

This report is to present a technical description and preliminary results of the multilevel stabilization screw (MLSS) technique designed to reduce the incidence of PJK for long-segmental thoracolumbar fusion surgery.

MATERIALS AND METHODS

Institutional review board approval was obtained and all patients with adult spinal deformity who underwent the MLSS technique at a single institution were analyzed.

Inclusion criteria and data collection

All MLSS procedures were performed at a single institution from 2009 to 2012. Only adults with degenerative scoliosis underwent segmental instrumentation utilizing the MLSS technique with a proximal upper instrumented vertebrae (UIV) in the upper thoracic spine to avoid PJK were included in the study. There were multiple exclusion criteria [Table 1]. Patient clinical characteristics are summarized in [Table 2]. Patients were later evaluated utilizing a phone-based questionnaire.

Radiographic analysis

Two independent analysts, a neuro-radiologist and spine-focused neurosurgeon, retrospectively evaluated 20 radiographic studies in a blinded fashion. Cobb angle measurements were performed on sagittal reconstructed CT scans and lateral radiographs.[2,3] Proximal junctional angle was defined as the caudal endplate of the UIV to the cephalad endplate of two supradjacent vertebrae above the UIV.[7] The UIV is defined as the most cephalad vertebra completely captured by the instrumentation [Figure 1]. PJK is defined in [Table 3].

Surgical technique

Unique to the MLSS is the preservation of the posterior elements at the cephalad end of the thoracic construct. Soft tissue dissection is carried out to allow for adequate exposure of the inferior lateral aspect of the most superior pedicles involved in the instrumentation. Biplane fluoroscopy guidance is used to ensure achievement of optimal placement. The most superior pedicle screw is started at the inferior lateral aspect of the pedicle. It is directed in a superior and oblique trajectory, which allows for limited dissection of supporting tissue structures. Advancement under fluoroscopy guidance ensures the neural foramina superior and inferior are not encroached upon and the medial cortex of the pedicle is well visualized during instrumentation [Figure 2].

In the AP trajectory, instrumentation should not cross the midline to avoid a medial wall breach of the pedicle and also to prevent screw overlap. The starting point and trajectory capture the pedicle of the vertebra at the same level as well as the vertebral bodies one to two levels superior to the screws' starting point. A total of four to six cortical surfaces are incorporated into the construct

throughout the length of the screw adding to the strength against pullout [Figure 3].

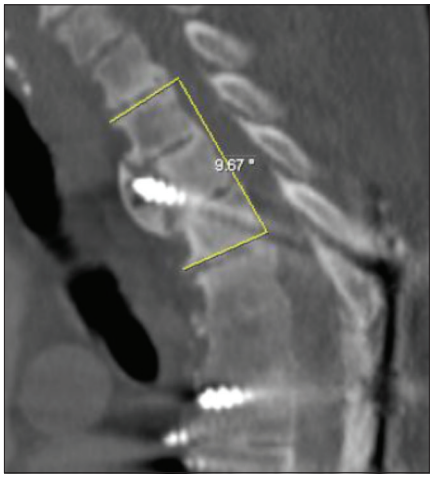

Figure 1: Cobb angle measurements after the MLSS technique

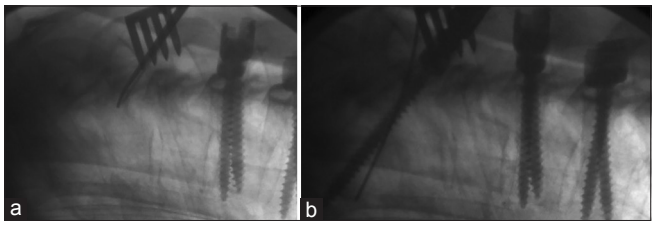

Figure 2: (a) Lateral fluoroscopy with pedicle probe indicating the ideal trajectory through the inferior aspect of the pedicle. (b) Lateral fluoroscopy of final superior-inferior trajectory and position of the guide wire and pedicle screw

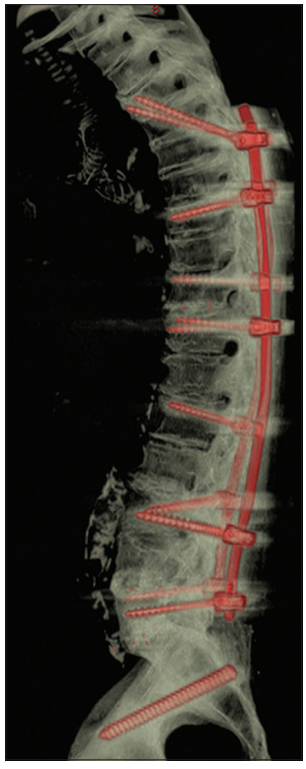

Figure 3: Three-dimentional reconstruction demonstrating MLSS screw construct

RESULTS

The MLSS screw was placed most often through the T4 vertebral body, T3-T5 at the cephalad end of the construct [Table 4]. The lowest instrumented vertebra (LIV) was S1/pelvis in most cases. There was one patient whose construct ended caudally at L5. The average number of instrumented levels was 16, ranging from 14 to 17 levels. The mean change in Cobb angle at the proximal junction was 3.90 degrees with a range of -0.92 to 9.13 degrees

There were no fractures or instrumentation failures at or near the proximal junction when using the MLSS technique. There was no revision surgeries performed for proximal junctional failure.

DISCUSSION

Unique to the MLSS is the preservation of the posterior elements at the cephalad end of the thoracic construct. It is well documented that extension soft tissue dissection and disruption of the posterior tension band is a significant risk factor

Table 1: Exclusion criteria

Primary diagnosis other than adult degenerative scoliosis
Adult idiopathic scoliosis
Adolescent idiopathic scoliosis
Instrumented constructs ending at or near the thoracolumbar junction
Non-segmented hybrid constructs
Hooks or herrington rods
Patients must have a minimum of twelve months follow up for data analysis

Table 2: Patient clinical data

Average age	BMI	Gender	Follow up
44-84	24-44	Male: 4	14-45 mos
Mean: 66.27	Mean: 31.5	Female: 11	Mean: 30.7

BMI: Body mass index

Table 3: Proximal junctional kyphosis criteria

Generally agreed upon diagnostic measures[1,7,8]
Sagittal Cobb angle >10 degrees
Proximal junctional Cobb angle at least 10 degrees greater than preoperative measurement
The presence of both criteria is necessary to demonstrate radiographic PJK

Note: Recent studies suggest 20 degrees may be a critical angle for determining symptomatic PJK. PJK: Proximal junctional kyphosis

Table 4: Anatomical distribution for MLSS levels

MLSS levels	T2-T4	T3-T5	T4-T6	T5-T7
% of patients	13% (2/15)	40% (6/15)	33% (5/15)	13% (2/15)

MLSS: Multilevel stabilization screw

for developing PJK[3,4,7,10] Initiating the most superior pedicle screw placement at the inferior lateral aspect of the pedicle and directing it in a superior-oblique trajectory minimizes dissection of supporting tissue structures. In addition, the kyphotic curve of the upper thoracic spine allows for ease of placement of the instrumentation along a superior-oblique trajectory and the absence of major vessels and visceral organs allows for bi-cortical placement with relative safety.

However, this study is not without limitations. Ideally, prospectively gathered outcome measures specific to degenerative scoliosis, such as Scoliosis Research Society or Oswestry disability index, would provide a more relevant view of patient satisfaction. The overall initial sample size is small and the lack of long-term follow up with many patients further diminishes the subject population included in the analysis. Preferably, a larger sample size with multiple surgeons at multiple institutions would increase the credibility of the technique's effectiveness. PJK and failure are well-recognized suboptimal outcomes of long-segmental fusions of the thoracolumbar spine that can lead to significant neurological morbidity and costly revision surgeries.[6,7] With no known proximal junction failures to date, the MLSS technique has shown promising results in preventing adverse proximal junctional conditions and can be safely performed under fluoroscopy guidance. Future direction includes a comparative study establishing the relative risk of developing PJK with this novel technique versus a traditional long-segmental thoracolumbar fusion.

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