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Case Report

Treatment of Spondylolisthesis Using a Motion Preserving Lumbar Total Joint Replacement: A Case Report

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Abstract

Spinal fusion is the primary treatment option for symptomatic spondylolisthisis. Although effective in alleviating pain and restabilizing the spine, lumbar fusion is associated with long-term sequelae due to the elimination of a motion segment. Alternatives to lumbar fusion for the treatment of grade 1 spondylolsithesis have remained limited due to the complex anatomy, need for stabilization and neural elements. To our knowledge, there are no motion-preservation options that would allow the surgeon to perform a complete laminectomy, facetectomy and segment reconstruction in the setting of isthmic spondylolisthesis. Here we present the case of a 19-year-old female that received motion-preserving lumbar Total Joint Replacement (TJR) for a grade 1 isthmic spondylisthesis at L5-S1. Patient data, including radiographs, were prospectively collected. Two years after lumbar TJR, the patient's ODI and NRS back and leg pain scores were all 0. Our patient was symptom free at two years follow up which demonstrates that lumbar joint replacement may be a motion-preserving option for similar patients.

Introduction

Spondylolisthesis is a common cause of back and leg pain leading to the need for lumbar fusion [1]. While the two main subtypes of spondylolisthesis (isthmic and degenerative) differ in their etiology, both are commonly treated with a fusion procedure once a patient has failed to improve with nonoperative management [2-4]. For isthmic spondylolisthesis, fusion of the unstable segment is widely regarded as the treatment of choice. To our knowledge, there are no motion-preservation options that would allow the surgeon to perform a complete laminectomy, facetectomy and segment reconstruction in the setting of isthmic spondylolisthesis. Here we describe the first case report of a motion-sparing posterior lumbar total-joint replacement as a treatment alternative for grade 1 isthmic spondylolisthesis.

Case Report

Patient presentation

A 19-year-old female acrobat dancer presented with five years of atraumatic low back pain and bilateral radiculopathy in the L5 distribution. Symptoms were exacerbated with standing, walking and climbing stairs and were alleviated in the supine position. Lumbar spine mobility was restricted, most notably in flexion. The patient ambulated with a normal gate, but was unable to heel or toe walk bilaterally. The patient's tibialis anterior motor strength was 4/5 bilaterally. Extensor hallucis longus was 3/5 bilaterally. All other motor strengths were normal.

There was decreased sensation to light touch and pinwheel testing in the L5 distribution left and right. Patellar reflexes were normal and Achilles reflex was absent bilaterally. Straight leg raising signs supine and sitting was positive on the left and right sides.

Preoperative radiographs

Preoperative standing radiographs demonstrated a grade 1 isthmic spondylolisthesis at L5-S1 without coronal plane deformity (Figure 1 A&B). Flexion/extension stress radiographs did not show dynamic instability at L5-S1. Preoperative CT scan confirmed L5 pars interarticularis defect with 7mm spondylolisthesis of L5 on S1 (Figure 2 A&B). MRI revealed a foraminal disc herniation with impingement of the exiting L5 and S1 nerve roots (Figure 3 A&B). Patient Reported Outcomes (PRO's) included an Oswestry Disability Index (ODI) score of 56 with Numeric Rating Scale (NRS) back and leg pain scores of 60 and 40, respectively.

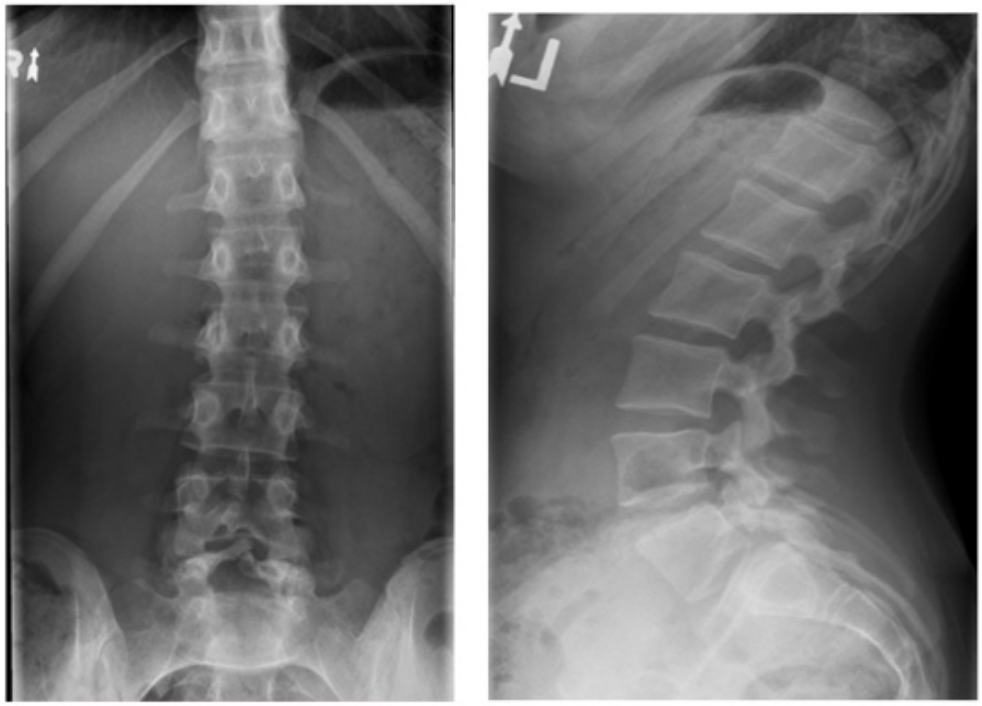
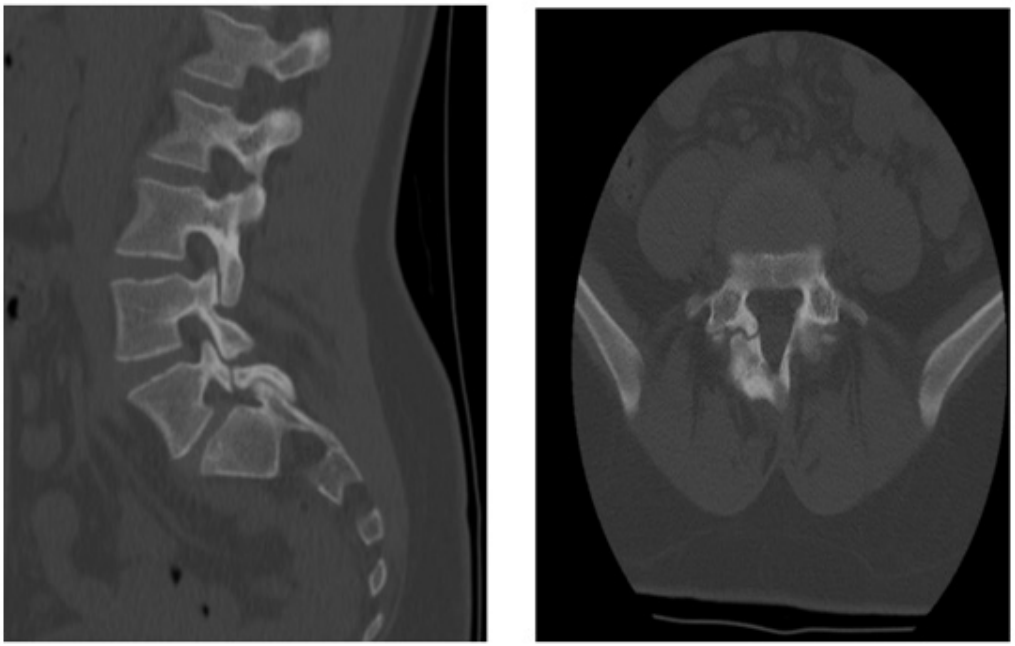


Figure 1:



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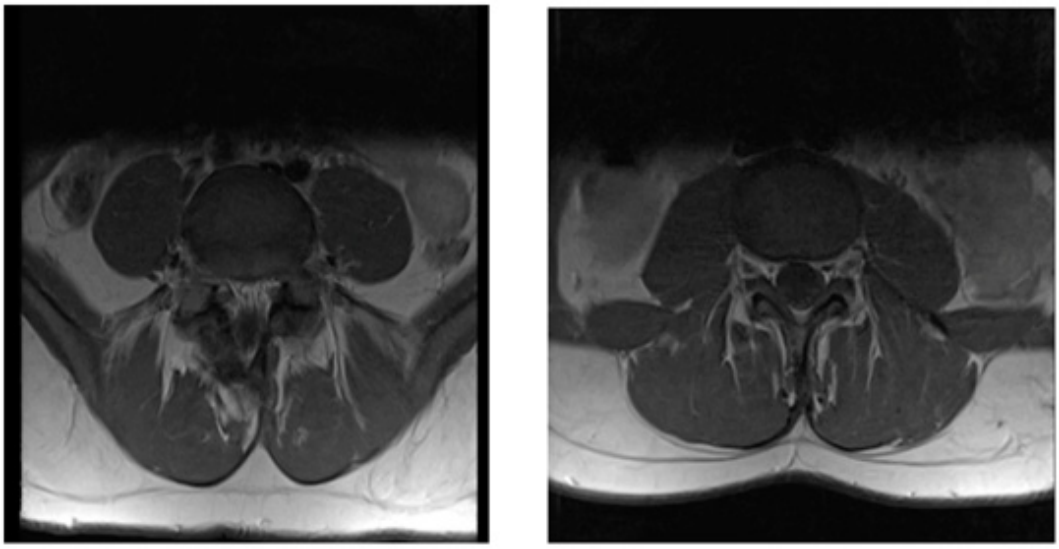

Figure 3:

Procedure decision

Patients with L5-S1 isthmic spondylolisthesis are not usually candidates for approved motion preservation techniques, such as anterior disc replacement. However, lumbar TJR is indicated for grade 1 spondylolisthesis due to its posterior approach and reconstruction and stabilization of the motion segment. Given the patient's clinical and radiographic presentation and satisfaction of all of the inclusion criteria of the indicated lumbar TJR, the lumbar TJR was chosen as the appropriate procedure for her condition. The biomechanical attributes of the lumbar TJR are among the reasons why the TJR was utilized for this patient. First, the surgical technique and bilateral joints of the prostheses enable the adjacent segment to re-balance the segmental lordosis, compared to the adjacent segment hyper lordosis often observed in fusion cases. Additionally, many of isthmic spondylolisthesis's cases present with a high Pelvic Incidence (PI) with associated high Sacral Slope (SS). The supra-pedicular three-column osteotomy, associated with the lumbar TJR procedure, allows a 1:1 reduction in PI and SS. The reduction in SS allows the mechanical shear forces acting across the joint to be reduced and the compression forces to be increased. This change in force distribution allows for greater stability of the reconstructed joint. Further benefits of motion at the lumbosacral junction are reduced stress in the pelvis including the Sacroiliac Joints (SI) and the hip joints. Patients with a grade II spondylolisthesis are not a candidate for the lumbar TJR procedure due to multiple factors. Firstly, the center of rotation of the implant utilized in this patient does not allow for the major offset of the two vertebral bodies that are greater than 25%. In order to have a matching fulcrum, the two vertebral bodies must have an offset of 25% or less. Secondly, there needs to be adequate bone-implant contact surface area to ensure a stable bony ingrowth to provide long term stability.

Surgical technique

The surgical technique and implant details are described in a 2021 publication [5]. The lumbar TJR is indicated for the reconstruction and stabilization of the lumbar motion segment to treat symptomatic lumbar degeneration with or without spinal stenosis and up to a grade 1 spondylolisthesis, after failing conservative care. The procedure utilized a bilateral Transforaminal Lumbar Interbody Fusion (TLIF) approach subsequent to laminectomy, bilateral facetectomy and comprehensive discectomy at L5-S1 while preserving the anterior longitudinal ligament, lateral annulus and the cortical endplate. Far lateral tethering ligaments to the exiting L5 nerve roots were released and the L5 nerve root gently mobilized. Fluoroscopy was used to assist with length and height trialing. Powered osteotomies were used to create parallel endplates between inferior L5 and superior S1 vertebral bodies, followed by parallel and co-planar keel slots in the L5 inferior endplate along the axis of the pedicle. The right sided implant was inserted in neutral alignment. The S1 osteotomy, keel cuts and implantation were repeated for the left side. Final radiographs demonstrated appropriate implant positioning and alignment. The wound was closed in a layered fashion. Minimal adaptive changes are needed in the TJR surgical technique for isthmic L5-S1 spondylolisthesis cases. The supra-pedicular osteotomy used to decrease the sacral slope will be larger L5-S1, compared to other lumbar levels. Also, because the vertebral body of L5 and the superior portion of S1 is larger than the remaining levels, it is advantageous to have a higher convergence angle of the keel cuts and implants in the axial plane to provide greater resistance to anterior translation at the bone-implant interface.

Postoperative course

Standardized Enhanced Recovery after Surgery protocol allowed mobilization within 4 hours of surgery completion. The patient was walking independently with standby assist and cleared for discharged home 8 hours post operatively. Multimodal pain regimen consisting of an NSAID, a muscle relaxer and a short course of oral narcotic as instructed for 2 weeks. Daily rehabilitation program included independent walking, stair climbing and truncal isometric muscle strengthening. Unrestricted standing, sitting and

walking were allowed immediately following surgery. At 3-months, her radicular symptoms had largely resolved (ODI: 28, NRS-back: 9, NRS-leg: 9) and continued to improve at both 6-months (ODI: 10, NRS-back: 9, NRS-leg:9) and 24-months (ODI: 0, NRS-back: 0, NRS-leg:0). She returned to all desired physical activity. All prior recorded weakness has resolved with normal motor strength in all muscle groups of both lower extremities (5/5). There are no sensory deficits in the lower extremities.

Postoperative radiographs

24-month postoperative standing and sitting dynamic views reveal no evidence of instability with dynamic motion of 12 degrees at the index level as well as normal motion in the remaining lumbar spine and in the pelvis (Figure 4 A&B). CT scan of the lumbar spine shows stability of implants with no osteolysis or heterotopic ossification (Figure 5).

Figure 4:

Figure 5:

Discussion

Here we present the first case report of a patient treated with a lumbar total joint replacement for grade 1 isthmic spondylolisthesis at L5-S1. The patient had progressive improvement in pain and at two years postoperatively, was engaged in numerous athletic activities with no reported back or leg pain and an ODI score of 0. The treatment of high-grade isthmic spondylolisthesis in symptomatic patients will likely continue to require arthrodesis; however, these results suggest that grade-1 isthmic slips may be amenable to a motion-preserving alternative. The clinical outcomes for fusion for L5-S1 spondylolisthesis appear similar regardless of surgical approach or technique used [6]. While a fusion allows for stabilization of the motion segment, altered lumbopelvic kinematics may lead to Adjacent Segment Disease (ASD) [7-9]. Re-operation rates two and five years after lumbar fusion average approximately 10% and 20%, respectively, with most of the need for revision surgery being attributed to proximal ASD [10-12]. However, alternatives to fusion remain limited due to the complex anatomy, neural anatomy and need for re-stabilization. This case illustrates the potential benefits including complete decompression of the neural elements and re-stabilization of the mobile segment using a motion preserving implant. Large scale and longer-term Food and Drug Administration studies are underway to determine the efficacy and durability of this lumbar total joint replacement procedure [13-25].

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