Review Article

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Review Article On Recent Trends in Surgical Techniques for High-grade Spondylolisthesis

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Abstract

Introduction: High-grade spondylolisthesis defined as cases with more than 50% displacement and spondylolisthesis with Meyerding grade III and higher. The surgical management of high-grade spondylolisthesis is highly controversial. Many surgical methods have been reported like posterior in situ fusion, instrumented posterior fusion with or without reduction, combined anterior and posterior procedures, spondylectomy with reduction of L4 to the sacrum (for spondyloptosis), posterior interbody fusion with trans-sacral fixation. Minimally invasive transforaminal lumbar interbody fusion for high-grade spondylolisthesis has also been recently mentioned in literature. This study aimed to review the recent literature which has described the surgical outcomes associated with various surgical techniques used for high-grade spondylolisthesis.

Materials and Methods: Recent articles were searched on search engines such as PubMed, Google Scholar with the use of Key words like 'High-grade Spondylolisthesis', 'Surgical Techniques' 'complications'.

Discussion: The surgical management of high-grade spondylolisthesis is an area of significant controversies. The literature is replete with regards to need for reduction, need for decompression, levels of fusion, the nature of instrumentation, surgical approaches including open, minimally invasive, and "mini-open" procedures, as well as various techniques for reduction of the slip and fusion strategy. The three basic options of high-grade spondylolisthesis includes: in-situ fusion, partial reduction and fusion, and complete reduction.

Conclusion: Various techniques have been described for high-grade spondylolisthesis. Spine Deformity Study Group (SDSG) classification gives guidelines about balanced and unbalanced pelvis and advising reduction and fusion in case of unbalanced pelvis for correction of biomechanical and global sagittal alignment. Each of the surgical techniques has their own advantages and disadvantages. Although individual authors' experience, skill levels, anatomic reduction with fusion techniques has yielded highly encouraging results.

Keywords: High-grade spondylolisthesis, Surgical techniques, In situ fusion, Reduction and fusion, Complications

Introduction

High-grade spondylolisthesis defined as cases with more than 50% displacement and spondylolisthesis with Meyerding grade III and higher [1]. Patients can present with back pain, leg pain, hamstring tightness, neurological deficits, and significant spinopelvic malalignment. After the failure of appropriate non-operative measures for controlling the symptoms, postural deformity, slip progression, the operative methods are indicated. Surgery is aimed to achieve pain relief, adequate neural decompression, correction of a kyphotic slip angle, and obtaining solid fusion. The surgical management of high-grade spondylolisthesis is highly controversial. Many surgical methods have been reported like posterior in situ fusion, instrumented posterior fusion with or without reduction, combined anterior and posterior procedures, spondylectomy with reduction of L4 to the sacrum (for spondyloptosis), posterior interbody fusion with trans-sacral fixation. Minimally invasive transforaminal lumbar interbody fusion for high-grade spondylolisthesis has also been recently mentioned in literature [2, 3]. Numerous prospective and retrospective studies have been carried out over the past decades to evaluate surgical outcomes of various techniques for high-grade spondylolisthesis. This study aimed to review the recent literature which has described the surgical outcomes associated with various surgical techniques used for high-grade spondylolisthesis

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Materials and Methods

Recent articles were searched on search engines such as PubMed, Google Scholar with the use of Key words like 'High grade Spondylolisthesis', 'Surgical Techniques' 'complications'. Additional articles were identified by checking the references. Studies were initially screened based on titles and references and study of relevant topics were selected and a review was done of the same.

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Discussion

The surgical management of high grade spondylolisthesis is an area of significant controversies. The literature is replete with regards to need for reduction, need for decompression, levels of fusion, the nature of instrumentation, surgical approaches including open, minimally invasive, and "mini-open" procedures, as well as various techniques for reduction of the slip and fusion strategy. The three basic options of high grade spondylolisthesis includes: in-situ fusion, partial reduction and fusion, and complete reduction. The main aim of surgical treatment is to restore the posterior tension band as well as anterior structural support, eventually preventing the conversion of axial load to shear forces at the lumbosacral junction [2, 3].

In-situ fusion Techniques

First in situ fusion for spondylolisthesis through an anterior approach using a tibial autograft strut to stabilize L5-S1 spondylolisthesis was attempted by Speed in 1938 [4].

Poussa et al studied 22 patients of high-grade listhesis operated by in situ fusion over 14.8 years from 1983 to 1991 and reported improved Oswestry Disability Index (ODI) scores and Scoliosis Research Society Scoring questionnaires scores. They also lesser chance of adjacent segment disc degeneration, decreased mean slip in the reduction group and less muscle atrophy on magnetic resonance imaging. Although patient population size was relatively small and reductions were not anatomic were drawbacks of the study [5].

In 2007, Lamberg et al studied high-grade spondylolisthesis in children and adolescents 21 patients treated using posterolateral, 23 using anterior, and 26 using the circumferential fusion technique without instrumentation over 17.2 years from 1977–1991 and concluded that circumferential fusion provided significantly better long-term clinical, radiographic, and SRS total score than posterolateral or anterior fusion groups [6]. The advantages of in-situ fusion include shorter operative times,lesser blood loss, lesser chance of adjacent segment disease and lower risk of neurological deficit. Although 6% chance of cauda equine syndrome have been reported with in situ fusion techniques without reduction [7]. The possible explaination suggested was the muscle relaxation caused by general anesthesia may have compromised the neural canal leading to a cauda equina syndrome. Also higher chances of pseudoarthrosis, progression of deformity and persistence of symptoms have been reported with in situ fusion techniques.

Transacral Fixation Techniques

In 1982, Bohlman et al attempted three column spinal fixation in two cases for spondyloptosis using a posterior approach. They introduced a fibular autograft across S1 into the L5 vertebral body along with a decompression and uninstrumented L4-S1 posterolateral fusion which achieved good success [8].

In 2001, Smith et al reported in situ transsacral delta fixation technique with good outcomes. In this technique pedicle screw are placed in the L4 and L5 bilaterally. The S1 screw entry is taken in a standard fashion; however, the screw trajectory is planned to extend beyond the anterior sacral cortex and into the L5 vertebral body [9].

Maestre et a in 2016 studied 56 patients operated with transdiscal screw fixation They reported good ODI, COMI, SF-12, physical and mental scores were in the transdiscal group without any pseudoarthrosis. The length of such delta screw is usually between 60-70 mm [10].

Jamshidi et al in 2019 studied 14 patients six treated by modified Bohlman technique and eight patients by Reverse Bohlman technique and reported solid fusion in all cases with improvements in anterolisthesis, the slip angles improved and lumbar lordosis [11].

The concept of three-column fixation achieved is achieved by transvertebral trans sacral screw fixation by either posterior or anterior approach, which reduces chances of pseudoarthrosis and reducing the shear forces across the disc space for better fusion. With advances in techniques and instrumentation, supplementary methods of achieving three-column fixation include transvertebral interbody cage fixation and use of intrasacral rods and custom made screws which reduces complications including fibular graft fracture, graft resorption, slip progression, and pseudoarthrosis, donor site morbidity and graft-related complications associated with the use of fibular graft [2, 3].

Reduction and Fusion

The Spine Deformity Study Group (SDSG) came up with a classification offering treatment guidelines to perform reduction in high grade spondylolisthesis. The pelvis in high grade spondylolisthesis can be considered to be balanced when the sacral slope is high and pelvic tilt is low. In a balanced pelvis, the global spine alignment is normal and fusion without reduction is acceptable. However, in case of an unbalanced pelvis with low sacral slope and high pelvic tilt, a reduction with fusion is indicated. In unbalance pelvis due to the significant retroversion of the pelvis, the global sagittal alignment is abnormal which necessitates need to reduce the lumbosacral kyphosis, pelvic tilt and a partial reduction in the translation which can restore the spinal sagittal balance [12, 13].

Harrington et al in 1969 demonstrated technique of reduction for in two cases of grade III and IV listhesis using principle of distraction mediated though spinal instruments and lag screws with latreral gutter arthrodesis. One case had developed cauda equine syndrome which recovered in postoperative period [14].

Karampalis et demonstrated nine patients from 1988-2006 with gradual reduction using Magerl's external fixator followed by circumferential fusion technique and good long-term radiological and patient outcome results [15]. The surgery was performed in 3 stages. In first stage L5-S1 posterior wide decompression with both L5 nerve roots identification with L5-S1 discectomy done. Stab incisions taken and 6 mm Schanz pins are inserted in the pedicles of L4 and iliac crests followed by Magerl's external fixator is assembled on them.In second stage gradual and progressive distraction of L5-S1 done over Magerl's external fixator and once distraction is achieved gradual reduction of L5 over S1 done with retraction. On daily basis pin site care, radiographic and neurological status monitoring with patient's comfort evaluation is done. The second stage on an average takes 2 weeks. Restriction to supine posture was the drawback of this procedure although the frame caused no activity restrictions and patients were ambulated free. In third stage once slip reduction is achieved, via anterior retroperitoneal approach L5/S1 fusion was performed. Excision of the hypertrophied anterior longitudinal ligament and anterior annulus were done with thorough discectomy followed by autograft or allograft insertion in the disc

space and kept in place using 6.5 mm cortical screws and washers. They concluded the procedure is effective and safe and it corrects the lumbosacral kyphosis and cosmetic deformity without the neurological complications.

Gaines et al in 2005 reported 30 cases of high grade spondylolisthesis operated over 30 years with complex two stage procedure. In the first stage using an anterior approach the L5 vertebral body, L4-5 disc and L5-S1 disc is resected. Followed by a second stage posterior procedure in which L5 pedicles and the posterior elements are excised to eventually allow the reduction of L4 over the S1. They achieved good outcomes in both cases [16].

Harms et al in 1997 in their case series of 112 patients, reported good functional and radiological outcomes with decompression, distraction, reduction, and posterior lumbar interbody fusion. They achieved distraction by using hooks in the upper lumbar spine and reduction was accomplished using long-headed pedicle screws. They suggested whenever L4/L5 segment is not primarily involved, it should be preferably preserved [17].

Shufflebarger et al. in 2006 in their case series of 18 patients operated by Gill laminectomy, temporary distraction via sacral alar hooks and proximal lumbar hooks, lumbosacral discectomy, anterior decortications and grafting,and placement of bilateral titanium mesh cages packed with morselized autograft, kyphosis correction by posterior compression against anterior support reported significant improvement in slip angles,with Slip angle improved from 35 to 3.8 degrees initially and 4.3 degrees at final follow-up with slip improvement from 77% to 13%. Fusion was achieved in all cases without any neurologic or infectious complications. They concluded that ideal biomechanical environment for fusion will be created by reducing slip and lumbosacral kyphosis. Also, structural anterior column support and posterior transpedicular instrumentation provide more resistance to shear forces than posterior instrumentation alone [18].

Hresko et al in 2009 studied 26 patients with high-grade spondylolisthesis operated with posterolateral instrumented fusion using either Jackson intrasacral rods or Luque box instrumentation to achieve stable L4/sacrum fixation reported successful fusion and good outcomes. They also reported about the "unbalanced" high grade listhesis with high pelvic tilt and low sacral slope and the "balanced" with low pelvic tilt and high sacral slope. They advised reduction and fusion should be preferred in unbalanced high grade listhesis [19].

Goyal et (2009) studied 13 patients from 1999 to 2003, with mid and high grade isthmic spondylolisthesis (Meyerding grades II, III, or IV) operated with posterior lumbar decompression, TLIF at listhetic disc space , instrumented PSF, and reduction of the listhetic vertebrae with good outcomes [20].

Minimally Invasive Techniques

Quraishi et al in 2013 reported the minimal access surgery approach for mobile high-grade spondylolisthesis (grade III) with good outcomes [21].

Rajakumar et al in 2017 studied grade II (29 patients) and higher (grade III- 7 patients) lumbar spondylolisthesis operated by the minimally invasive "rocking" technique reported good radiological and patient outomes [22].

Peshattiwar et al in 2020 reported the minimally invasive transforaminal lumbar interbody fusion surgery in high grade spondylolisthesis (grade III) patient with rheumatoid arthritis. Their surgical technique includes interbody disc space preparation, distraction of disc space and achieving reduction by ligamentotaxis of soft tissues, inserting lardotic cage followed by percutaneous screw fixation with contoured lordotic rods fixation over reduction phalanges. They concluded that, it is a feasible, safe, and clinically effective technique, with less blood loss, perioperative pain and hospital stay with good recovery rate, solid fusion and patient satisfaction [23].

Conclusion

Various techniques have been described for high grade spondylolisthesis with significant controversies regarding in situ fusion versus reduction, the techniques for achieving fixation. Spine Deformity Study Group (SDSG) classification gives guidelines about balanced and unbalanced pelvis and advising reduction and fusion in case of unbalanced pelvis for correction of biomechanical and global sagittal alignment. Each of the surgical techniques has their own advantages and disadvantages. Although individual authors' experience, skill levels, anatomic reduction with fusion techniques has yielded highly encouraging results.

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