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Case report

Indirect decompression and reduction of lumbar spondylolisthesis does not result in higher rates of immediate and long term complications

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ABSTRACT

Nerve root decompression and spondylolisthesis reduction is typically reserved for open surgery. MIS techniques have been thought to be associated with higher rates of neurological complications. This study aims to report acute and chronic neurologic complications encountered with MIS surgery for spondylolisthesis, specifically, the incidence of nerve root injury and clinical and radiographic outcomes. A retrospective review of 269 patients who underwent MIS LIF or ALIF treatment for lumbar degenerative or isthmic grade 1 or 2 spondylolisthesis was conducted. Immediate and long-term complication rates were the primary outcome. Only patients who had symptomatic anterolisthesis and 2-year outcome data were included in the study. 52 patients met inclusion criteria with 54 lumbar spondylolisthesis levels treated. Five patients (9.6%) experienced postoperative anterior thigh numbness, which completely resolved within 3 months. There were no permanent neurologic deficits; however, 2 patients (3.8%) suffered a transient foot weakness that resolved with physical therapy by 3 months follow-up. There was one incidence of wound breakdown that required revision and one incidence of L5/S1 endplate/sacral promontory fracture and relisthesis 3 months postoperatively. Overall fusion rate was 98% at 6 months. Indirect decompression and closed anatomical reduction for treatment of low-grade spondylolisthesis using ALIF and LIF with posterior percutaneous fixation was not associated with an increased risk of neurologic deficit. This study suggests that this technique is safe, reproducible, durable, and provides adequate fusion rates.

1. Introduction

The Meyerding classification of spondylolisthesis is described as translation of a spinal vertebral body relative to an adjacent vertebral body and is separated into 5 different grades [1]. Meyerding grades 1 and 2 are the most common types spondylolisthesis encountered in clinical practice and are typically considered "low grade". The initial treatment for symptomatic patients is usually conservative. However, if the slip worsens or the pain becomes disabling causing neurologic deficit, then surgical intervention is warranted [2–6].

Treatment options vary widely from a limited decompression, to anterior/posterior decompression with or without listhesis reduction and fusion, to a multilevel deformity correction [2–4,7–13]. It is generally accepted that fusion has a better clinical outcome than decompression alone for symptomatic patients [6,14–16]. In our study, we used indirect decompression and closed reduction with ALIF (anterior lumbar interbody fusion) and the minimally invasive retroperitoneal transpsoas lateral interbody fusion (LIF) complemented with posterior percutaneous screw (PPS) placement.

The incidence of neurologic injury associated with spondylolisthesis treatment whether in situ or with open reduction has been well documented [17,18]. However, neurological injury sustained specifically after indirect decompression by either ALIF or LIF is still undetermined as MIS is generally not the surgical approach used. It is believed that due to the nature of this operation in patients with listhesis the neurologic complications would be higher than with open procedures that include posterior decompression of the nerve roots.

We hypothesize the incidence of neurologic injury with indirect decompression and reduction of degenerative spondylolisthesis is low. We report the neurologic complications encountered with this method, specifically addressing the incidence of sensory and motor nerve root injury. We also address the short-term and long-term clinical and radiographic outcomes secondary to this procedure.

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2. Methods

A retrospective review of a prospectively collected single center database of all patients who underwent treatment for a primary diagnosis of lumbar degenerative spondylolisthesis (Meyerding grade I and II) between 2008 and 2014 was performed. IRB and patient consent was obtained prior to data collection. The methods of treatment were limited to the less invasive LIF and/or the ALIF, both complemented with posterior percutaneous instrumentation (PPS) in all but 3 cases. Both ALIF and LLIF are combined in the results as both share the same mechanism of closed reduction. Preoperative symptoms included axial back pain, radiculopathy, and/or neurogenic claudication that failed to improve with conservative measures. Study inclusion criteria were focal L2-3, L3-4, L4-5, and/or L5/S1 anterolisthesis; no history of previous lumbar surgery; absence of degenerative disc disease at other levels; and data from at least 2 outcome measures (VAS and ODI).

Surgical indications for indirect decompression were: grade 1 or grade 2 spondylolisthesis with or without dynamic instability as assessed on flexion/extension X-rays, back pain with or without radiculopathy, at least 6 months of failed conservative management including pain management, epidural injections, facet blocks, and physical therapy. Instrumentation was only performed when there was evidence of dynamic instability on flexion/extension. Radiographic indications assessed other than dynamic instability were included foraminal stenosis, facet T2 signal changes on MRI, and vacuum disc phenomenon.

Primary outcomes measured included immediate neurological complication rates, incidence of reoperation, fusion rate, and patient self-reported quality of life questionnaire scores (VAS and ODI). Fusion was assessed at each follow up with static/dynamic radiographs or helical CT scans when available. X-ray radiographic patters were categorized into four grades: A) definitely solid, B) possibly solid, C) probably not solid, and D) definitely not solid [19]. Evidence of motion of dynamic radiographs was assessed as definite non-fusion, even if bone growth across the endplates was noted on static imaging. Fusion was assessed by the senior author and confirmed by an independent neuroradiologist. Fusion material used included commercially available allograft mixed with osteoprogenitor cells and stem cells. Motor and sensory complications were assessed as previously described in literature [14]. However, HRQOL scores were secondary end point of the study. Clinical follow-up was scheduled for 1, 3, 6, 12, and 24 months postoperatively. Fusion and hardware integrity were confirmed with plain radiographs or CT scans at the last follow up.

2.1. Statistical analysis

The most recent follow-up clinical outcome measure was compared to the preoperative score for averaging using SPSS software. The Shapiro-Wilk test confirmed normal data distribution. The paired *t*-test was used to confirm means. The p-values were determined for both VAS and ODI with statistical significance defined as $p < 0.05$. Statistical significance was measured used for long-term outcome improvement.

3. Results

A total of 269 patients with spondylolisthesis were treated with MIS-LIF or ALIF between 2008 and 2014 with 52 meeting our inclusion criteria. The average age of the patient cohort was 60 years (range 32–79 years). Thirty four were male and 18 were female. Fifty four lumbar spondylolisthesis levels were treated, of which 40 were Meyerding grade I and 14 were Meyerding grade II. Overall fusion rate was 98% at 6 months. There were no incidences of pseudarthrosis or hardware failure. The most common listhesis type was degenerative followed by isthmic; however, not all could be categorized due to lack of preoperative CT imaging. The average length of follow-up was 16.5 months (Table 1).

There were no anesthesia related complications. Five patients (9.6%) experienced immediate postoperative anterior thigh numbness, which completely resolved within 3 months. Other sensory deficits had no predilection to any specific vertebral sensory zone, and were likely positional. There were no permanent neurologic deficits; no foot drop associated with correction of spondylolisthesis, however, 2 patients (3.8%) suffered a transient 4/5 foot weakness that resolved with physical therapy by 3 months follow-up. All motor complications occurred immediately postoperatively, all were at the L5/S1 level, and all were transient in nature (Table 1). There were no incidences of hardware failure or pedicle screw malposition. Only one endplate fracture/sacral promontory fracture with a standalone L5/S1 ALIF was found in a patient with osteoporosis (Fig. 1). There was one incidence of wound breakdown in L5/S1 ALIF that required revision and one incidence of an L5/S1 endplate/sacral promontory fracture and relisthesis 3 months postoperatively (Fig. 1, Table 2). This did not require reoperation and symptoms resolved at 8 months post-operation. Overall, there were no reoperations related to instrumentation failure or relisthesis. Only one patient required a reoperation for wound revision secondary to wound dehiscence.

The average VAS improved from 6.4 pre-operatively to 4.2 on the most recent follow-up ($p < 0.0005$). The average ODI improved from 50.6 pre-operatively to 34 on the most recent follow-up ($p < 0.0005$) (Fig. 2, Table 1). All but one patient had complete reduction of the spondylolisthesis. All patients clinically improved from baseline exam, including one patient with relisthesis and none required a reoperation for open laminectomy and direct decompression.

4. Discussion

There is limited data specifically reviewing the immediate and long-term complications associated with indirect decompression and closed reduction of spondylolisthesis. Data for the retroperitoneal transposoas approach is becoming more prevalent, however, no studies are dedicated to the treatment and complications of spondylolisthesis alone with the exception of Ahmadian et al. [2,20–31], where only complications at single level L4/5 were investigated. Complications associated with the anterior lumbar interbody fusion (for spondylolisthesis) are slightly more established [32,33]. In the present study, we review the immediate neurologic complications and long-term clinical outcomes of patients treated with indirect decompression and closed reduction of lumbar spondylolisthesis using anterior column interbody fusion techniques (ALIF and LIF).

A major concern of closed reduction is injury to the exiting nerve, most commonly L5. Several hypotheses have attempted to describe this event [7,34–37]. Some describe entrapment of the nerve root during translational correction of the spondylolisthesis thereby contributing to a crush injury against the facet or other bony structure. Alternatively, an overdistraction neuropraxia can occur by stretching the nerve root from its origin during reduction or by axial traction from anterior column restoration created by increasing lordotic cages.

There were only 2 (3.8%) reported events of motor neurologic deficit in our series; transient minimal foot weakness (specifically EHL weakness). One occurred 3 months post-operatively and the other immediately after surgery; both underwent an L5/S1 ALIF for a grade I spondylolisthesis and both completely resolved within 3 months of presentation. Transient sensory thigh numbness was

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