Discussion of the Current Treatment Methods for Degenerative Lumbar Spondylolisthesis

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Abstract: *Degenerative spondylolisthesis (DS) is caused by degeneration that causes the lumbar vertebral body of the diseased segment to be displaced relative to the lower vertebral body, which is usually forward, and is not accompanied by pedicle fracture or defect, also known as "pseudospondylolisthesis". DS is more common in the L4/L5 segment, followed by the L3/L4 and L5/S1 segments, and is mostly mild slippage of the first and second degrees [2-4]. At present, the pathogenesis of DS is not fully understood, and it may be related to age-related degeneration of supporting structures, such as intervertebral discs, facet joints, bones, ligaments, facet capsule, and paravertebral muscles. In addition, the decrease in estrogen in women is also associated with the development of DS [1]. Clinically, DS is characterized by recurrent symptoms such as low back and leg pain, numbness of the lower limbs, intermittent claudication, and in severe cases, colorectal symptoms may occur [4].*

Keywords: Degenerative spondylolisthesis, DS.

1. Background

Belgium obstetrician Herbinaux was the first to discover spondylolisthesis, reporting in 1782 a case of dystocia caused by a narrow pelvic outlet due to the discovery of a slipped forward L5 during delivery. The concept of spondylolisthesis was proposed in 1854 by the German killan, who named spondylolisthesis in Greece (spondylo-listhisis). In 1930, Junghanns H. boldly proposed the concept of "pseudospondylisthen" when he performed autopsies on the bodies of 14 patients with spondylolisthesis and found that there were no defects in the isthmus of the vertebral arch [5]. Macnab I., after a thorough analysis of the anatomical changes, clinical manifestations, and surgical treatment of 22 of these patients, concluded that the term "pseudospondylolisthesis" was not precise enough, and proposed in 1950 that it should be called "spondylolisthesis with an intact neural arch" [6]. Newman PH. discovered in 1955 that what Macnab called spondylolisthesis with intact vertebral arch was associated with spinal degeneration, and combined with pathological changes, he officially named this "spondylolisthesis with intact arches" as "degenerative spondylisthesis" [7].

2. Natural History

Patients with degenerative lumbar spondylolisthesis usually have a good prognosis. Atalay et al. [8] found that during the 4~25-year follow-up period, the proportion of DS slippage progression was 12%~34%. Matsunaga et al. [9] followed 145 conservatively treated patients for more than 10 years and found that only 49 (34 percent) had an aggravated degree of slippage, with a mean slippage percentage of 15.6%; In patients with unaggravated spondylolisthesis, the height of the vertebral space of the lesion segment can be significantly narrowed, and the symptoms of low back pain are improved. Secondary narrowing of the intervertebral space, arthritic bone spur formation, subchondral sclerosis, and ligament ossification and thickening may prevent the progression of spondylolisthesis, a process of spinal restabilization [4]. Spondylolisthesis has been found to be less likely when the disc loses 80 percent of its intrinsic height and intervertebral osteophytes form [10]. Matsunaga et al. [9] also found that 84 (76 percent) of the 110 patients who did not have neurological deficits at the initial presentation did not show neurological deficits at 10 years of follow-up, but had neurological symptoms such as intermittent claudication or bladder rectal dysfunction at the initial presentation and did not undergo surgery, and that the outcome prognosis was poor. Thus, changes in clinical symptoms are not associated with the progression of spondylolisthesis [11-12]. However, there is still controversy about the treatment of DS, and the current progress in the treatment of degenerative lumbar spondylolisthesis is reviewed.

3. Conservative Treatment

The treatment of degenerative spondylolisthesis is divided into conservative treatment and surgical treatment. Through the study of the natural history of the disease, it has been found that the vast majority of patients with degenerative lumbar spondylolisthesis do not require surgery. According to statistics, only about 10%~15% of patients end up with surgery [13]. However, patients with radicular pain or neurogenic claudication are better candidates for surgery, and patients with cauda equina syndrome (eg, bladder rectal dysfunction, sellar sensory deficits) require urgent surgical intervention [14]. Conservative management is generally recommended as first-line treatment for patients without neurogenic claudication or radicular symptoms and for patients with stable low-grade degenerative spondylolisthesis. Conservative management is the treatment of choice for degenerative spondylolisthesis and should be the initial treatment for most patients, with or without neurological symptoms. Conservative treatment of DS mainly includes: rest, medication, physical therapy, functional exercise, manual therapy and adjuvant therapy. However, there are currently no prospective clinical studies that can provide the best conservative treatment options. Vibert et al. [15] proposed in the study that conservative treatment should first start with 1~2 days of rest, followed by short-term anti-inflammatory drugs, and if symptoms persist for more

than 1~2 weeks, physical therapy including aerobic exercise should also be performed. Frymoyer et al. [16] proposed a conservative treatment regimen for DS: (1) nonsteroidal anti-inflammatory drugs, but should pay close attention to gastrointestinal symptoms and melena during use; (2) aerobic exercise is encouraged, and this exercise can improve cauda equina circulation; (3) weight loss; (4) Treatment of osteoporosis.

3.1 Rest and Brace Immobilization

Patients should stay on bed rest and avoid heavy physical activity when symptoms are acutely onset; After acute symptoms have resolved, waist immobilization may be applied. Brace wearing is a common treatment for chronic low back pain, which can increase spinal stability and adjuvant DS therapy by restricting the movement of the lower back and lumbosacral joints, but there are few studies on wearing waist circumference for the treatment of degenerative lumbar spondylolisthesis. Prateepavanich et al. [17] evaluated the effectiveness of wearing a waist circumference in a self-controlled study of 21 patients with symptomatic degenerative lumbar spinal stenosis, and patients who wore a waist circumference showed significant improvements in walking distance and pain scores compared with those who did not. However, neither bed rest nor wearing a brace should be too long to avoid apraxia and atrophy of muscles.

3.2 Pharmacotherapy

Non-steroidal anti-inflammatory drugs are often used in the treatment of chronic low back pain, which can reduce the inflammatory response of nerve roots and surrounding tissues, and have anti-inflammatory and analgesic effects. Given the gastrointestinal side effects of nonsteroidal anti-inflammatory drugs, the cardiovascular side effects of selective cyclooxygenase-2 inhibitors, and the predominance of older adults in patients with DS, acetaminophen should be the treatment of choice for degenerative spondylolisthesis [4, 18].

3.3 Functional Exercise

Functional exercise is an important way to conservatively treat low back pain and can help reduce pain and strengthen the stability of spinal musculature to restore range of motion and stabilize the spine. However, there is still controversy about whether back flexion or stability exercises are exercised. Core stability exercises have long been a routine treatment for chronic low back pain. Coulombe et al. [19] found that core stabilization exercise was more effective than general exercise in reducing low back pain in the short term, but recent studies have questioned this result. Nava-Bringas et al. [20] randomly assigned 92 DS patients over the age of 50 years to lumbar stabilization and flexion exercises, and showed that flexion exercises were not inferior to stabilization exercises in terms of pain reduction and disability index. Sinaki et al. [21] randomized 48 patients with lumbar spondylolisthesis into flexion and extension groups and followed them for three years, and concluded that flexion training was superior to straightening training. This may be due to narrowing of the spinal canal as it is extended, which increases nerve root involvement; It widens with flexion and slows nerve root involvement [4].

3.4 Comprehensive Treatment:

For some patients with severe DS symptoms, especially those with obvious symptoms of spinal stenosis. In addition to the above-mentioned treatments, commonly used treatments such as traction, physiotherapy, electrical stimulation, acupuncture, and epidural steroid injections also have some efficacy.

4. Surgery

DS's main goals of surgery include reducing pain, improving neurological symptoms, and improving quality of life. In another study of 150 patients with DS, SF-36 and the Oswestry disability index (ODI) were significantly improved at three months, one year, and two years in the surgical group compared with the nonoperative group [22-23]. Similarly, Weinstein et al. [24] followed 395 patients who underwent surgery and 210 patients who underwent conservative management and found that those who underwent surgery had significant improvements in ODI and pain compared with those who underwent conservative management, and that surgery was superior to conservative management for degenerative lumbar spondylolisthesis [25].

DS's indications for surgery mainly include: (1) patients with no significant improvement in symptoms after 3~6 months of conservative treatment, which seriously affects the quality of life; (2) progressive neurological deficits; (3) progressive radicular pain or neurogenic claudication; and (4) clinical signs and symptoms of cauda equina nerve dysfunction [15-16]. The core of DS surgery is decompression, which mainly includes: (1) simple spinal decompression; (2) Spinal decompression and fusion, with or without internal fixation. The choice of procedure depends on the degree of facet resection required for decompression, the degree of vertebral spondylolisthesis, the stability of the lumbar spine in flexion and extension, the severity of low back pain, and the characteristics of the patient [26]. However, there is controversy about the need for combined fusion and internal fixation for decompression surgery, and there is a lack of consensus on the optimal surgical approach [27-29]. The following suggestions are given for the diagnosis and treatment of degenerative spondylolisthesis: (1) For the treatment of single-level DS, decompression fusion can obtain satisfactory long-term efficacy, and the effect is better than conservative treatment [30]. (2) For patients with DS and spinal stenosis, decompression and fusion can improve clinical symptoms better than spinal decompression alone. However, for single-level mild DS (20 percent of < percent spondylolisthesis) without foraminal stenosis, decompression alone with preservation of midline structures (unilateral laminotomy combined with bilateral decompression) is as effective as decompression fusion surgery [23]. (3) For patients with DS and spinal stenosis, internal fixation can improve the fusion rate, but not the clinical efficacy [23]. No clear recommendations have been made regarding the choice of fusion approach, minimally invasive or open approach, whether combined internal fixation is required, whether reduction is required intraoperatively, postoperative rehabilitation, and cost-effectiveness.

4.1 Spinal Decompression Alone

Spinal canal decompression alone directly decompresses the central canal, lateral recesses, and foramina by removing part or all of the lamina and part of the articular process. A meta-analysis by Mardjetko et al. [31] showed satisfactory outcomes in 69 percent of patients who underwent laminectomy alone. Austevoll et al. [32] in a randomized trial of 267 patients with lumbar spinal stenosis and degenerative spondylolisthesis, 95 of 133 patients (71.4 percent) in the decompression group alone and 94 of 129 patients (72.9 percent) in the decompression fusion group had ODI scores reduced by more than 30 percent. The mean change of ODI score in 2 years was 20.6 points in the decompression group and 21.3 points in the fusion group. It can be seen that the efficacy of simple decompression is no less than that of decompression fusion internal fixation. Försth et al. [33] also found that the 2-year ODI score, 6-minute walk test results, and reoperation rate were similar between the decompression group and the decompression fusion group, but the hospital stay, operation time, and blood loss were higher in the fusion group. A randomized prospective trial conducted by Inose et al. [34] also supported this view, with significant improvements in postoperative scores in both the decompression and fusion fixation groups, and no statistically significant differences between the two groups at 1 and 5 years follow-up, but higher blood loss, operation time, and hospital stay were higher in the fusion internal fixation group. Thus, decompression alone is preferred for older patients with low-grade (<30 percent) stable lumbar spondylolisthesis because of the shorter procedure, less blood loss, shorter hospital stay, and lower morbidity and mortality [34-35].

4.2 Spinal Decompression Fusion, with or Without Internal Fixation

Decompression therapy alone is not suitable for all patients with DS, but the absolute indication for decompression fusion is unclear. Decompression fusion is recommended for patients with significant slipped lesions (≥5 mm), lumbar instability, and lumbar dislocation. In addition, decompression alone carries the potential risk of iatrogenic lumbar instability and progression of lumbar spondylolisthesis, leading to restenosis, so fusion is also indicated in cases where the facet joint is over-excised intraoperatively to achieve complete decompression. Conversely, fusion surgery is not recommended in patients with low-grade spondylolisthesis, lumbar spine stabilization, reduced lumbar range of motion, and older age [16, 26, 36-37]. Herkowitz et al. [38] found that patients who underwent decompression fusion had significantly lower lower extremity and back pain, with a satisfaction rate of 96% compared with 44% in the decompression group alone, and laminectomy plus fusion was superior to laminectomy alone. Martin et al. [39] conducted a meta-analysis of 13 studies and found that patients who underwent fusion surgery were more likely to achieve satisfactory clinical outcomes than decompression alone.

Commonly used lumbar fusion modalities include lumbarposterolateral fusipon (PLF) and lumbar interbody fusion (LIF). Lumbar interbody fusion can be divided into 5 types according to different surgical approaches: (1) anterior lumbar interbody fusion (ALIF); (2) posterior lumbar interbody fusion (PLIF); (3) transforaminal lumbar interbody fusion (TLIF); (4) lateral lumbar interbody fusion (LLIF); (5)

oblique lumbar interbody fusion (OLIF). The choice of surgical approach has its own advantages and disadvantages and usually depends on the surgeon's experience, proficiency in the surgical approach, and the patient's changing condition [40]. Studies have shown significant differences in the rate of postoperative fusion with or without decompression fusion with and with internal fixation, but an increase in fusion rate does not lead to better clinical outcomes [25]. Fischgrund et al. [41] divided 67 patients into internal fixation and non-internal fixation in a prospective randomized study, with a fusion rate of 82 percent in the internal fixation group, of which 76 percent achieved satisfactory clinical outcomes; The fusion rate in the non-internal fixation group was only 45%, but 85% of these patients achieved satisfactory clinical outcomes; Therefore, there was no correlation between the fusion rate and clinical outcomes. Thomsen et al. [42] found that the satisfaction rate of patients in the internal fixation group was 82% and that the satisfaction rate of patients in the non-internal fixation group was 74%, and the difference was not statistically significant. The fusion rate and pain outcomes were similar between the two groups, but the internal fixation group had longer operation time, more blood loss, and a higher rate of early reoperation. Similarly, a retrospective study of 57 patients with DS by Kimura et al. [43] reached similar conclusions; However, it has also been noted that internal fixation is more beneficial for patients who slip ≥ 3 mm on flexion and extension x-rays.

4.3 Application of Minimally Invasive Concepts

In recent years, with the advancement of surgical instruments and endoscopic techniques, minimally invasive concepts have been widely used in spine surgery, and the rapid development of small incisions to percutaneous endoscopy is based on the basic concept of protecting spinal muscles, ligaments, and other structures, which plays an important role in maintaining spinal stability [44]. Minimally invasive spine surgery (MIS) enables early recovery and improved quality of life by reducing skin incisions, muscle damage, and perioperative pain [45]. Kotani et al. [46] divided DS patients into MIS-PLIF group and open PLIF group, and the MIS group had less blood loss during surgery and on the first day after surgery, and higher ODI and Roland-Morris questionnaire scores during the follow-up period from 2 weeks to 24 months after surgery. However, there were no significant differences in operative time, fusion rate, and complication rate; MIS not only has similar clinical outcomes to open surgery, but also has less bleeding and shorter recovery time after surgery. However, due to factors such as anatomical variation and obesity, MIS is not applicable to all patients [25]. It is important to note that the disadvantages of minimally invasive surgery include limited intraoperative field of view, limited operating space, steep learning curve, radiation exposure, long operative time, and high cost, which require trade-offs in the choice between surgeons [47].

5. Discussion

Degenerative spondylolisthesis is a common spinal disease in middle-aged and elderly people, but the best treatment for DS is still controversial. Conservative management is the mainstay of treatment for degenerative spondylolisthesis and should be the initial treatment regimen for most patients with

spondylolisthesis, with or without neurological symptoms. Surgical treatment can achieve better clinical outcomes compared with conservative treatment, but there is a lack of consensus on the best surgical approach, and the use of internal fixation is still controversial. A large number of studies have found that conservative treatment of degenerative spondylolisthesis is effective. However, there are still many deficiencies and problems that need to be solved urgently: (1) Lack of objective evaluation of the efficacy of conservative treatment. Many clinical studies lack strict control data and long-term follow-up, the scientific research design is not rigorous, and most of them use the degree of symptom improvement as the efficacy evaluation criteria, and the classification criteria of symptom severity lack uniformity, reliability and validity lack of verification, and the subjectivity is strong. Therefore, it is necessary to strengthen the standardization and objectivity of efficacy evaluation in clinical research. and (2) the lack of prospective studies on conservative treatment. Most of the studies on the non-surgical treatment of degenerative lumbar spondylolisthesis are retrospective, and there is a lack of exploration of prospective studies, which needs to be strengthened in future research work.

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