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Surgical versus non-surgical treatment for the staging of spondylolisthesis: systematic review and meta-analysis

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Abstract:

Objective: To evaluate the limits of conservative treatment compared to surgical treatment.

Methodology: Information was searched using the Pubmed database using the keywords: "developmental", "spondylolisthesis", "classification", "surgical", "treatment", "graft", "fusion", "Gaines". The search was restricted to articles in English, French and Portuguese. After selection, 05 articles were consulted for analysis and construction of the study.

Results: Surgical treatment proved to be more effective in assessing pain in studies in which the patients were children and adolescents. Conservative treatment, in the majority of studies, was not effective in terms of improving mental health and consequently improving the quality of life experienced by the patient.

Conclusion: Conservative treatment is indicated as the first choice in most cases, leaving the invasive option for residual symptoms or advanced degrees of anatomical involvement, and it is worth noting that the surgical procedure is shown in the evaluation of pain, mental health and quality of life in the studies in which the patients were children and adolescents.

Keywords: spondylolisthesis; developmental; treatment; classification; review; reduction; fusion.

INTRODUCTION:

It was first described in 1782 as an anterior prominence of the sacrum that causes narrowing of the birth canal, supposedly caused by a subluxation in the 5th lumbar vertebra over the 1st vertebral column of the sacral spine. It evolved 12 years later to the term spondylolisthesis of Greek origin, which corresponds to “slippage,” which affects the anatomical region of the spine and has an etiology that is not well established with a multifactorial origin, namely mechanical, hormonal and hereditary factors. Spondylolisthesis is the anterior or posterior slippage or displacement of one vertebra over another and may be a unilateral or bilateral lesion of the isthmus without slippage of the vertebra, and is called spondylolysis. [1]

The clinical presentation is variable and extensive in view of the possibility of anatomical involvement: 1. minimal vertebral slippage with exuberant symptoms and 2. exuberant vertebral slippage with minimal or no symptoms. The presence of low back pain and/or lumbosciatica of radicular origin, due to compression/stretching of the roots, are the most common symptoms. Therefore, the diagnosis changes according to the manifestation, from the accidental discovery through imaging tests performed for other pathological causes. It affects the general population with an incidence of 4-8% and twice as high as that of men, relatively common in the pediatric population. 1,2,3

Anatomically, the spine plays an important role in the stability and general balance in the coronal and sagittal planes of the spine, given by the integrity of the osteo discoligamentous complex. Thus, the lumbosacral level of stability depends on the spatial orientation of the 5th lumbar vertebra in relation to the sacrum, lumbosacral angle, sacral slope and pelvic incidence, and an intact osteo discoligamentous complex. Therefore, the involvement of the pathology causes deformation of the sacral in growing children, which can have an impact on the development of the locomotor system.,2,3

As for complementary exams, simple radiographs in the orthostatic position are sufficient and well indicated to diagnose the disease in cases with a lower degree of slippage. Bone scintigraphy is useful in identifying acute fractures and pseudarthrosis in old fusion areas, aiding in the prognosis. 3D computed tomography allows the identification of compression of nerve roots by soft tissues and the identification of bone inside and outside the spinal canal. And magnetic resonance imaging allows the assessment of disc degeneration, which may be useful for determining the extreme upper limits of fusion and assisting in the therapeutic procedure.2,3,4

There are many therapeutic options for spondylolisthesis: limitation of activities, exercises, especially hip flexion, immobilization, repair of the isthmic defect, fusion, decompression with/without fusion, and finally, partial/total reduction and fusion. This leads to the classic orthopedic dilemma: surgical or conservative treatment? Thus, the general criteria for indication for surgical treatment include persistent pain or neurological symptoms in the face of good conservative application, progression of the slippage greater than 30%, a degree of slippage at presentation equal to or greater than Meyerding grade 3, and the existence of a cosmetic deformity associated with postural and gait difficulties. Overall, only 20% of patients with symptomatic spondylolisthesis require surgical treatment.3,4,5,6

Although conservative approaches are successful in

children and adolescents, during development there are more presentations of spondylolisthesis with a high degree of slippage or with progression of the lesion, therefore requiring surgical intervention. It is suggested that risk factors associated with progression in the younger population are age under 15 years, presence of slippage greater than 30%, ligamentous laxity, female gender and lumbosacral hypermobility (presence of rounding of the upper platform of S1 and concavity of the lower surface of L5). 3,4,5,6

Thus, this proposed article aims to evaluate the limits of conservative treatment compared to surgical treatment, through a systematic review with meta-analysis, assisting in the therapeutic management of patients and in the prognosis of the pathology.

METHODOLOGY

A systematic literature search on the prevalence of spondylolisthesis in children was carried out. General information on the study patient characteristics and the prevalence of spinal abnormalities was extracted from the studies. Prevalence data for the most commonly reported abnormalities were pooled using random effects proportion meta-analysis. The study protocol was prospectively registered in PROSPERO under ID CRD42024519351.

Data sources

The information was searched using the Pubmed database using the keywords: “developmental”, “spondylolisthesis”, “classification”, “surgical”, “treatment”, “graft”, “fusion”, “Gaines”. The search was restricted to articles in English, French and Portuguese. After selection, 05 articles were consulted for analysis and construction of the study.

Data synthesis:

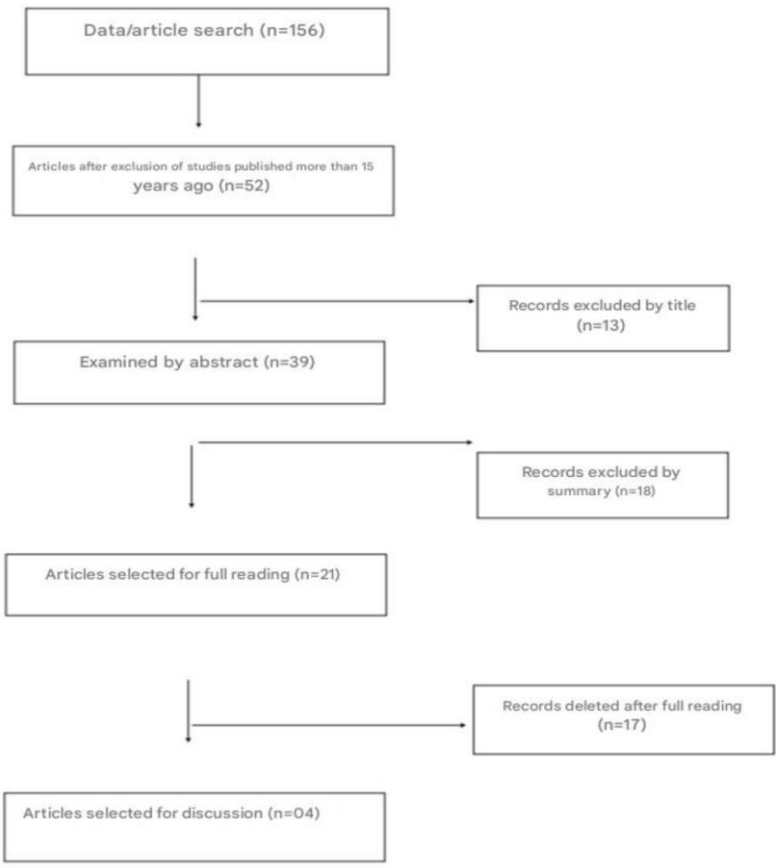
There are currently two classification systems with wide global acceptance, the Wiltse, Newman and MacNab classification system and the Marchetti and Bartolozzi classification system. The latter proposes a new subtype of spondylolisthesis, which is developmental spondylolisthesis. However, this classification system was not established as a guide for surgical treatment and was not based on the sagittal spinopelvic balance, which is considered by several authors as an important parameter in the pathogenesis and treatment of developmental spondylolisthesis. Therefore, Jean-Marc Mac-Thiong and Hubert Labelle proposed a new classification of lumbosacral developmental spondylolisthesis in children and adolescents with the aim of serving as a basis for the creation of a surgical treatment algorithm for which there are several options.

RESULTS

Initially, 156 articles were selected, 104 were excluded because they had been published more than 20 years ago, leaving 52. Thirteen studies were eliminated based on their titles and 18 were eliminated based on their abstracts, as they did not evaluate the therapeutic efficacy of clinical and surgical treatments. Finally, 5 articles were selected for analysis and as the basis for the study (Figure 1).

FIGURES

Figure 1 - Flowchart of the studies evaluated according to the PRISMA parameters.



Source: Own authorship (2024).

The 5 selected articles correspond to patients diagnosed with spondylolisthesis who underwent surgical or conservative treatment. The population of 2 studies was children and adolescents, while the other 2 studies corresponded to elderly patients. In total, 820 patients were included. The surgical techniques used varied, such as in situ bone fusion with posterior graft, in situ instrumented fusion, anterior interbody fusion, instrumented fusion, L5 corpectomy with L4 to S1 fusion.

Table 1 presents the selected studies and their results. 8,9,10,11

Table 1. Results obtained from the selected studies.

Study	Results Approach	
Lundine et al	Surgical Non-surgical	SRS-30 (Scoliosis Research Society); VAS (Visual analogue scale); Mental health assessment; Slip angle; Complications
Bourassa-Morea u and col	Surgical Non-surgical	SRS-30 (Scoliosis Research Society); VAS (Visual analogue scale); Mental health assessment.
Weinstein e col	Surgical Non-surgical	SF-36 questionnaire; VAS (Visual analogue scale); Mental health assessment; Oswestry disability index.
Passias et al	Surgical Non-surgical	SF-36 questionnaire; VAS (Visual analogue scale); Mental health assessment; Oswestry disability index.

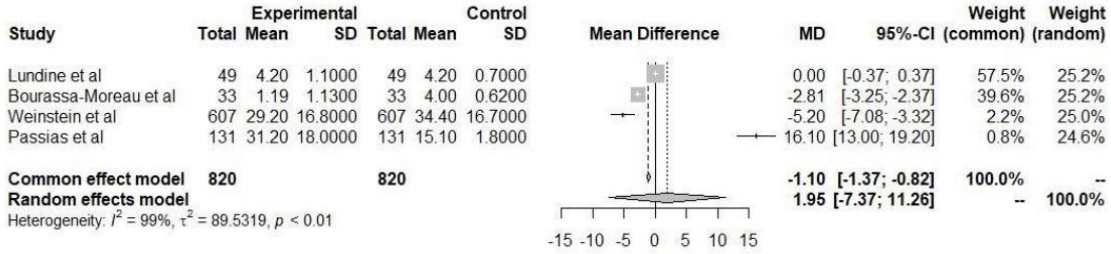
Table 2 contains the Visual Analogue Scale (VAS) of patients who underwent surgical or conservative treatment for spondylolisthesis. 8,9,10,11

Table 2- Visual Analogue Scale (VAS) of patients undergoing surgical or conservative treatment for spondylolisthesis.

Study	Sample	Age	Surgical treatment (VAS)	Treatment surgical **(VAS)**	no
Lundine et al	49 patients	12.6 years	4.2+-1.1	4.2+-0.7	
Bourassa-Moreau et al.	33 patients	15 years	1.19+-1.13	4.00+-0.62	
Weinstein e col	607 patients	66 years	29.2±16.8	34.4±16.7	
Passias et al	131 patients	68 years	31.2+-18	15.1+-1.8	

Figure 2 presents the forest plot with the analysis of the Visual Analogue Scale (VAS) of patients who underwent surgical or conservative treatment for spondylolisthesis. 8,9,10,11

Figure 2 - The forest graph with the analysis of the Visual Analogue Scale (VAS) of patients undergoing surgical or conservative treatment for spondylolisthesis.



In the study by Lundine et al8, 24 patients were selected for the surgical treatment group and 25 for the conservative treatment group, of which 10 patients subsequently required surgical intervention. The surgical techniques used were in situ bone fusion with posterior graft only, anterior interbody fusion, in situ instrumented fusion, L4-S1 instrumented fusion with reduction, L4 pelvic instrumented fusion with reduction and posterior interbody graft, L5 corpectomy with L4 to S1 fusion. The SRS-30 questionnaire (Scoliosis Research Society) demonstrated preoperative pain values of patients who would undergo the surgical procedure of 4.3 ± 1.1 versus 4.2 ± 1.1 postoperatively, while patients undergoing conservative treatment reported a VAS (Visual Analogue Scale) score of 4.2 ± 0.7 before treatment and 4.2 ± 0.5 after it. Regarding mental health, the surgical group reported an improvement from 4.1±0.8 to 4.3±0.5, while the non-operative group initially reported a score of 4.1±0.7 and after treatment of 3.8±0.8. The total SRS-30 score of the operated patients was 80.4±14.0 versus 79.5±11.0 non-operated.

Bourassa-Moreau et al9 included 05 patients in conservative treatment and 28 in surgical treatment. The technique used was primary fusion. The VAS index ranged from 4.17±0.78 to 1.19±1.13 in patients undergoing surgical treatment and from 4.12±0.64 to 4.00±0.62 in conservative treatment. The mental health of patients improved both in the surgical group (4.15±0.57 to 4.65±0.95) and in the conservative group (4.32±0.44 to 4.44±0.33). No complications were reported.

In the study by Weinstein et al10, 332 patients initially underwent the surgical procedure, while non-surgical treatment was chosen for 275 patients. During the study, 40 patients in the non-surgical group needed to undergo the procedure. The SPORT (Spine Patient Outcomes Research Trial) questionnaire was applied. The pain reported by surgical patients after the procedure was 29.2±16.8 and non-surgical patients 34.4±16.7. The mental health reported by surgical patients was 49.5±11.6 versus 51.3±11.3 non-surgical patients. The Oswestry disability index for surgical patients was 45.0±16.6 and for non-surgical patients 36.2±18.5.

Passias et al11 initially selected 145 patients to receive non-operative treatment, however, after the beginning of the study, 80 required the surgical procedure. The SF-36 questionnaire was administered, and the preoperative pain reported was 32.2±18.7 to 31.2±18 after the procedure, for non-surgical patients this variation was 35.5±18.4 to 15.1±1.8. The surgical Oswestry disability index was 22.6±1.4 and the non-operative one was 29±1.4.

DISCUSSION

Surgical treatment has been shown to be more effective in assessing pain in studies in which the patients were children and adolescents. Regarding the assessment of disability, the studies did not demonstrate significant variations between the groups. Conservative treatment, in most studies, was not effective in improving mental health and consequently improving the quality of life experienced by the patient.

Conservative treatment in low-grade spondylolisthesis is the indication, due to the good results and prognosis[12]. However, there is no agreement and it is still controversial as to what is the best treatment for

high-grade spondylolisthesis in pediatric patients[13]. Some researchers advocate surgical therapy in these patients, despite the clinical presentation, with the argument of preventing slippage and progression of symptoms[14]. Others suggest that conservative therapy may be indicated in less symptomatic or asymptomatic high-grade spondylolisthesis[15], [16].

The role of conservative treatment in small patients with high-grade slippage[12] is not yet well understood. However, it is known to include non-steroidal anti-inflammatory medication, physiotherapy, activity modification and immobilization with a brace[17]. The focus of physiotherapy is on relieving tension in the extension of the lumbosacral junction, stretching the hip flexors and hamstrings, working the deep abdominal muscles and strengthening the lumbar multifidus[17], [18], [19]. There have been reports of good results with the use of these therapies[20]. However, these studies are usually retrospective and with different patient populations, thus limiting the validity of their effects[13].

Surgical treatment is usually indicated for patients who have undergone conservative treatment without improvement, who continue to have symptoms and neurological deficits[21], [22]. In particular, growing children with high-grade spondylolisthesis usually require surgical intervention due to the high risk of compression. An absolute indication is cauda equina syndrome, but motor weakness, low back pain and radicular pain in the lower limbs are also strong indications. In adolescents, the progression of slippage is a relative indication[23].

Although there are numerous surgical options, and it is not yet known which is the best[24], the primary aim of surgery is to achieve a solid fusion to correct the deformity in order to achieve vertebral balance and perform neurological decompression[23], [25]. Some of the operative techniques used are in situ bone fusion with posterior graft only, anterior interbody fusion, instrumented in situ fusion, instrumented L4-S1 fusion with reduction, instrumented L4 pelvic fusion with reduction and posterior interbody graft, L5 corpectomy with L4 to S1 fusion. 8,9,10,11,12

One of the last preoperative decisions to be made involves which levels will be fused, whether it incorporates the pelvis and whether it needs to provide support for the anterior column[23]. Many surgeons have used monosegmental fusion for high-grade spondylolisthesis[26]. However, even when associated with anterior column support, posterior fusion of L5/S1 alone was related to a nonunion rate of 17% in a study of 34 patients[26] and a structural complication rate of 11% in another study of adolescents[27]. Both authors therefore recommended fusion of L4 to S1[26], [27].

Although proximal fixation usually ends at L3 or L4, distal fixation can end at S1[28] or incorporate the ileum[29]. In children and adolescents, distal fixation at S1 or S2 works well, but older patients with high-grade slippage, an open S1/S2 disc space, poor sacral bone quality or connective tissue disease may benefit from an increased iliac screw[23].

For low-grade spondylolisthesis, a well-known technique and many surgeons report good clinical results is posterolateral fusion in situ[30]. However, in high-grade spondylolisthesis, the procedure is favorable to a significant rate of non-union or subsequent progression of delamination[31].

Furthermore, circumferential fusion facilitates sagittal balance and local kyphosis[32]. Two recent meta-analysis studies observed that this technique takes longer than instrumented posterolateral fusion, but achieves a better fusion rate, restoration of alignment and clinical satisfaction[33].

There is much debate about whether or not to reduce high-grade spondylolisthesis, due to the difficulty of the procedure, questions about the benefit and associated complications, especially neurological[24], [34], [35], [36]. Some authors report good results with in situ fusion, especially in patients with preserved pelvic balance[24], [37]. Others consider in situ fusion to be better than gradual reduction, distraction and milled fusion[38].

Most of the apprehension is because of the risk of neurological injury and, although the reason for reduction is multifactorial, there is evidence that it is safe and biomechanically preferable[23].Even though there have been reports of nerve root injury following this maneuver[34], [35]. Some recent and larger studies show a prevalence of neurological deficit in the order of 5% to 10%[34], [35], [39]. A recent search of the Scoliosis Research Society Morbidity and Mortality database showed a neurological deficit in nine out of eighty-eight pediatric patients[35].

The ability to achieve direct neural decompression can avoid the risk of acute cauda equina syndrome in the post-operative period[40]. It also makes it possible to correct the local anatomy, since the surgeon can directly influence the sliding angle and sliding percentage[41], thus improving the overall sagittal alignment[23]. This is one of the main reasons for its use[42], [43].

A retrospective study by Martiniani et al.[34] showed that patients with unbalanced deformities who underwent reduction and fusion recovered with improvements in sacral and pelvic inclination. Supporting the idea that patients with unbalanced high-grade spondylolisthesis benefit more from reduction than those with balanced high-grade spondylolisthesis[42], [43].

Due to the change in local forces, this reduces the risk of pseudoarthrosis[23]. Numerous studies have revealed an increase in this risk in patients who have not had the reduction[34].This is most likely due to the continued presence of shear forces through the lumbosacral disc space, which puts excessive stress on the implants, leading to non-consolidation, loosening and failure[41].

Post-operative patients are warned and advised to avoid knee extension with hip extension, so that the lumbar plexus is not stretched. In the first 48 hours, neurological tests assess the motor strength of the tibialis anterior, extensor hallucis longus and quadriceps. Narcotics are offered as drug therapy for pain relief, and diazepam is used to relieve spasms. In some cases, gabapentin is useful to control temporary radiculitis. Most patients are discharged from hospital on the third or fourth day[23].

CONCLUSION

Spondylolysis and spondylolisthesis are known to be common etiologies of low back pain in the pediatric and adolescent population. This leads to functional limitations in sports that require repetitive hyperextension of the lumbar spine, although the asymptomatic form is common.

The clinical presentations in the mild forms include low back pain, radiculopathy, postural alterations and, rarely, neurological deficits. Therefore, the need for a thorough physical examination associated with imaging tests has an important diagnostic and prognostic outcome. Added to this is the potential risk of pathological progression.

Conservative treatment is indicated as the first choice in the majority of cases, leaving the invasive option for residual symptoms or advanced degrees of anatomical involvement, and it is worth noting that the surgical procedure is shown in the evaluation of pain, mental health and quality of life in studies in which the patients were children and adolescents.

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