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Low-Grade Spondylolisthesis

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Spondylolisthesis is defined as translational displacement or nonanatomic alignment of one vertebral segment on another. It was first described by Herbiniaux, a Belgian obstetrician, in 1782 as an obstetric problem associated with narrowing of the birth canal. The word is derived from the Greek words *spondlylos,* which means vertebra, and *olisthesis,* which means slippage down a slope. The nomenclature describing the lesion denotes the following: the involved vertebral levels, the degree of slippage (usually based on the Meyerding grading scale [1]; (Table 1), the presumed etiology (see section on classification and etiology), and the position of the superior vertebral body relative to the inferior one in the malaligned pair. For example, Fig. 1 is described as L5-S1, grade 1, spondylolytic (isthmic) anterolisthesis. Displacement is most commonly found anteriorly (anterolisthesis) but may rarely occur posteriorly (retrolisthesis) or laterally (lateral listhesis) from the standard anatomic position. For this reason, the term *spondylolisthesis* is often used interchangeably with *anterolisthesis*. The lumbosacral junction and middle lumbar spine are most often involved, but the lesion is also found in the cervical or, rarely, the thoracic vertebrae. The classification, clinical and radiographic features, and nonoperative and operative management of low-grade spondylolisthesis are discussed in this review.

Natural history and epidemiology

The cause of spondylolisthesis is uncertain; however, it is commonly thought to have familial and mechanical etiologies [2,3]. The pars interarticularis is the weakest segment of the neural arch. Many studies report that acquired spondylolisthesis is precipitated by spondylolysis, lysis of the pars interarticularis, from fatigue fracture. Eisenstein [4] showed a 3.5% prevalence of spondylolysis without race or gender difference in South African "whites" and "blacks." Wynne-Davies and Scott [5] found a one in three risk of spondylolysis in first-degree relatives of patients with the dysplastic form of spondylolisthesis. Once bilateral pars fractures have occurred, there is a tendency for sheer forces to cause a variable amount of anterior displacement over time. Although spondylolytic spondylolisthesis is twice as common in boys and men, female gender and spina bifida are associated with a higher risk of progression. The adolescent growth spurt and teenage years are common times for progression of spondylolytic spondylolisthesis; however, the likelihood of progression decreases with each additional decade thereafter [6].

The fetal incidence of spondylolisthesis is confirmed to be 0% [2,3,7–9] but is reported to be 4.4% by the age of 6 years, increasing slightly to 6% to 7% in the adult population [2,6,10–13]. Among Yukon Eskimos, however, the prevalence of spondylolisthesis has been reported to be up to 50% [14], illustrating a possible ethnic predisposition. Most childhood and adolescent spondylolisthesis is associated with spondylolysis of the pars interarticularis at the L5-S1 motion segment. The prevalence of spondylolisthesis stabilizes after adulthood, and new occurrences after this time are usually of a degenerative rather than developmental etiology. Degenerative spondylolisthesis is nearly six times more likely to occur in women than men [15,16], and the lesion is most commonly found at the L4-L5 motion segment [17].

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Table 1
Meyerding classification of spondylolisthesis severity

Grade	Percent slip	
1	0–25	This simple grading system describes the position of the superior vertebral body relative the inferior one.
2	26–50	
3	51–75	
4	76–100	
5	>100 (spondyloptosis)	The percent slip is calculated as Slip = a/A × 100%, where is a is the distance of translation and A is the anteroposterior diameter of the inferior vertebral body.

Fig. 1. L5-S1, grade 1, spondylolytic (isthmic) anterolisthesis.

Classification and etiology

The first classification of spondylolisthesis came from Neugebauer [18] in 1882. He described spondylolisthesis as congenital or acquired based on the presence or absence of L5-S1 facet dysplasia. The increasingly widespread use of radiology has led to a better understanding of the pathoanatomic features of spondylolisthesis, resulting in the development of several complex classification systems. The first comprehensive classification system was described by Newman and Stone [3] in 1963 and comprised five groups:

1. Congenital (type I)
2. Spondylolytic (type II)
3. Traumatic (type III)
4. Degenerative (type IV)
5. Pathologic (type V)

It was later expanded by Wiltse and Winter [19] in 1976, as shown in Table 2. The Wiltse-Newman classification, based on etiology and anatomy, remains the most widely accepted in clinical practice and research.

Wiltse and his colleagues [10,20,21] originally divided his classification into the same five types as Newman; however, type II was further subdivided into lytic, elongated, and acute fracture subtypes. Later, congenital spondylolisthesis was also divided into three subgroups. Type IA is caused by improper or incomplete formation of the anatomic elements. In this subtype, dysplasia of the facet joints is always evident and the pars interarticularis may be intact, elongated, or defective. Progression of spondylolisthesis past 25% with an intact pars interarticularis may result in cauda equina syndrome [21]. Type IB is associated with sagittal oriented facets and results in instability, which is most prominent at the lumbrosacral junction.

Isthmic spondylolisthesis (type II) is caused by a bilateral defect of the pars interarticularis that results in translation of the lateral elements and vertebral body [20]. Three subtypes exist based on the pathogenesis of the pars defect. In type IIA, the pars defect is caused by fatigue fracture. In type IIB, repeated fracture and healing of the defect cause a pars elongation and allow gradual slippage of the vertebral body. Type IIC results from an isolated acute fracture of the pars after severe trauma.

Degenerative spondylolisthesis, type III, is a result of increased instability and hypermobility caused by degenerative changes, including disc degeneration with narrowing and loss of annular support or articular degeneration of the facet joints. Spondylolisthesis resulting from trauma to elements other than the pars interarticularis, such as dislocation of facet joints or bilateral pedicle fracture, is classified as posttraumatic spondylolisthesis (type IV). Bony systemic pathologic conditions, such as osteopetrosis, arthrogryposis, or local disease (eg, infection, tumor), may destroy supporting bony structure, resulting in type V pathologic spondylolisthesis.

Table 2
Wiltse-Newman classification of spondylolisthesis

Dysplastic/congenital (type I)	Congenital abnormalities of the upper sacrum or the arch of L5 permit the olisthesis to occur Type IA: dysplastic posterior elements and facets usually associated with spina bifida Type IB: dysplastic articular process with sagittal-oriented facet joints Type IC: other congenital abnormalities, such as failure of formation or segmentations producing spondylolisthesis
Isthmic (type II)	Lesion within the pars interarticularis Type IIA: lytic fatigue fracture Type IIB: elongation (microfracture healed with elongation) Type IIC: acute fracture secondary to trauma
Degenerative (type III)	Long-standing intersegmental instability, such as within the apophyseal joints, permitting slippage
Traumatic (type IV)	Due to fractures in areas of the bony hook other than the pars.
Pathologic (type V)	Results from generalized or localized bone disease (ie, osteogenesis imperfecta, Paget's disease)

Data from Refs. [3,10,19,21].

In 1982, Marchetti and Bartolozzi [22] developed a new classification of spondylolisthesis, later modified in 1994 (Table 3), which is based on two fundamental groups: developmental and acquired spondylolisthesis. Developmental spondylolisthesis includes all dysplastic forms and is divided into high or low dysplastic types, with lysis or elongation subtypes.

Acquired spondylolysis is broken down into traumatic, postsurgical, pathologic, and degenerative types. Each of these types also has two subtypes, as shown in Table 3, to specify the etiology further. Traumatic spondylolisthesis is further divided into acute or chronic stress type fracture. The postsurgical group is separated into direct or indirect postsurgical instability. Pathologic spondylolisthesis is divided into pathologic findings related to local factors and pathologic findings related to systemic factors. Finally, degenerative spondylolisthesis is broken down into primary and secondary types based on existing congenital or acquired pathologic alterations.

Table 3
Marchetti-Bartolozzi classification of spondylolisthesis [11,22]

Developmental	High dysplastic	With pars lysis
		With pars elongation
	Low dysplastic	With pars lysis
		With pars elongation
Acquired	Traumatic	Acute fracture
		Stress fracture
	Postsurgical	Direct surgery
		Indirect surgery
	Pathologic	Local disease
		Systemic disease
	Degenerative	Primary
		Secondary

Data from Marchetti PG, Bartolozzi P. Spondylolisthesis: modern trends in orthopaedic surgery. Bologna (Italy): 1999. p. 165–8; and Marchetti PG, Bartolozzi P. Classification of spondylolisthesis as a guideline for treatment. The textbook of spinal surgery. 2nd edition. Philadelphia: Lippincott-Raven; 1997. p. 1211–54.

The Wiltse-Newman and the Marchetti-Bartolozzi classification systems have been shown to have high intra- and interobserver reliability [10,11,21,22]. Neither the Wiltse-Newman system nor the less frequently used Marchetti-Bartolozzi system takes into account sacropelvic balance, however, which has been shown to be an important predictor of progression [23–32]. Labelle and colleagues [33,34] have proposed a new classification system, as shown in Fig. 2, focused on the risk of progression and operative management of spondylolisthesis. This system classifies spondylolisthesis along three axes: slip grade, degree of dysplasia, and sagittal spinopelvic balance. Conveniently, the evaluation can be made grossly without the need for radiographic measurements. Labelle and colleagues [33,34] demonstrated high intraobserver reliability and moderate interobserver reliability in a preliminary study using this new surgical classification system. The addition of radiographic measurements to measure the degree of dysplasia more objectively is likely to improve overall interobserver reliability.

Biomechanics

Biomechanical studies have shown that under normal conditions, the lumbar vertebral bodies and discs support 80% to 90% of axial load, whereas the remaining 10% to 20% of the load is borne by

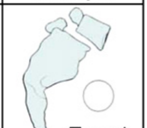
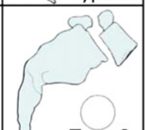
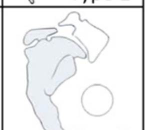
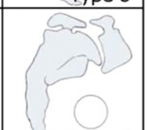
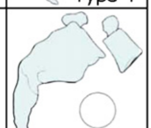
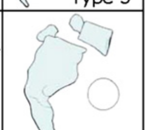
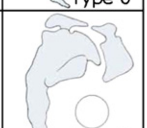
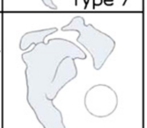
Grade	Dysplasia	Spinopelvic balance	Example
Low-grade (< 50% slip)	Low-dysplastic • Minimal lumbosacral kyphosis • Almost rectangular L5 • Minimal sacral doming • Relatively normal sacrum • Minimal posterior elements dysplasia (e.g. spina bifida occulta) • Relatively normal transverse processes	Low PI/low SS (nutcracker type) • Sacral slope ≤ 40°	 Type 1
		High PI/high SS (shear type) • Sacral slope > 40°	 Type 2
	High-dysplastic • Lumbosacral kyphosis • Trapezoidal L5 • Sacral doming • Sacral dysplasia and kyphosis • Posterior elements dysplasia • Small transverse processes	Low PI/low SS (nutcracker type) • Sacral slope ≤ 40°	 Type 3
		High PI/high SS (shear type) • Sacral slope > 40°	 Type 4
High-grade (≥ 50% slip)	Low-dysplastic • Minimal lumbosacral kyphosis • Almost rectangular L5 • Minimal sacral doming • Relatively normal sacrum • Minimal posterior elements dysplasia (e.g. spina bifida occulta) • Relatively normal transverse processes	High SS/low PT (balanced pelvis) • Balanced sacrum • Sacral slope ≥ 50° • Pelvic tilt ≤ 35°	 Type 5
		Low SS/high PT (retroverted pelvis) • Vertical sacrum • Sacral slope ≤ 50° • Pelvic tilt ≥ 25°	 Type 6
	High-dysplastic • Lumbosacral kyphosis • Trapezoidal L5 • Sacral doming • Sacral dysplasia and kyphosis • Posterior elements dysplasia • Small transverse processes	High SS/low PT (balanced pelvis) Balanced sacrum Sacral slope ≥ 50° Pelvic tilt ≤ 35°	 Type 7
		Low SS/high PT (retroverted pelvis) Vertical sacrum • Sacral slope ≤ 50° • Pelvic tilt ≥ 25°	 Type 8

Fig. 2. Labelle's surgical classification of spondylolisthesis.

posterior elements. The anterior shear force across a lumbar disc is the combined result of gravity acting on a sloped sacrum and the contractions of the lumbar anchored musculature. These anterior shear forces increase incrementally from the superior to inferior lumbar segment as the angle of the supporting vertebral body increases relative to the ground. Shear forces are primarily countered by intact posterior elements by means of a tension band principle and by the ligamentous function of the annulus fibrosus [35]. When bilateral pars fractures have occurred, shear forces result in a tendency toward anterior displacement of the vertebral body as well as the anterosuperior pars fragment, especially during flexion [36–38]. This displacement makes healing of bilateral pars defects infrequent [36,38]. Displacement after a unilateral defect is less common, which allows healing to occur in some patients [2,6,36,38].

A defective pars interarticularis leads to loss of the posterior tension band and a reduced ability to resist shear force. Steffee and Sitkowski [39] have shown that the pars interarticularis, annulus fibrosis, and posterior longitudinal ligament are responsible for maintaining the L5 vertebra in a normal position. The compromise of these structures leads to progression, early degeneration, failure of load sharing, and the development of symptoms.

Individual anatomy is likely to affect the initiation and progression of anterolisthesis. Labelle and colleagues [27] performed a retrospective study that demonstrated positive correlations between spondylolisthesis and four anatomic measures: pelvic incidence (PI), sacral slope (SS), pelvic tilt (PT), and lumbar lordosis (LL), respectively. Fig. 3 depicts the radiographic measurement of these parameters. It is unclear if there is a causative relation between these parameters and the predisposition toward or progression of spondylolisthesis.

Clinical presentation and evaluation

The clinical presentations of spondylolisthesis vary widely. Many patients remain asymptomatic and do not seek medical attention. Low back pain is the most common symptom in patients with spondylolisthesis. Increasing instability resulting in disc degeneration may cause the previously asymptomatic individual to become symptomatic in middle life or in later years.

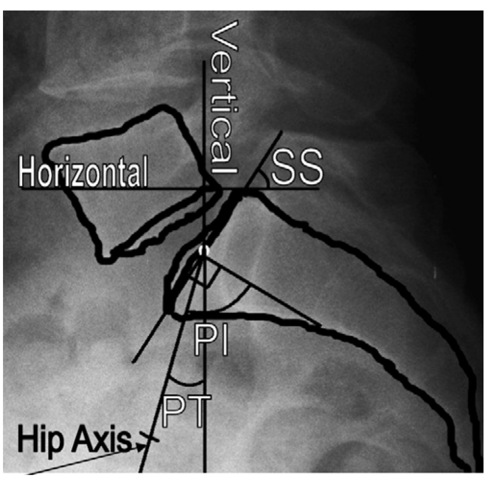


Fig. 3. Pelvic incidence (PI) = sacral slope (SS) + pelvic tilt (PT).

Adult patients often present with radicular pain or neurogenic claudication. In patients with bilateral leg pain, bowel or bladder symptoms, or saddle anesthesia, care should be taken to rule out an early presentation of cauda equina syndrome, a most feared complication of spondylolisthesis. Radicular pain from nerve root irritation, inflammation, or impingement can arise from several locations. This most commonly involves foraminal or central canal stenosis, disc bulging or herniation, fibrous tissue hypertrophy from a pars defect, or ligamentum flavum hypertrophy or infolding.

Although less radiographically striking than high-grade spondylolisthesis, low-grade lesions often cause a great deal of pain and disability for patients. Thus, management decisions can be complex. Whereas a high-grade lesion prompts the question of "which operation is the best choice," a low-grade lesion leaves us to ponder whether surgery is the correct approach at all. In the absence of severe pain, impending neurologic compromise, or rapid progression of the slip, a patient can be managed conservatively. This is particularly true in a skeletally mature patient, in whom progression is less likely to occur. The thorough conservative approach involves encouragement of activities and fitness as tolerated, physical therapy, weight loss, pain management, and reassurance that the condition can be safely monitored. It is important that these patients have close follow-up, because the likelihood of them developing worsening pain or neurologic symptoms is substantial.

The child or adolescent with low-grade spondylolisthesis is far more worrisome, because the growth spurt is a common time for progression to occur. It has been observed that these patients are more likely to develop a steeper lumbar inclination, establishing a cycle that may lead to progression of the slip.

Radiographic findings

The appropriate radiographic workup of low back pain or radicular pain includes anteroposterior (AP) and lateral radiographs of the lumbar spine. On review of these films, the diagnosis of spondylolisthesis can be established. Oblique views can aid in detecting spondylolysis, with 84% sensitivity, by demonstrating the characteristic "collar or broken neck of the Scotty-dog" finding [40–42]. Next, flexion-extension films should be obtained if the clinician suspects instability. Fig. 4 demonstrates instability detected on flexion-extension films. In the presence of predominant neurologic or radicular symptoms, MR imaging or a CT myelogram of the lumbar spine should be obtained to determine the site of stenosis or impingement.

Nonoperative management

Many patients with low-grade spondylolisthesis can be treated conservatively. Physical therapy and pain management are the mainstays of conservative treatment. Flexion and extension core-strengthening exercises may increase the stability of the lumbar spine and reduce pain and functional disability [43,44]. Weight loss, smoking cessation, and cardiovascular conditioning may benefit a non-operative treatment regimen and are important early steps to optimizing a future surgical intervention. Local steroid injections at nerve roots offer temporary relief for some patients [45]. Nonetheless, patients with prolonged, severe, or worsening symptoms may receive more definitive treatment with operative management. Moller and Hedlund [46] looked at 111 patients with adult isthmic spondylolisthesis with at least 1 year of low back pain or sciatica and restricted functional ability. Patients were randomized to posterolateral fusion or an exercise program. Patients who underwent posterolateral fusion showed significantly greater improvement in functionality and pain.

Operative management

Primary indications for surgery in patients with spondylolisthesis are significant low back or radicular pain refractory to nonoperative treatment. The operative goals are as follows:

1. Neural decompression (when applicable)
2. Stabilization to prevent further slippage
3. Solid fusion to reduce pain from a painful motion segment (when applicable)
4. Reduction and restoration of disc and neuroforaminal height in select patients

Pain relief from surgical stabilization is notoriously unreliable in patients with predominant back pain; however, demonstrable instability on flexion-extension radiographs may portend a favorable result from fusion [47]. In adults with predominant neural symptomatology, laminectomy or decompression alone is often inadequate, because a large decompression predisposes to instability [48–50]. Most studies agree that for isthmic spondylolisthesis, spinal fusion provides better results after decompression than decompression alone. It is unclear whether the benefit of fusion is attributable to complete immobilization of the affected motion segment, greater

Fig. 4. A lateral radiograph (*left*) showing grade I anterolisthesis of L4 on L5 that increases with extension (*right*) and reduces slightly with flexion (*center*). There is some degenerative disease at L4-5 disc, as evidenced by a loss of disc and neuroforaminal height. The posterior elements are absent at L4 and L5, which may be postsurgical in nature or may represent spinal dysraphism.

reduction of the olisthesis, or simply limitation of pathologic movement.

There has been strong debate as to the efficacy of pedicle screw instrumentation in low-grade spondylolisthesis. Although some investigations have shown no significant difference in clinical outcomes between in situ fusions and instrumented fusions [49,50], others have shown a higher rate of fusion and improved outcomes when fusion is augmented with instrumentation. Fischgrund and colleagues [51] showed that although instrumentation increased the rate of fusion, it did not improve the patient-reported clinical outcomes. Christensen and colleagues [47] performed a prospective randomized trial of instrumented posterolateral fusion (IPLF) versus non-IPLF. At 5-years of follow-up, they found that patients with low-grade isthmic spondylolisthesis had superior long-term outcomes with noninstrumented fusion ($P < .03$). In contrast, patients with primary degenerative instability had more improvement when the posterolateral fusion was augmented by instrumentation ($P < .02$). This study points to the importance of pathoetiology in surgical planning. Fig. 5 demonstrates posterior instrumentation using pedicle screw instrumentation.

Posterior instrumentation provides rigid fixation and segmental control and likely improves fusion rates. Some believe that IPLF alone does not provide enough anterior support to treat some cases of spondylolisthesis, however. They attribute unsatisfactory results for IPLF to residual micromotion and shear forces at the disc and recommend interbody grafting for increased stability and reduction of discogenic pain. Nonetheless, IPLF without interbody graft for spondylolisthesis is clinically successful in 70% to 85% of patients [46,47,50].

Additional interbody fusion reconstitutes the anterior structural support, maintaining the sagittal profile, and provides superior immediate stability [52,53]. Normal LL is primarily created by disc wedging as opposed to vertebral body wedging. This is most prominent at L4-L5 and L5-S1, which, together, account for approximately two thirds of overall LL [54,55]. Posterior lumbar interbody fusion (PLIF) was first described by Cloward [56–59] for treatment of spondylolisthesis and was used without posterior instrumentation for many years.

A variation on his concept, transforaminal lumbar interbody fusion (TLIF), was introduced by Blume and Rojas [60] and later popularized by Harms and Jeszensky [61]. The technique uses an approach through Kambin's triangle [62,63] to access the disc space without dural retraction or extensive destruction of the posterior longitudinal ligament [64]. Both techniques require preservation or augmentation of the posterior elements to maintain the tension band as well as distraction of the intervertebral disc space to place the interbody graft in compression. Complete disc removal, with the exception of the outer annulus, is optimal. Finally, partial decortication of the end plates facilitates fusion [65,66].

Degenerative spondylolisthesis with a large degree of disc space narrowing may make TLIF unfeasible; thus, a combined IPLF and anterior lumbar interbody fusion (ALIF) may be necessary to restore disc height and stabilize the segment. Biomechanical studies and clinical experience show that PLIF or TLIF without posterior instrumentation results in significant destabilization, and thus should always be supplemented by posterolateral (ie, pedicle screw) instrumentation [53,67,68]. For the remainder of this review, PLIF and TLIF refer to PLIF and TLIF with additional IPLF. Fig. 6 shows preoperative and postoperative radiographs of isthmic spondylolisthesis treated with a TLIF procedure.

The authors' group performed a retrospective analysis of 130 consecutive patients who underwent IPLF or TLIF with IPLF. In this study, 38 patients underwent the TLIF procedure and the remainder underwent the IPLF procedure. All patients had at least 24 months of follow-up. Clinical efficacy was measured by the Oswestry Disability Index and 36-Item Short-Form Health Survey (SF-36), and radiographic evaluation of the preoperative, postoperative, and final follow-up films was performed by an independent reviewer. Clinical presentations were as follows: 74% back and leg pain, 22% back pain alone, and 4% leg pain alone.

The authors' data showed a 70% overall satisfaction rate for all subjects combined. Sixty-five percent of the patients reported functional improvement, and 73% reported a considerable decrease in their level of pain. No significant difference in clinical outcomes was observed in the TLIF group. Although this study does not show a significant improvement with additional interbody fusion, a prospective randomized trial of TLIF versus IPLF for spondylolisthesis should offer a more definitive conclusion. To the authors' knowledge, no such trial has yet been reported.

Other authors have reported superior outcomes for additional interbody fusion in clinical

Fig. 5. A 36-year-old man with L5-S1, grade 1, isthmic spondylolisthesis causing back and leg pain that was managed with IPLF.

series. Suk and colleagues [69], in a retrospective study of 76 patients with isthmic spondylolisthesis, reported improved results with PLIF compared with IPLF alone. Major outcomes measured in this study were union rate, reduction of olisthesis, and clinical outcomes. They found no evidence of nonunion in the PLIF group, whereas 7.5% of the IPLF group had nonunion. Additionally, the PLIF group had a significantly larger reduction of the slip: 41.6% versus 28.3%. Furthermore, 20% of patients in the IPLF group lost 50% or more of the reduction. This supports the notion that interbody caging and grafting lend immediate stability to the reduction before fusion develops [52,64]. Although both groups had a satisfactory clinical result in greater than 90% of patients, there was a significant increase in the percentage of patients who reported an excellent clinical result among the PLIF group (75% versus 45%). This study might suggest that the addition of interbody fusion may increase efficacy in treating specifically isthmic spondylolisthesis; however, being retrospective, this conclusion is not definitive.

Fig. 6. A 52-year-old man with L5-S1, grade 1, isthmic spondylolisthesis causing back and leg pain that was treated with a TLIF procedure.

It is reasonable to expect that most benefits attributed to PLIF also apply to the currently more popular TLIF procedure. It still remains to be seen in a prospective randomized trial whether TLIF has positive effects on fusion rate and overall clinical outcome when compared with IPLF, however. TLIF has been shown to have at least as high a fusion rate as PLIF, with a significantly lower complication rate. Humphreys and colleagues [70] compared PLIF and TLIF in a retrospective study of 74 patients. They found no difference between the groups in terms of blood loss, operative time, or duration of hospital stay for single-level procedures and significantly less blood loss in the TLIF group for multilevel procedures. Importantly, the PLIF group had many complications, including four cases of radiculitis, one case of hardware breakage, and one case of nonunion. The TLIF group was free of complications.

Guidelines are being developed for when the addition of interbody fusion is appropriate. Based on their series of 120 TLIFs for various types of spondylolisthesis, McAfee and colleagues [71] concluded that "interbody cages in spondylolisthesis are useful to increase neuroforaminal height, to facilitate reduction, and to achieve 360° fusion." In a radiographic review of 35 TLIFs for isthmic spondylolisthesis, Kwon and colleagues [72] concluded that TLIF aided in anterolisthesis reduction and disc height restoration but added that sagittal balance restoration depended on anterior placement of the interbody cage.

Postoperative assessment

The assessment of fusion in the presence of an interbody fusion device must include the radiographic evaluation of four key elements [73]:

1. Spinal alignment
2. Dynamic motion studies
3. Device–host bone interface
4. New bone formation and bone remodeling

In clinical studies, successful fusions are commonly assessed by the criteria of Lenke and colleagues [74] for the posterior fusion and by those of Brantigan and colleagues [75] for the TLIF graft incorporation.

The Lenke system of union evaluation scores follow-up radiographs as one of the following:

1. Probable radiographic fusion
2. Radiographic status uncertain
3. Probable radiographic pseudarthrosis
4. Obvious radiographic pseudarthrosis

This scoring system illustrates the ambiguity in determining nonfusion rates by plain radiographs, especially in the asymptomatic patient for whom the clinical suspicion of nonunion is low. It is important to consider whether asymptomatic nonunion should be a cause for concern on an individual case basis. Clinical research outcomes, especially those of retrospective studies, seldom use CT, a more sensitive method of detecting nonunion, because CT evaluation is not routinely indicated after surgery. A CT scan should be obtained to rule in or out a less obvious pseudoarthrosis as the cause of postoperative axial back pain, however.

Summary

In summary, low-grade spondylolisthesis is an often painful condition affecting millions of people in North America with some ethnic variability. There are familial predispositions to having the lesion, and a family history of spondylolisthesis may raise one's clinical suspicion. Although the diagnosis is easily made on radiographic evaluation, the pathoetiology and appropriate treatment modality are not always as clear. In the absence of severe neurologic symptoms or an unsafe component of instability, a trial of conservative management is reasonable and prudent. Nevertheless, surgical management is more efficacious for enduring symptomatic relief and restoration of physical function. Posterolateral instrumentation is usually indicated in addition to neurologic decompression. One may consider additional interbody fusion to ensure maintenance of reduction; 360° fusion; or restoration of disc height, neuroforaminal height, or sagittal profile. Severe loss of disc height may prohibit the TLIF approach, however. Finally, whereas assessment of radiographic results lends insight to surgical technique, the true barometer of treatment success is improvement in patient quality of life.

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