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CURRENT CONCEPTS IN THE MANAGEMENT OF SPONDYLOLYSIS AND SPONDYLOLISTHESIS

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ABSTRACT

Spondylolysis and spondylolisthesis encompass a heterogeneous group of spinal disorders with varying etiologies, age distributions, clinical presentations, and management strategies. This narrative review was prepared in memory of Prof. Dr. Emin Alıcı, whose residency thesis and subsequent academic career were devoted to spondylolysis and spondylolisthesis, and whose early work significantly influenced the understanding and surgical management of these conditions in our institution. By integrating his foundational concepts with contemporary evidence, this review traces the evolution of knowledge from classical principles to current practice. Clinical manifestations range from mechanical low back pain to radiculopathy and neurogenic claudication, highlighting the importance of a careful clinical evaluation, supported by appropriate imaging. Standing radiographs remain essential for assessing slip severity, sagittal alignment, and pelvic parameters, while computed tomography and magnetic resonance imaging provide detailed evaluation of morphology. Traditional classification systems, such as Meyerding and Wiltse, remain widely used because of their simplicity, but they are limited in prognostic value and in guiding treatment. More recent systems, including those proposed by the French Society for spine surgery, clinical and radiographic degenerative spondylolisthesis classification, and the University of California San Francisco degenerative spondylolisthesis classification, incorporate sagittal balance, instability, and clinical symptoms, offering a more comprehensive framework for individualized treatment planning. This shift toward biomechanically informed and patient-specific assessment reflects principles emphasized in Prof. Dr. Emin Alıcı's early work. Management strategies differ substantially between pediatric and adult populations. Conservative treatment is the first-line approach for most cases of spondylolysis and low-grade spondylolisthesis. Surgical intervention is reserved for patients with persistent pain, neurological deficits, progressive deformity, or high-grade slips. Spondylolysis and spondylolisthesis require individualized evaluation and management, grounded in an understanding of the biomechanics, natural history, and clinical presentation. This review summarizes current evidence while honoring the lasting academic legacy of Prof. Dr. Emin Alıcı, whose contributions continue to shape modern approaches to these complex spinal disorders.

Keywords: Spondylolisthesis, spondylolysis, posterior surgery

INTRODUCTION

Spondylolisthesis is a general term used to describe anterior displacement of a vertebral body along with the vertebral column above it over the vertebra below. Spondylolisthesis may be caused by different clinical entities. Congenital dysplasia of posterior elements of vertebra, a defect or elongation of isthmus (pars interarticularis), degenerative changes of intervertebral disc or facet joints, traumatic fractures of vertebra, pathologies such as neoplasms or infection, and posterior decompression surgeries with no stabilisation are among different clinical scenarios which may cause spondylolisthesis. Spondylolysis is a defect or elongation of pars interarticularis. Spondylolysis may be unilateral or bilateral. Spondylolysis or spondylolisthesis may be seen in different age groups, spondylolyis being commonly encountered in active adolescents, whereas degenerative spondylolisthesis is mostly seen in elderly age group. Clinical presentation may vary from mild low back pain to neurological claudication or neurological deficisits depending on etiology. There are many classification systems, relying on displacement percentage (Meyerding) or causative etiology (Wiltse), or relatively newly described classification taking sagittal alignment and/or instability into consideration such as French Society for spine surgery (FSSS) and clinical and radiographic degenerative spondylolisthesis classification (CARDS). Conservative methods (non-steroidal anti-inflammatory drug, physical thearpy, bracing) are usually

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firstline treatment for patients with mild symptoms[1]. Patients with segmental instability, persisting pain and neurologic deficits often require surgical treatment varying from fusion, reduction, decompression and/or fusion with instrumentation.

Epidemiology and Natural history

Spondylolisthesis and spondylolysis are disorders of bipedals, and have not been reported newborns or in non-ambulants[2,3,4]. Lumbar spondylolysis is seen radiologically in 4.4% percent of 6 year old children and 6% of young adults[3]. Children who are actively involved in sports activities that require repetative spine flexion-extension and rotation such as gymnastics, volleyball, wrestling and diving are more prone to develop spondylolysis. Wimberly and Lauerman[5] reported the incidence of spondylolysis to be up to 50% among athletes engaged in high-risk sports with persistent back pain. Pelvic geometry, increased pelvic incidence and related larger lumbar lordosis are reported to increase the risk of pars interarticularis stress fracture[6]. Most of pars interarticularis fractures develop on lower lumbar levels. A magnetic resonance imaging (MRI) study by Kriz et al.[7] revealed that 65% of pars fracture occured at L5, 24% at L4, 8.4% at L3, and only 7.1% at or above L3. The incidence of spondylolysis is estimated to be 3-8%, with a prevalence of approximately 11.5%[8]. Unilateral spondylolysis or stress reaction in isthmus detected by MRI without a fracture is a self-limiting condition and has been reported to heal at a mean of 14 weeks[9,10]. A computed tomography study revealed fusion of acute partial or complete isthmus fracture in 67% of of patients after activity restriction of 4 months[11]. Progression to spondylolisthesis was encountered in 25% of patients with bilateral spondylolysis in a 2 year follow-up study[11]. Healing and fusion of spondylolytic defect depends on anatomical features and more likely with unilateral defect or defect in L4, whereas non-healing or progression to spondylolysis is more common in patients with a trapezoidal L5, rounding of sacral dome, and more than 5% spondylolisthesis, whereas union is not expected to occur with sclerotic and round fracture lines (Figures 1 and 2)[12]. 80% of patients with spondylolysis return to sport activities and remain pain-free but persistent low back pain may develop in 20%[13]. Increased incidence of spondylolysis among first degree relatives are reported and genetic predispostion such as seen in Alaska Natives as well as sagittal and coronal plane vartebral deformities may predispose to development of spondylolysis[11,14,15].

Spondylolisthesis can be seen in approximately 6% of general population[3]. Progression of spondylolisthesis depends on the etiology. Degenerative spondylolistesis is mostly seen in adults, frequently associated with aging, with predominance in females (two to six times more common), possibly related to increased laxity and hormonal factors, with prevelance of 24-43% in women over 65 years of age[16,17,18]. Most cases of degenerative spondylolisthesis are low-grade and do not progress beyond Meyerding grade I or II. Dysplastic (low or high-grade) sponylolisthesis tend to progress and may present with pain and neurologic deficits and may progress to Meyerding grades III, IV or even to spondyloptosis (Figure 3). Rate of progression is reported to be 34% in degenerative spondylolisthesis, 32% in isthmic spondylolisthesis, and 45 in traumatic cases[19].

Clinical Features

Although not all patients develop clinical symptoms, main presenting symptom of patients with spondylolysis or spondylolisthesis is low back pain. The low back pain has typical mechanical characteristics, worsening when transitioning from supine to erect and flexion or extension of the spine[16,20]. With aging, especially in degenerative spondylolisthesis cases,

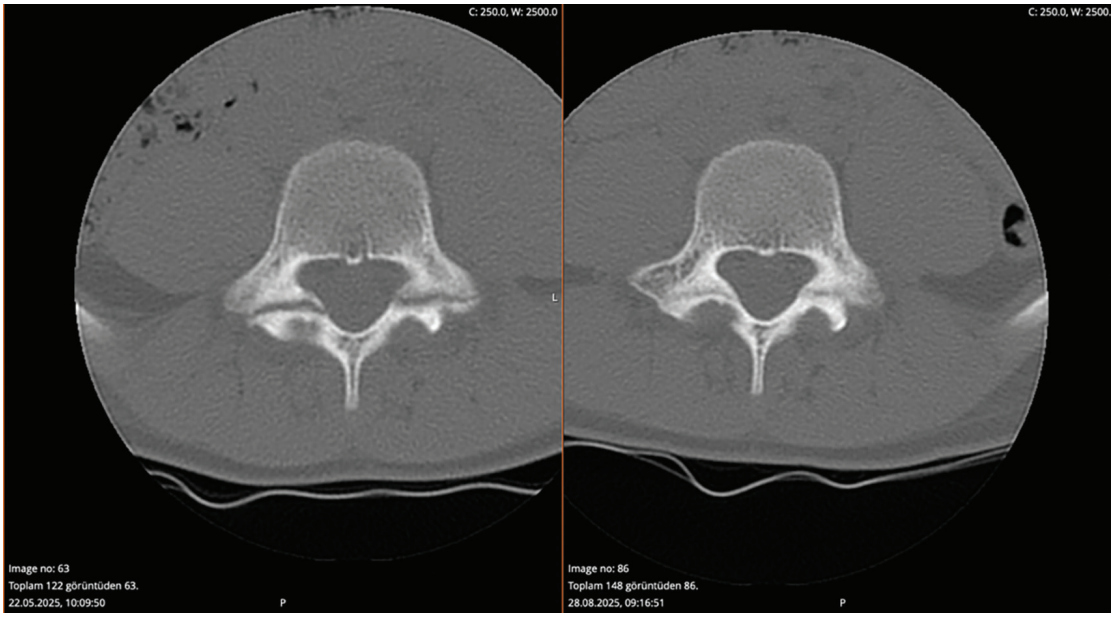

Figure 1. Fused pars defect after 3 months of conservative treatment

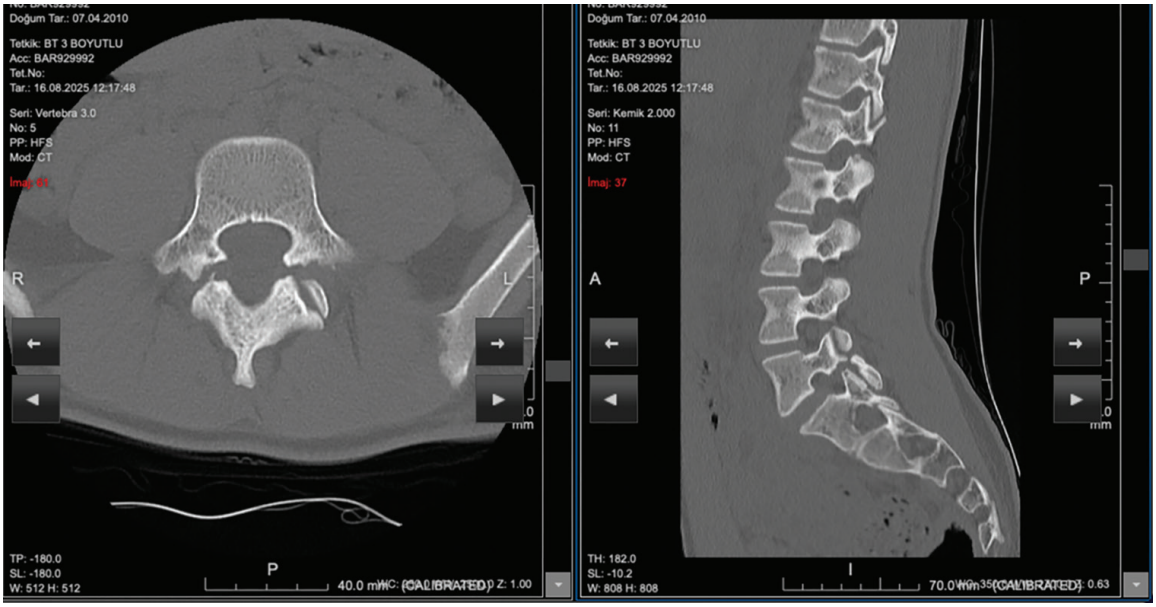

Figure 2. Chronic, non-union of pars defect in 14 years old female gymnast. CT: Computed tomography

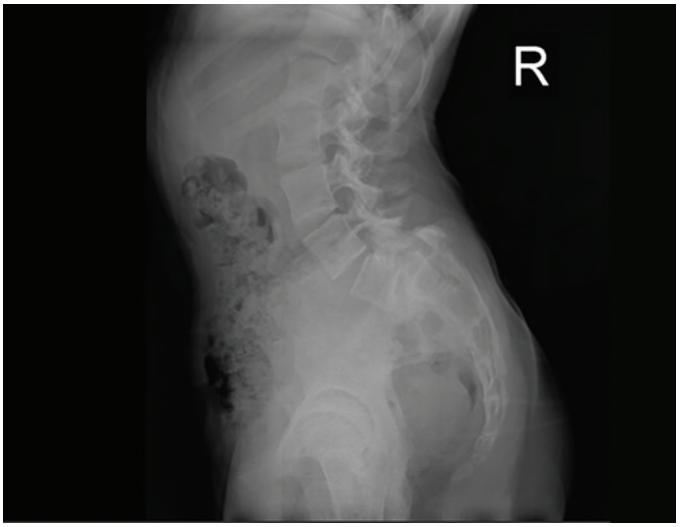

Figure 3. High-grade spondylolisthesis

degenerative changes develop at the functional segmental unit and leg pain, neurological claudication, radiculopathy become more dominant[21]. In the spine patient outcomes research trial study, only 7% of patients had instability, whereas 34% had pain radiating to legs, 26% back pain and 40% had both leg and back pain[2]. Symptoms become more apparent with higher grade spondylolisthesis (grade III-IV), 55% to 91% back pain, 44% to 55% radicular symptoms and up to 50% activity limitation[17,22,23]. Physical examination requires detailed assessment of posture, lumbar lordosis, gait (for Phalen Dickson sign), spinal mobility at flexion and extension, neurological status, and motor and sensory deficits. Palpation of spinous processes may delineate instability which is usually pathognomonic for bilateral pars defects and step-off sign for spondylolisthesis. Stork test (patient extends spine while standing on one leg) is also helpful for detecting pars defects. Hamstring tightness and pain at lower back and thigh on spinal extension indicates isthmic spondylolisthesis.

Imaging

First-line imaging modality for patients suspected of spondylolysis or spondylolisthesis is standing anterior-posterior and lateral X-rays. Standing lumbosacral vertebral xray is valuable for detecting bilteral pars defects, spondylolisthesis grade (percentage of slippage), slip angle, and lumbar lordosis. Supine X-rays should be avoided as this position allows listhesis to reduce into its normal position (Figure 4). Full vertebral scoliosis X-rays are importand and must be obtained whenever possible, to detect sagittal and coronal plane deformities and pelvic parameters (pelvic incidence) which are important for development and may be a predisposing factor for spondylolisthesis[6]. Dynamic lateral flexion and extension X-rays taken supine are valuable in detecting segmental instability. Segmental instability must be suspected when translation is more than 3mm and change in disc angle is more than 10 degrees[24]. Right and left oblique X-rays to detect pars defects are no longer recommended as they do not improve diagnostic accuracy[25,26].

Computerised tomography provides valuable information about the presence and status of pars defects, whether the fracture is acute, or chronic with sclerotic round edges[27]. MRI is also valuable in detecting pre-fracture stress reaction in pars interarticularis or edema in pedicle[28]. MRI is also valuable for diagnosis in case of neurologic deficits, however, it must be remembered that MRI takes 20 min lying down in supine position, therefore is not accurate for diagnosing spondylolisthesis.

Classification

One of the most commonly used classification for spondylolisthesis is Meyerding classification. First described in 1932, it basically defines the percentage of slip on lower vertebra on lateral X-ray. The upper end-plate of caudal vertebra is divided into 4 parts, and the location of the posterior end of cranial vertebral corpus determines the grade (Table 1). Grade 1 indicates up to 25%, grade 2 up to 50%, grade 3 up to %75, and grade 4 up to %75 slippage. Grade 5, although was not in the original classification indicates 100% displacement and often reffered as spondyloptosis. Although Meyerding a is well-known and used classification, this system can not differentiate between low and high-risk patients for slippage. Also many patients with severe degerative changes and clinical finding may be classified as grade 1 or 2. Therefore, although widely used and easily describes the amount of slip, Meyerding classification lacks the accuracy to guide treatment and predict prognosis.

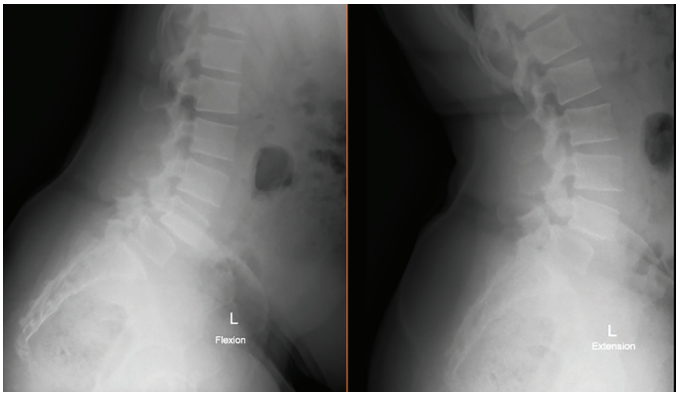

Figure 4. Flexion-extension dynamic X-rays

Wiltse et al.[29] proposed a classification based on etiology and causative mechanism in 1976: dysplastic (type I), isthmic (type II), degenerative (type III), traumatic (type IV), pathologic (type V) (Table 2). Type I is the result of dysplasia of posterior elements of L5. Type II corresponds to a defect in isthmus and further divided into type IIA, stress fracture of pars interarticularis and type IIB, elongated pars interarticularis resulting from repeated fractures and healing. Type III is caused by degeneration of intervertabral disc, facet joints and ligament. Type IV, traumatic type is fractures caused by fractures due to high energy trauma. Type V is caused by pathologies such as neoplasms or metabolic bone diseases. Type IV is added to the classification later which is iatrogenic, and caused by wide decompressions during surgery with no stabilisation. Although Wiltse classification clearly distinguishes the etiology of spondylolisthesis, it can not describe the severity of listhesis, nor risk for progression of slip.

Marchetti and Bartolozzi, in an effort to take into account the natural history and risk of progression, described their classification as developmental and acquired, and further divided developmental group into low dysplastic and high displastic groups (Table 3). However, as Lan et al.[30] pointed out in their review, this system lacks the ability to accurately describe the degree of slippage, describe and predict disease severity and prognosis, and surgical treatment methods. Many classification systems have been described recently to accomplish the insufficiencies of these widely used classification, like FSSS and CARDS[31,32]. The FSSS classification take into account the lumbar lordosis, pelvic incidence, sagittal vertical axis and pelvic tilt and reccommend surgery accordingly (Table 4). CARDS classification system takes into account 3 radiographic and 1 clinical parameters, as intervertebral disk height preservation, segmental angle, vertebral translation

Table 1. Meyerding classification

Grade	Percentage of slip	Definition
Grade I	**0-25%**	Mild anterior translation of the vertebral body.
Grade II	**26-50%**	Moderate slip with partial forward displacement.
Grade III	**51-75%**	Advanced slip; significant anterior translation.
Grade IV	**76-100%**	Severe displacement approaching complete dislocation.
Grade V (spondyloptosis)	**>100%**	Complete anterior dislocation; vertebral body fully translated beyond sacrum.

Table 2. Wiltse-Newman-Macnab classification

Type	Name	Definition
I	Dysplastic	Congenital deficiency of L5-S1 facets or sacral anatomy leading to slip.
II	Isthmic	Pars interarticularis defect; includes stress fracture (IIA), pars elongation (IIB), and acute fracture (IIC).
III	Degenerative	Slip due to facet joint degeneration with intact pars; typical in older adults.
IV	Traumatic	Slip caused by fracture of posterior elements other than the pars.
V	Pathologic	Slip due to bone-weakening disease (tumor, infection, metabolic disorder).
VI*	Iatrogenic	Post-surgical instability (e.g., after wide laminectomy). Not in original* Wiltse.

IIA: Type II A, IIB: Type II B, IIC: Type II C

and presence and bilaterality of leg pain (Table 5). In 2024, Rangwalla et al.[33] proposed a novel classification for degenerative spondylolisthesis, University of California San Francisco degenerative spondylolisthesis classification, which includes four components; 1) segmental dynamic instability, 2) location of spinal stenosis, 3) sagittal alignment, and 4) primary clinical presentation (Table 6).

Classifications based primarily on etiology or slip percentage are inadequate for prediction of prognosis or guiding the treatment plan. Recently described classifications which include sagittal parameters and clinical findings may ameliorate the process of classification and decision making in lumbar spondylolisthesis.

Treatment

Treatment of Pediatric Spondylolysis and Spondylolisthesis

Pediatric spondylolysis and spondylolisthesis is addressed seperately from adult spondylolisthesis as degenerative type is the most common type in adults where clinical symptoms are usually caused by secondary changes in the spinal segment in addition to instability. As acute pediatric spondylolysis usually has a favorable prognosis and has a chance of fracture healing, conservative treatment is the first-line treatment. Restriction of high-risk activities including flexion-extension or rotation, core muscle strengthening for 4 months usually increases the likelihood of fusion[34]. Immobilisation or brace

Table 3. Marchetti Bartolozzi classification

Main type	Subtype	Definition
Type I-developmental	Ia-high dysplastic	Severe congenital lumbosacral dysplasia with high-risk of progression.
	Ib-low dysplastic	Mild–moderate congenital dysplasia with limited progression potential.
	IIa-isthmic (lytic)	True pars interarticularis defect caused by stress or fatigue fracture.
	IIb-isthmic (elongation)	Pars elongation due to chronic repetitive stress without complete defect.
Type II-acquired (secondary)	IIIa-postsurgical (iatrogenic)	Slip associated with posterior arch insufficiency after spinal surgery.
	IIIb-posttraumatic	Slip due to fractures of posterior elements other than the pars.
	IVa-degenerative	Slip secondary to facet joint arthrosis or segmental degeneration with intact pars.
	IVb-pathologic	Slip resulting from bone-weakening diseases such as tumor, infection, or metabolic disorders.

Table 4. FSSS classification

Type	Subtype	Radiographic criteria	Description
Type 1	**1A**	PI-LL <10°; SL >5°	Normal global sagittal alignment with preserved segmental lordosis
	1B	PI-LL <10°; SL <5°	Normal global sagittal alignment with loss of segmental lordosis
Type 2	**2A**	PI-LL >10°; PT <25°	Compensated malalignment without pelvic compensation
	2B	PI-LL >10°; PT >25°	Compensated malalignment with pelvic compensation
Type 3	**-**	SVA >4 cm	Global sagittal malalignment

FSSS: French Society for spine surgery, PI: Pelvic incidence, LL: Lumbar lordosis, SVA: Sagittal vertical axis, SL: Segmental lordosis, PT: Pelvic tilt

Table 5. CARDS classification

Type	Radiographic criteria	Definition
Type A	Advanced disc collapse; no segmental kyphosis	Collapsed disc space with preserved segmental lordosis
Type B	Disc height partially preserved; translation ≤5 mm	Mild slip with maintained alignment
Type C	Disc height partially preserved; translation >5 mm	Significant slip with progressive instability
Type D	Segmental kyphosis present	Kyphotic alignment at the affected motion segment

CARDS: Clinical and radiographic degenerative spondylolisthesis classification

treatment does not improve results[11]. Patients that do not respond to conservative treatment may benefit from surgery. Many methods have been described for surgical treatment of symptomatic spondylolysis refractory to conservative which can be grouped as direct repair or spinal segmental fusion. Spinal segmental fusion is rarely indicated in spondylolysis without spondylolisthesis. Direct repair techniques are contraindicated in spondylolysis cases with more than Meyerding grade I, facet joint arthrosis, severe disc degeneration. Conservative treatment of spondylolysis is the first-line treatment for unilateral pars interarticularis defect, patients with high signal intensity on MRI, and acute bilateral defects. Conservative treatment includes 4 months of activity restriction, isometric trunk muscle strenthening exercises (core stability) and limiting trunk flexion and extension. Spondylolysis patients with unresolved clinical findings, bilateral defects with sclerotic edges indicating non-union may benefit from pars repair techniques. Many methods have been described for direct pars repair, including Buck screw, Scott wiring, Morscher screw, pedicle screw-hook-rod and V-rod (Figure 5)[35]. Resection and grafting of defect is followed by a stabilisation in these thechniques. Buck screw and Scott wiring are not practical and do not provide adequate stability[36]. Pedicle-screw-hook-rod and V-rod techniques are most popular methods for direct pars repair in patients with spondylolysis[37].

Surgical Management

Surgical treatment is usually indicated when conservative treatment fails and patients continue to experience persistent back pain or neurologic symptoms like radiculopathy or neurogenic claudication that affects their quality of life. High-grade spondylolisthesis due to dysplasia and segmental degenerative changes in degenerative spondylolisthesis are two different and main etiologies and indications requiring surgical intervention. Dysplastic spondylolisthesis and degenerative spondylolisthesis are two distinct entities with different treatment strategies, therefore will be discussed seperately.

High-grade Spondylolisthesis

High-grade (more than Meyerding grade II) spondylolisthesis usually develops in L5 with dysplasia of posterior elements. High pelvic incidence and sacral slope causes shear forces, therefore patients with this pelvic morphology are more prone to develop high-grade spondylolisthesis. Surgical treatment methods for high-grade spondylolisthesis include *in-situ* fusion, reduction and fusion, and reduction and instrumented fusion.

In-situ Fusion

In-situ fusion can be posterolateral, interbody and circumferential. Posterolateral *in-situ* fusion via muscle splitting Wiltse approach between L4 and S1 is a safe method but has more than 20% risk of non-union and progression of slip[38]. Interbody fusion has the advantage of creating a fusion between vertebral bodies of L5 and S1, thus obtaining a wider fusion area when combined with posterolateral fusion. Interbody fusion can be obtained with a fibular strut graft (Bohlman technique), pedicle screws or transsacral interbody cage[39,40]. Bohlman method is a popular method. In this method in which a fibular strut graft is inserted into a bony tunnel from posterior body of S1 to anterior body of L5 after wide laminectomies of L5 and S1, then augmented with posterolateral grafting between L4 and S1. Alıcı, in 1991, decribed methods used for *in-situ* fixation of spondylolisthesis (Figures 6-8)[41].

Table 6. UCSF DS classification

Category	Subcategory	Definition
1. Segmental dynamic instability	**<3 mm translation**	Stable segment with minimal motion
	3-5 mm translation	Moderate dynamic instability
	>5 mm translation	Marked dynamic instability
2. Location of spinal stenosis	**Central/lateral recess stenosis only**	Stenosis limited to central canal or lateral recess
	Foraminal stenosis without up/down stenosis	Foraminal narrowing without pedicle-on-pedicle compression
	Foraminal stenosis with up/down stenosis	Foraminal stenosis involving superior/inferior compression (pedicle or osteophyte impingement)
3. Sagittal alignment	**Maintained segmental lordosis**	Normal local alignment at the involved segment
	Segmental neutral or kyphotic alignment	Loss of local lordosis or segmental kyphosis
	Global sagittal malalignment	SVA >5 cm or PT >30°
4. Primary clinical presentation	**Primarily leg pain**	Leg pain VAS ≥4; back pain <4
	Both leg and back pain	Leg pain VAS ≥4 and back pain VAS ≥4
	Primarily back pain	Back pain VAS ≥4; leg pain <4

UCSF DS: University of California San Francisco degenerative spondylolisthesis, SVA: Sagittal vertical axis, PT: Pelvic tilt, VAS: Visual analog scale

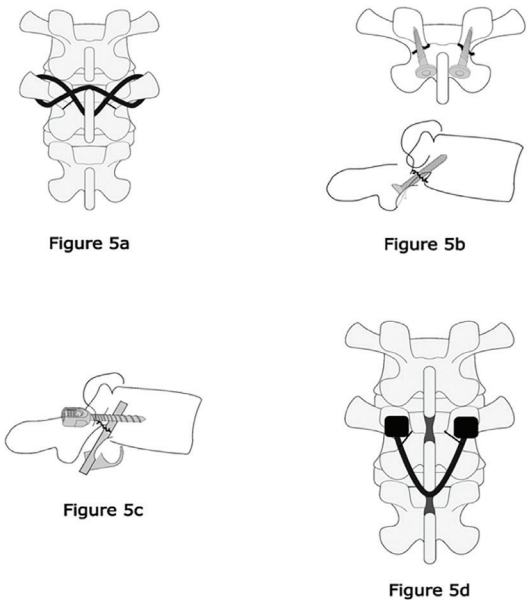

Figure 5. Direct repair techniques. **a)** Scott wiring, **b)** Buck screw, **c)** Screw-hook, **d)** V-rod

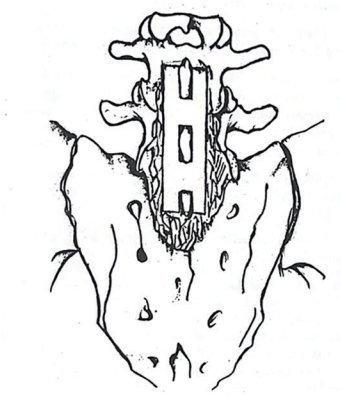

Figure 6. Bosworth-Sicard method

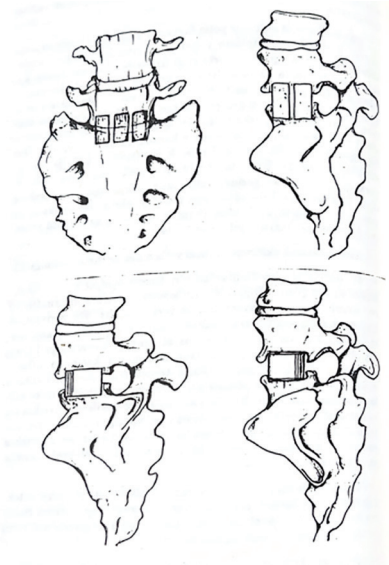

Figure 7. Wilterberger method

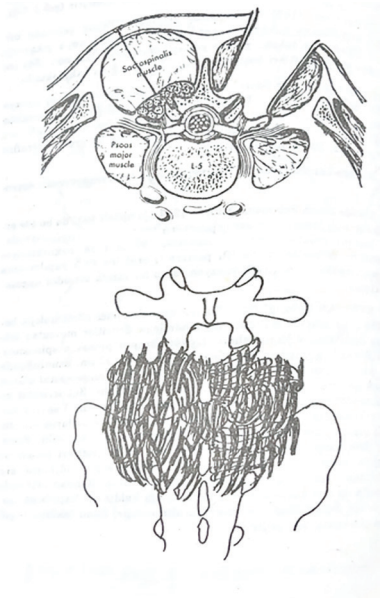

Figure 8. Wiltse and Hibbs method

Reduction and Fusion

Sagittal balance is generally disturbed in high-grade spondylolisthesis. Reduction of slip aids in restoration of sagittal balance, global spinopelvic balance and also increases fusion rates[42]. Alıcı[41], in his 1991 textbook described Scaglietti maneouvre for closed reduction of high-grade spondylolisthesis. Instrumented reduction and fusion techniques are generally indicated in patients with high slip angle or severe sagittal imbalance, high-grade spondylolisthesis, high-grade dysplastic spondylolisthesis, hyper-mobility of L5-S1 segment, and anatomic factors such as small transverse processes, sacral dysplasia, trapezoidal L5 vertebral body, and rounding of the sacrum[43]. L5 nerve stretch is a potential complication during reduction of a long standing slip of L5 over S1 vertebra. Therefore wide decompression of posterior elements of L5 is mandatory. Sacral dome osteotomy aids in reducing L5 nerve stretch and increasing fusion. Extension of instrumentation and fusion to L4 is usually recommended[44]. In rare cases like spondyloptosis L5 vertebrectomy or transsacral *in-situ* fusion are options.

Degenerative Spondylolisthesis

Degenerative changes in the vertebral segment that take place during stabilisation phase in the unstable vertebral segment frequently cause facet joint arthritis and hypertrophy of malfunctioning ligaments thus cause lumbar spinal stenosis. Furthermore, segmental instability in degenerative spondiylolisthesis is not as common as it is isthmic or dysplastic spondylolisthesis. Studies demonstrate substantially greater improvement of pain and function with surgical methods compared to conservative treatment in degenerative spondylolisthesis[45,46]. Decompression alone and decompression with instrumented fusion are two surgical methods widely

used in spondylolisthesis. Decompression of hypertrophic facet joint osteophytes and ligamentum flavum without creating instability is a safe and less invasive method for relief of symptoms in degenerative spondylolisthesis. However, in the presence of instability on flexion extension lateral X-rays fusion is generally recommended to decrease the risk of progression of slip after decompression. Decompression with fusion became widely considered standart treatment with support from studies indicating increased instability after decompression alone[47,48]. There is an ongoing debate on whether fusion should be added to decompression. Recent meta-analysis and systematic review studies demonstrated no significant advantages of fusion in terms of pain relief, patient reported outcomes and reoperation rates, rather reported increased operative time and surgical complications[49,50]. Fusion in degenerative spondylolisthesis can be performed by posterior only with pedicle screws, or interbody fusion either by anterior, posterior lumbar interbody fusion (PLIF) or transforaminal lumbar interbody fusion (TLIF). PLIF is performed through posterior approach and involves extensive exposure, nerve retraction which may increase neurological complication and greater blood loss[51]. TLIF is performed unilaterally, requires less nerve retraction decreasing neurological complications[52]. Both TLIF and PLIF help correcting lordosis and sagittal balance and increasing fusion rates. In a systematic review of studies comparing TLIF and PLIF by Zhang et al.[53] demonstrated increased complication rates and operative time with PLIF with no difference in fusion rates, patient reported outcomes and functional results.The decision to add fusion and to perform fusion either posterior or anterior with TLIF or PLIF during decompression surgery for degenerative spondylolisthesis must be individualised based on presence of instability, severity of sympomts and requirement of correction of sagittal profile.

CONCLUSION

Spondylolisthesis and spondylolysis are two different entities. Spondylolisthesis is an anterior displacement of a vertebral body, and spondylolysis is a defect or elongation of pars interarticularis. There are different classifications of spondylolisthesis, based on etiology, grade of slip, and recent classifications taking sagittal profile, clinical symptoms or instability into consideration. While spondylolysis is common among adolescent athletes, spondylolisthesis can be encountered in different age groups depending on etiology. Conservative treatment is the first-line treatment for spondylolysis and spondylolisthesis. In patients inresponsive to consterva tive treatment or with progressive neurological and clinical symptoms surgical methods can be performed. Defect repair and monosegmental fixation must be the surgical method of choice for spondylolysis with minimal slip. Decompression and fixation and/or reduction is generally required spondylolisthesis cases, depending on neurologic deficits, clinical symptoms and sagittal deformity.

Footnotes

Authorship Contributions

Concept: M.C.K., Design: R.H.B., Data Collection or Processing: M.C.K., E.Ak., Analysis or Interpretation: E.Ak., Literature Search: E.Ak., Writing: M.C.K.

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