

Evaluation of Pars Repair Using Smiley Face Rod Technique in Isthmic Spondylolisthesis

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Abstract

Background: Among adults, isthmic spondylolisthesis affects a relatively tiny percentage of people. Even though low back pain is prevalent in these individuals on a level with the general population, both the pars interarticularis defects and forward slide can act as separate pain inducers.

Degenerative changes brought on by the deformity or nerve root impingement linked to the pars defect may cause neurologic symptoms. Surgical decompression and stabilization may be beneficial for patients with neurologic symptoms or intractable pain, though the majority of symptomatic cases can be effectively managed without surgery.

Surgery on carefully selected patients had >80% success rates with a low rate of complications. Surgical procedures can include decompression, fusion at the posterolateral level, fusion at the anterior lumbosacral interbody level, and fusion at the circumferential level.

Aim of Study: The aim of the study is to evaluate direct pars repair using smiley face-shaped rod technique by utilizing bony graft from iliac crest for direct fusion at the site of the pars defect in isthmic spondylolisthesis patients admitted to the Neurosurgery Department at Alexandria Main University Hospital.

Patients and Methods: This study is conducted on 30 consecutive adult patients presenting with isthmic lumbar spondylolisthesis. Direct pars repair using smiley face-shaped rod technique with iliac crest bone graft for 30 patients.

Preoperatively, all patients included in the study will be subjected to:

- Detailed history taking.
- Complete physical examination.

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- Clinical assessment preoperatively will include complete neurological examination and estimation of low back pain and sciatica severity.

Investigations for assessment of the patients:

- 1- Plain X-ray of the lumbar spine (anteroposterior, lateral, and dynamic views).
- 2- Computed tomographic (CT) scan of the lumbar spine.
- 3- Magnetic resonance imaging (MRI) of the lumbar spine.

Results: According to post-operative fusion for pars defect, the study showed that at 3 months post operative it ranged from 25.0-35.0 with mean value 31.10 ± 4.19 and median 32.0, while at 6 months post operative it ranged from 40.0-60.0 with mean value 52.17 ± 6.52 and median 50.0, however at 12 months post operative it ranged from 73.0-92.0 with mean value 79.23 ± 4.84 and median 80.0. Between various follow-up intervals, there was a statistically significant variation in the post-operative fusion rates. ($p \leq 0.05$).

Conclusion: The Smiley face rod method for pars repair in patients with isthmic spondylolisthesis is an effective technique to manage pars defect if the disc is healthy, if there is no or minimal slippage of the vertebrae (<2mm), and efficient for preservation of the motion segment especially in adolescent athletes.

Key Words: Pars repair – Smiley face rod technique – Pedicular Screw – Oswestry disability index – Visual analogue score.

Introduction

AMONG adults, isthmic spondylolisthesis affects a relatively tiny percentage of people. Even though low back pain is prevalent in these individuals on a level with the general population, both the pars interarticularis defects and forward slide can act as

separate pain inducers [1]. Degenerative changes brought on by the deformity or nerve root impingement linked to the pars defect may cause neurologic symptoms. Surgical decompression and stabilization may be beneficial for patients with neurologic symptoms or intractable pain, though the majority of symptomatic cases can be effectively managed without surgery [1].

Surgery on carefully selected patients had >80% success rates with a low rate of complications. Surgical procedures can include decompression, fusion at the posterolateral level, fusion at the anterior lumbosacral interbody level, and fusion at the circumferential level [1]. Spondylolisthesis has only ever been observed in people and no other species. The ability of a man to keep his posture upright alongside with specific lumbar lordosis are thought to be linked to the development of spondylolisthesis [2].

The most common forms of spondylolisthesis are the isthmic variety, the dysplastic variety, and the degenerative variety.. Spondylolisthesis affects between 4 and 8% of adults in general, varying widely by ethnicity, age range, and sex. As would be anticipated, spondylolysis occurs more frequently than spondylolisthesis; approximately 50% of pars defects result in vertebral body subluxation. It has been estimated that Spondylolysis tend to occur between 4.4 and 5.8% of population, while isthmic spondylolisthesis occurs between 2.6 and 4.4% [3].

Between the ages of 5 and 7 and during adolescence, two peaks are in the appearance of isthmic spondylolisthesis. Isthmic spondylolisthesis affects men twice as frequently as it does women. However, women are four times more prone than men to experience slippage progression. The danger of progressive deformity is generally greatest in higher-grade slippages (Meyerding Grade I) [4]. A significant percentage 24-70% of patients with isthmic spondylolisthesis also have occult spina bifida. Hypoplastic or missing posterior parts, as seen in spina bifida occulta, can increase the tension on the pars, leading to injury and deformity [5].

The mean incidence of pars defects is higher in young athletes, and this is notably true among gymnasts and weight lifters. The high incidence of pars stress fractures in athletes has been linked to the repetitive bending, stretching, and twisting motions required by many sports [6].

Biomechanical stresses along with genetic tendency for a dysplastic cartilaginous region in the developing posterior arch may result in spondylol-

ysis. Patients who already had slippage, specially L4-L5 region, at the time of diagnosis progressed to 7% to 20% more. 10% of all slips are at the L4-L5 level, where they are more likely to progress and manifest symptoms [8].

It is expected that 5% of asymptomatic adults with bilateral L5 defects will experience slip progression, with the probability of progression generally decreasing with age. According to MRI research, disc degeneration is more common in patients with bilateral L5-S1 defects than it is in individuals with unilateral pars defects, and higher levels of disc degeneration are linked to higher levels of slip [9]. Adults with symptoms are thought to experience slip progression in 20% of cases, and all of these cases have disc degeneration at the slipped level. Progression is more prevalent, tends to be more evident in adults than in teens, and is associated with disc degeneration at the slipped level in people with bilateral L4 spondylolysis [7].

Only 5% of individuals may experience progression greater than 10mm. In individuals with spondylolysis, mechanical factors are important [8]. Adult high-level athletes have a similar prevalence of spondylolysis (8%) to the general population. Greater occurrences are observed in throwers (27%) as well as in artistic gymnasts (17%), rowers (17%), weightlifters (13%), and swimmers (10%) [10].

Twelve out of fifty-one cricket bowlers examined by Engstrom and Walker, also exhibited pars stress fractures, which have been observed in 15% of American college football players. As a result of posterior pull back of paraspinal muscles on the loose posterior elements alongside with anterior shearing of the intervertebral discs in patients with bilateral pars interarticularis defects, these individuals may experience micromotion at the affected level. In the etiology of spondylolisthesis, bipedal walking, lumbar lordosis, and sacral inclination shear all play important mechanical roles [11,12].

The anterior subluxation of the vertebrae stresses the nearby disc, causing it to degenerate gradually. The L5-S1 level is the location of isthmic spondylolisthesis that occurs most frequently due to an L-5 pars deformity. According to estimates, this pars abnormality occurs in 90% of cases at L-5, 5% of cases at L-4, and the remaining instances in other locations [14]. The pars interarticularis is the part that connects the lamina with the pedicle, facet joint, and transverse process of the spinal column. Thus, this is crucial for maintaining segmental continuity [13]. Isthmic spondylolisthesis is hypothe-

sized to result from a combination of mechanical, genetic, and hormonal factors. In an upright position, the pars interarticularis is subjected to the combined forces of gravity and postural stress [15].

It is well established that bending, twisting, and twisting stresses all contribute to the development of fatigue cracks. In the presence of predisposing variables, microfractures of the pars can be caused by repeated trauma. These fractures can heal, but in some cases fibrous union made of fibrocartilaginous tissue forms [16].

The fibrous union formed across the pars is normally weaker than bone and can worsen in response to increased tension. The high incidence of isthmic spondylolisthesis among first-degree relatives of people who have it provides evidence for a hereditary contribution to the disorder, however this remains controversial [17].

Adults with spondylolysis or spondylolisthesis have rates of low back pain and related disabilities comparable to those of the general population. Among children and teenagers, back discomfort is unusual, but it becomes increasingly prevalent with age. Women with pars defects do not have a higher incidence of pregnancy-related low back pain [18].

Due to the high occurrence of asymptomatic spondylolysis and spondylolisthesis, it is important to examine other reasons of back pain in all instances. It is important to get a detailed description of the pain, which should include its precise position, duration, intensity, and other characteristics as well as potential causes of relief and aggravation [1].

Physical examination of a spondylolisthesis patient may reveal a step-off at the spinous process above the slip level.

More sacral inclination leads to lumbar hyperlordosis and torso restriction. Tight hamstrings and a decreased ability to fully extend the back are common symptoms among those suffering from this ailment.

Pain in the lower back often travels down the back of the thighs and buttocks in adults. The stretched anulus fibrosus may be stimulating degenerative discs or deteriorating facet joints, causing referred pain [7].

Pain or tingling that radiates in a dermatomal pattern below the knee, which may be accompanied by weakness or numbness, is often the result of nerve root impingement. Static or dynamic listhesis, osteophytes on the vertebral end plates, hypertrophic fibrocartilaginous or bony tissue im-

pinging on the exiting nerve root at the region of the pars interarticularis defect, all contribute to the neurologic symptoms and indications seen in spondylolisthesis [19].

When the transverse process diameter is considerable and the degree of isthmic spondylolisthesis is greater than 20%, nerve root impingement can occur as a result of disc herniation or bulge-induced nerve root compression. Forward slip of the vertebral body itself does not often result in foraminal or central stenosis in the isthmic variety, in contrast to degenerative spondylolisthesis [20]. However, the patient with a loose posterior neural arch with a lesion in both of their pars interarticularis is not likely to have a completely obstructed cauda equina. The thecal sac may protrude beyond the posterosuperior margin of the sacrum in patients with an enlarged pars interarticularis and severe listhesis [21]. Finding radicular symptoms that anatomically correspond to the level of the pars defect is one way to determine if the pars defect is the cause of pain. Those with solely axial back pain need a comprehensive history review and clinical evaluation to determine the source of their discomfort [22].

Axial back pain could be caused by a pars defect if the patient has neurologic discomfort at the level of the pars defect, complained of back pain as a teenager, has no other spinal pathology, and dynamic radiographs show no pathologic motion [23].

Imaging is used to determine the lumbar index, which measures the degree of listhetic deformity of the vertebral bodies, and the pelvic incidence, which evaluates the degree to which the lumbosacral-pelvic orientation is related to the sagittal alignment of the spine [24].

If the pars defect is not visible on the lateral radiograph and clinical concern persists, an oblique lumbar spine radiograph at 30 degrees should be obtained. AP radiographs, including AP radiographs tilted at 30 degrees caudally, may reveal spina bifida or an associated scoliosis. The physician needs to keep an eye out for dysplastic features such as sacral doming and a deficient inferior articular process, in addition to degenerative alterations like osteophyte production and disc height reduction [25].

In a patient with a confirmed pars defect, flexion and extension lateral radiographs may be useful for detecting dynamic motion at the listhetic region and mild spondylolisthesis. A larger proportion of slide at L5-S1 has been shown to statistically correlate with disc height decrease at this level [26].

Using upright, neutral lateral radiographs of the lumbar spine, the degree of slide is evaluated to determine the Meyerding classification grade. There are five distinct categories of slip based on the following characteristics: Grade I is between 0% and 25%, Grade II between 25% and 50%, Grade III between 50% and 75%, Grade IV between 75% and 100%, and Grade V over 100%. Calculating the superior vertebral body's translation as a percentage of the distance between the two lines drawn through the posterior walls of the superior and inferior vertebral bodies. Grades I and II are typically considered to be low-grade slip, whereas Grades III, IV, and V are considered to be high-grade slip. Spondyloptosis of Grade V is defined as a slide of more than 100 percent. Lateral flexion and extension views could be used to assess segmental translation for a more comprehensive assessment. In this way, the extent of mobility loss and the severity of the slip might be better assessed [27].

The lumbar index, which evaluates the degree to which the vertebral bodies are wedged, is low in premium slides. The average pelvic incidence of adults is 57 degrees, while the normal ranges for men and women are 53.2 degrees to 7.0 degrees and 48 degrees to 7.0 degrees, respectively. Slip substantially correlates with pelvic incidence greater than 68.5° ($p=0.03$). CT, which likewise has a great degree of sensitivity, provides the finest bony architectural detail [7].

Conservative treatment may provide temporary relief for the majority of patients suffering from axial or radicular pain due to lumbar spondylolisthesis [1].

Non-steroidal anti-inflammatory medications, adjustment of pain-inducing activities, and relative rest for 3–5 days are the mainstays of early treatment for these symptomatic persons. Some patients who are in extreme pain may benefit from using a muscle relaxant. When dealing with severe pain, narcotic analgesics should be taken sparingly and for only brief periods of time. Symptom relief is often greater with physical rehabilitation programs that emphasise flexion rather than extension. The best aerobic exercises include cycling and other low-impact alternatives. Physical rehabilitation techniques including heat, ultrasound, and massage have not been shown to be effective in the treatment of isthmic spondylolisthesis [28].

Antilordotic bracing and activity modification for three to six months will alleviate back and leg pain in more than 75% of patients with a pars defect and grade I to II spondylolisthesis [29]. Al-

though epidural steroid injections might help with radicular symptoms, they probably won't help with back pain [30]. An adult who experiences back and/or radicular discomfort for longer than six months can present with progressive neurologic deficit and neurogenic claudication that significantly limits their ability to function is a candidate for surgery [31].

Grade III or higher slip and increasing deformity are indications for surgery in young adults and adolescents. Surgery is an absolute necessity when cauda equina syndrome manifests itself [32]. Decompression of the thecal sac and nerve roots at the pars defect level was originally observed by Gill et al., in 1984. Pars defect hypertrophic fibrous tissue and the slack posterior region are decompressed [33].

The nerve root is decompressed by conducting a partial facetectomy and removing any compressing bone from the pedicle. The initial process was described as discectomy and debridement of projecting fragments [33,34].

Patients with spondylolisthesis and back discomfort have been shown to benefit from autograft posterior laminae and spinous process fusion. Regardless of the initial slip grade, >88% of patients had favourable or better clinical results. Originally known as unilateral posterolateral fusion (PLF), where the two transverse processes are fused together in [27].

PLF in patients with isthmic spondylolisthesis has been reported to have a wide variety of outcomes, including a fusion rate of 81% to 100% and a clinical success rate of 60% to 98% [35].

Anterior lumbar interbody fusion (ALIF), posterior lumbar interbody fusion (PLIF), and transforaminal lumbar interbody fusion (TLIF) are all techniques that surgeons can combine to make adequate fusion. The possibility of a successful fusion is theoretically increased by the size of the vertebral end-plate surfaces, and deformity correction is theoretically enhanced by simultaneous release and distraction of the disc area [36].

During ALIF, a synthetic cage or structural bone graft is implanted in place of the damaged disc after its removal under direct observation via an abdominal route. ALIF has been shown to have comparable clinical efficacy and fusion rates to PLF when used alone to treat isthmic spondylolisthesis. Decompressive laminectomy is performed at the spondylolisthesis level, and then PLIF is done [37,38].

The TLIF procedure entails a laminectomy, a unilateral facetectomy, and then accessing the disc space via the foraminal zone without a roof. In contrast to PLIF, the lateralized portal enables the surgeon to decompress both the traversing and exiting nerve roots concurrently with minimal manipulation of the thecal sac and nerve roots. There was a significant improvement shown in the Oswestry Disability Index score as well as in the fusion rate of 94.8% after performing TLIF in individuals with grades I and II isthmic spondylolisthesis ($p < 0.01$) [39,40].

The Smiley face rod approach is useful for repairing pars defects in lumbar isthmic spondylolisthesis and reducing slippage (grade 1 spondylolisthesis less than 2mm) in adolescent athletes.

Slipping of a high grade (more than 50%) poses special difficulties. Patients who just received posterior fusion have a higher risk of complications such pseudoarthrosis, slide progression, neurologic impairment, and implant failure [41,42].

Surgical technique:

The process consists of the following 5 steps: First, a pars interarticularis deficiency must be located and curettaged. Iliac crest cancellous bone harvesting is the second step. The third step is to place the pedicular screw (PS). The fourth step is to insert the bending rod and secure the rod in place with pedicle screws. Bony chips grafted from the iliac crest is implanted in Step 5 [43].

The patient is positioned on a Hall frame in a neutral position:

Step 1: A 5cm length mid-line skin incision is made. Paraspinal muscles are retracted laterally with a deep Gerpi retractor to reveal the lamina, pars, and transverse process base. The capsule surrounding the facet joints is treated with great care.

Step 2: Laterally from the iliac crest, cancellous bone graft is obtained before the implantation of pedicle screws.

Step 3: Anatomic landmarks and fluoroscopy are used to pinpoint the entry point for the pedicle screws. The correct entry location can be verified under clear visual inspection. After a starting hole has been burred at the entry point, a pedicle probe is utilized to enter the pedicle. The pedicle walls

and floor are all tested with a ball-tip sounder. Pedicle screws, usually 45mm in length and 6.5mm in diameter, are inserted bilaterally after the hall for the polyaxial pedicle screw is tapped.

Step 4: A 100mm rod is then shaped to fit, placed just caudal to the spinous process where it joins each screw head after the insertion of bilateral pedicle screws. After inserting a reduction screw into the slipped vertebra and pressing the bent rod into the screw head, the vertebra is “reduced”. We can tighten the loose lamina by using a rod pusher to press the curved rod against the spinous process. When the set screws have been inserted, the rods and screws are imaged using fluoroscopy to ensure appropriate placement.

Step 5: Finally, iliac crest bone grafts are implanted onto the pars defect. A drainage tube is inserted and the wound is routinely closed.

The drain is typically removed 48 hours following surgery. The patient begins standing and walking with a soft brace approximately six to eight hours after surgery. It is not necessary to strictly advise for the lumbar support three-month wear time, as the construct itself is strong enough to retain the posterior arch in place until union. Hamstring stretches and isometric workouts for the trunk muscles are recommended. The patient is permitted to begin light exercise, such as jogging, almost six months after surgery [43].

The smiley face rod technique was initially referred to as the “V-rod method.” Recently, this procedure has been referred to as the “smiley face rod method” as it resembles on AP plain radiograph view a smiley face of the rod and the screw head [44].

In contrast to other direct repair surgeries, biomechanical analysis of the Smiley face rod method revealed adequate stability as well as efficiency of a spondylolytic defect. (Fig. 1) [45].

By simply rotating the reduction tool over the screw extender, we can quickly realign the slipped vertebra. There are two demanding steps in the process. The first is a suitable bending rod. The rod is set up from a midline wound and evenly bent into the shape of a “U”. The other step is to firmly secure the rod to the inferior spinous process [45].

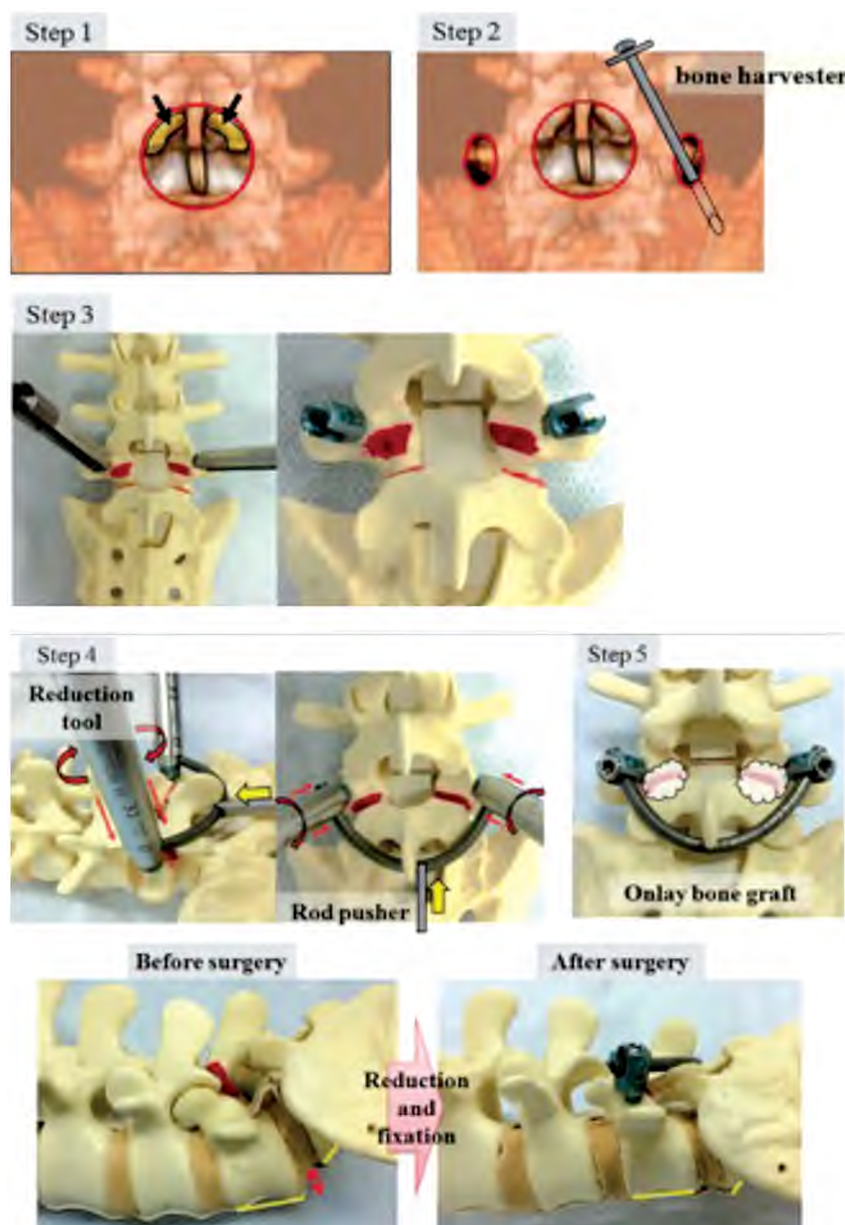


Fig. (1): Images taken during surgery to document the stages of the operation. Step 1: Make a horizontal skin incision (3-4 cm in length). Pars defect is exposed and curettaged. Step 2: Harvesting iliac crest cancellous bony chips. Step 3: Bilateral insertion of pedicular screws. Step 4: Inserting a bending rod and fixing it with the pedicular screws while using a rod pusher and a reduction tool. Step 5: Apply a bone graft to the repaired pars defect. Surgery using the Smiley Face Rod Method before (Left) and after (Right).

Patients and Methods

This retrospective analytical study was carried out on 30 patients with isthmic spondylolisthesis admitted to the Neurosurgery Department at Alexandria Main University Hospital in a randomized clinical trial.

The study was conducted at Alexandria Main University Hospitals in Egypt from December 2020 till June 2023.

Ethical approval and consent to participate:

All procedures performed in the study involving human participants were in accordance with the ethical standards of the institution and approved by the Ethics Committee of Alexandria University.

Statistical analysis:

Data were fed to the computer and analyzed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp). Qualitative data were described using number and percent. The Kolmog-

orov-Smirnov test was used to verify the normality of distribution. Quantitative data were described using range (minimum and maximum), mean, standard deviation, median and interquartile range (IQR). Significance of the obtained results was judged at the 5% level.

The used tests were:

Friedman test:

For abnormally distributed quantitative variables, to compare between more than two periods or stages and Post Hoc Test (Dunn's) for pairwise comparisons.

Methodology in details:

This study is conducted on 30 consecutive adult patients presenting with isthmus lumbar spondylolisthesis. Direct pars repair using smiley face-shaped rod technique with iliac crest bone graft for 30 patients.

Preoperatively, all patients included in the study will be subjected to:

- Detailed history taking.
- Complete physical examination.
- Clinical assessment preoperatively will include complete neurological examination and estimation of low back pain and sciatica severity using the Visual Analogue Scale (VAS) and Oswestry Disability Index (also known as the Oswestry Low Back Pain Disability Questionnaire ODI) [18].

Investigations for assessment of the patients:

- 1- Plain X-ray of the lumbar spine (anteroposterior, lateral, oblique and dynamic views).
- 2- Computed tomographic (CT) scan of the lumbar spine.
- 3- Magnetic resonance imaging (MRI) of the lumbar spine.

A written informed consent will be taken from all patients concerning the nature of the disease, origin of back pain, the nature of the procedure and type of anesthesia, the suspected time for hospital stay and the possible risk and complications of the procedure.

Post-operatively, we will evaluate clinically and radiologically.

Clinically, according to Visual Analogue Scale (VAS) and Oswestry Disability Index (ODI) to detect pain improvement.

Radiologically, by follow-up plain X-ray at 3, 6 and 12 months to detect pars fusion.

Results

We recruited 30 adult patients presented to Alexandria Main University Hospital during the period from December 2020 till June 2023 suffering from clinically diagnosed, radiologically and clinically confirmed to have isthmus spondylolisthesis. According to demographic data, patients' age ranged from 25-38 years with mean value 30.57 ± 3.62 , Males were 17 (56.7%) and females were 13 (43.3%). Weight ranged from 68-80 with mean value 75.87 ± 3.69 . According to comorbidities, (56.7%) 17 patients were smokers, (26.7%) 8 patients were hypertensive, (20%) 6 patients were diabetics, (26.7%) 8 patients were treated from hepatitis C, while no patient was on cardioprotective drugs. According to complain and pathology, Table below shows patients complaining of low back pain were 30 (100%), patients presenting with L5-S1 pars defect were 17 (56.7%) followed by patients with L4-5 pars defect were 12 (40%) while 1 patient presenting with L3-4 pars defect (3.3%) (Table 1).

Table (1): Distribution of the studied cases according to complain and pathology (n = 30).

	No.	%
<i>Complain:</i>		
Back pain	30	100.0
<i>Pathology:</i>		
L3-4 pars defect	1	3.3
L4-5 pars defect	12	40.0
L5-s1 pars defect	17	56.7

According to ODI for back pain, Table below shows that the preoperative ODI ranged between 40.0-50.0% (mean= 44.0 ± 3.57) and median 45.0. The Oswestry Disability Index at 3 months post-operative ranged from 28.0-40.0 with mean value 32.63 ± 3.85 and median 30.0, at 6 months post-operative it ranged from 23.0-35.0 with mean value 27.87 ± 3.25 and median 28.0, while at 12 months post-operative it ranged from 20.0-28.0 with mean value 23.97 ± 2.11 and median 23.0. There was statistical significant difference between Oswestry Disability Index pre-operative and at different period of follow up post-operative ($p \leq 0.05$) (Table 2).

According to visual analogue score (VAS) for back pain, Table below shows that the preoperative VAS for back pain ranged between 7.0 – 8.0 (mean= 7.43 ± 0.50) and median 7.0.

The VAS for back pain at 3 month post-operative ranged from 4.0-5.0 with mean value 4.73 ± 0.45 and median 5.0, while VAS at 6 months

post-operative ranged from 3.0-4.0 with mean value 3.53 ± 0.51 and median 4.0, however VAS at 12 months post-operative ranged from 2.0-3.0 with mean value 2.63 ± 0.49 and median 3.0. There was statistical significant difference between VAS pre-operative and at different period of follow-up post-operative ($p \leq 0.05$). (Table 3).

According to post-operative fusion for pars defect, A comparison between the different periods according to post-operative fusion for pars defect in table shows that at 3 months post operative it ranged from 25.0-35.0 with mean value 31.10 ± 4.19 and median 32.0, while at 6 months post operative it ranged from 40.0-60.0 with mean value 52.17 ± 6.52 and median 50.0, however at 12 months post-operative it ranged from 73.0-92.0 with mean value 79.23 ± 4.84 and median 80.0. Between various

follow-up intervals, there was a statistically significant variation in the post-operative fusion rates. ($p \leq 0.05$). (Table 4).

According to peri operative complications, no intra-operative complications have occurred in our study. However at 10 days post operative only 1 patient (3.33%) developed superficial infection that has resolved after 3 weeks. According to the need for post operative analgesia, 20 patients (66.7%) needed diclofenac analgesia only, while 10 patients (33.3%) needed narcotic analgesia in the postoperative period. according to hospital stay and return to work, the length of hospital stay ranged between 1-3 days (mean value= 1.40 ± 0.67 days and median 1.0), while according to return to work it ranged from 3-5 weeks (mean value= 3.37 ± 0.67 and median 3.0) ($p=0.029$).

Table (2): Comparison between the different periods according to ODI for back pain (n = 30).

ODI for back pain	Pre-operative	Post-operative			Fr	p
		3 months	6 months	12 months		
Min. – Max.	40.0-50.0	28.0-40.0	23.0-35.0	20.0 – 28.0		
Mean $\pm$ SD.	44.0 $\pm$ 3.57	32.63 $\pm$ 3.85	27.87 $\pm$ 3.25	23.97 $\pm$ 2.11	88.255*	<0.001*
Median (IQR)	45.0 (40.0-45.0)	30.0 (30.0-35.0)	28.0 (26.0-30.0)	23.0 (23.0 – 26.0)		
p0		0.002*	<0.001*	<0.001*		

Sig. bet intervals were calculated using the Post Hoc Test (Dunn's) for the Friedman test.

p : The p-value for comparing the studied periods.

p0: The p-value for contrasting the preoperative period with the other examined periods.

* : Significant statistically at $p \leq 0.05$.

IQR: Inter quartile range.

Table (3): Comparison between the different periods according to VAS for back pain (n = 30).

VAS for back pain	Pre-operative	Post-operative			Fr	p
		3 months	6 months	12 months		
Min. – Max.	7.0-8.0	4.0-5.0	3.0-4.0	2.0-3.0		
Mean $\pm$ SD.	7.43 $\pm$ 0.50	4.73 $\pm$ 0.45	3.53 $\pm$ 0.51	2.63 $\pm$ 0.49	86.436*	<0.001*
Median (IQR)	7.0 (7.0-8.0)	5.0 (4.0-5.0)	4.0 (3.0-4.0)	3.0 (2.0-3.0)		
p0		0.001*	<0.001*	<0.001*		

Sig. bet intervals were calculated using the Post Hoc Test (Dunn's) for the Friedman test.

p : The p-value for comparing the studied periods.

p0: The p-value for contrasting the preoperative period with the other examined periods.

* : Significant statistically at $p \leq 0.05$.

IQR: Inter quartile range.

Table (4): Comparison between the different periods according to post-operative fusion for pars defect (n = 30).

	Post-operative fusion for pars defect (%)			Fr	p
	3 months	6 months	12 months		
Min. – Max.	25.0-35.0	40.0-60.0	73.0-92.0	60.0*	<0.001*
Mean $\pm$ SD.	31.10 $\pm$ 4.19	52.17 $\pm$ 6.52	79.23 $\pm$ 4.84		
Median (IQR)	32.0 (28.0-35.0)	50.0 (50.0-60.0)	80.0 (75.0-80.0)		
Sig. bet. Grps	p1<0.001*, p2<0.001*, p3<0.001*				

Sig. bet intervals were calculated using the Post Hoc Test (Dunn's) for the Friedman test.

p: The *p*-value used to compare two examined periods.

p1: Is the *p*-value for comparing three and six months.

p2: The *p*-value for contrasting three and twelve months.

p3: The *p*-value for contrasting the length of time (6 and 12 months).

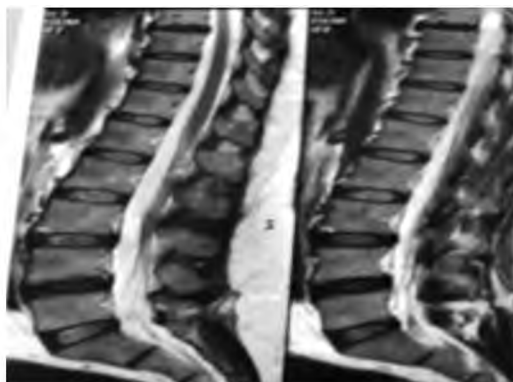
Significant statistically at $p \leq 0.05$.

IQR: Inter quartile range.

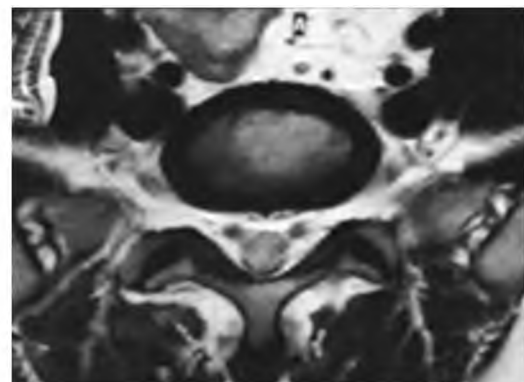
Case 1:

A twenty eight years old female presented with low back pain. The pre-operative VAS was 7 for low back pain. The pre-operative ODI was 40% for

back pain. The patient underwent smiley face rod technique fixation. 12 months post-operative, VAS improved to 3 for back pain, while ODI was 25%.



(A)



(B)



(C)

Fig. (2): Case (1): Pre-operative radiology and imaging. (A) MRI Lumbar spine sagittal view TW2 showing normal alignment with no disc bulge (B) MRI Lumbar spine axial view TW2 showing non compromised nerve roots bilaterally (C) Plain X-ray Lumbar spine AP view, lateral view and dynamic study showing pars fracture Lumbar 3 vertebra.

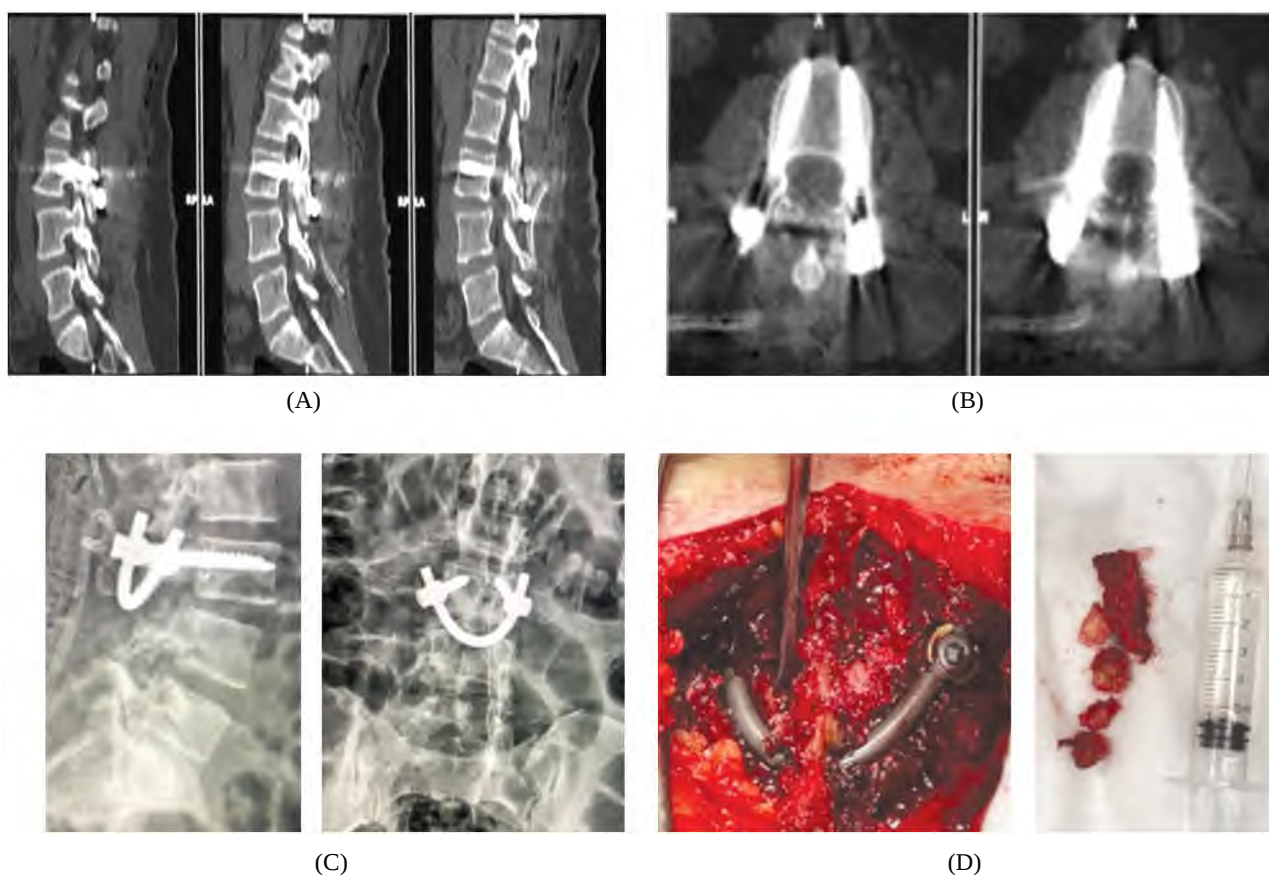
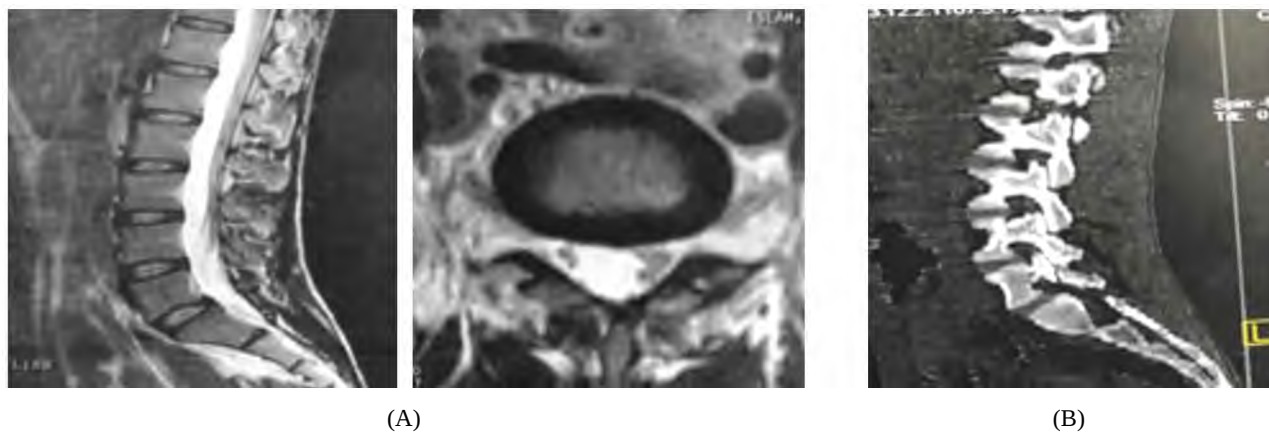


Fig. (3): Case (1): Intra and post operative radiology and imaging. (A) CT Lumbosacral spine sagittal reconstruction bone window showing placement of L3 pedicle screws with smiley face rod. (B) CT lumbosacral spine axial view bone window showing placement of L3 pedicle screws. (C) Plain Xray lumbosacral spine AP and lateral views showing placement of L3 pedicle screws with smiley face rod technique. (D) Intra operative images showing iliac crest bony chips placed on the pars interarticularis defect.

Case 2:

A twenty-nine years old male patient presented with low back pain. The pre-operative VAS was 8 for low back pain. The pre-operative ODI was

45% for back pain. The patient underwent smile face rod technique fixation. 6 months post operative, VAS improved to 3 for back pain, while ODI was 23%.



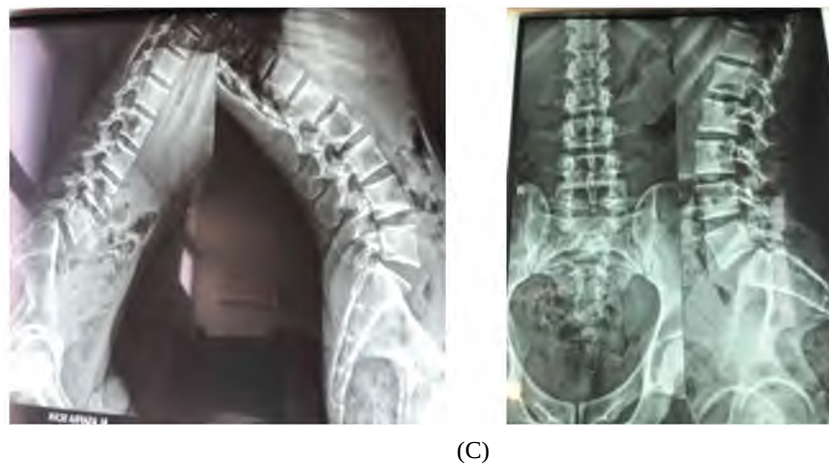
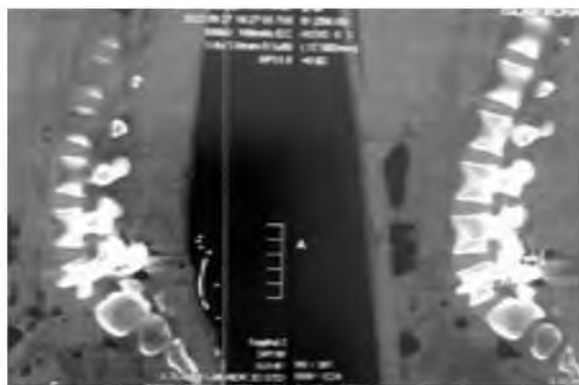


Fig. (4): Case (2): Preoperative radiology and imaging. (A) MRI lumbosacral spine sagittal and axial views TW2 showing healthy L5-S1 disc and uncompromised nerve roots. (B) CT lumbosacral spine sagittal reconstruction bone window showing L5 pars interarticularis fracture. (C) Plain X-ray lumbosacral spine AP, lateral views and dynamic study showing L5 pars interarticularis fracture with no slippage.



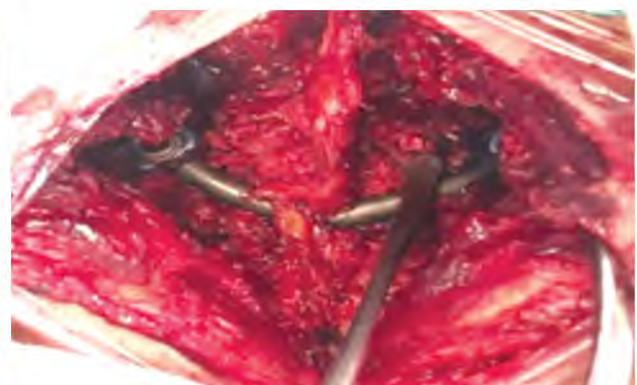
(A)



(B)



(C)



(D)

Fig. (5): Case (2): Intra and post operative radiology and imaging. (A) CT Lumbosacral spine sagittal and axial view bone window showing placement of L5 pedicle screws with smiley face rod technique. (B) Plain X-ray lumbosacral spine AP and lateral views showing placement of L5 pedicle screws with smile face rod technique. (C) Intra operative images showing iliac crest bony chips placed on the pars interarticularis defect.

Case 3:

A thirty years old male patient presented with low back pain. The pre-operative VAS was 7 for low back pain. The pre-operative ODI was 45%

for back pain. The patient underwent smile face rod technique fixation. 3 months post-operative, VAS improved to 2 for back pain, while ODI was 26%.

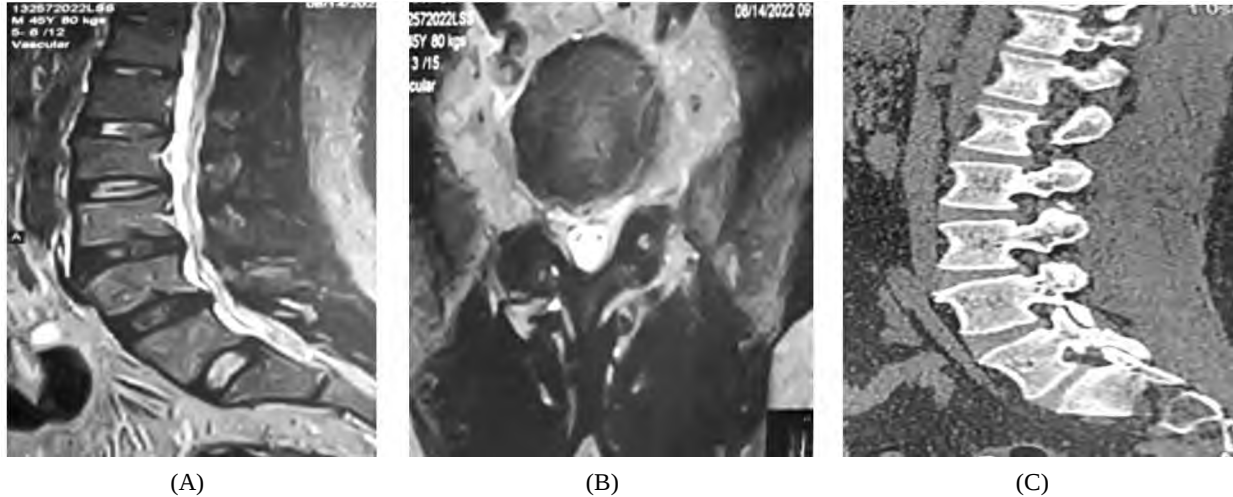


Fig. (6): Case (3): Pre-operative radiology and imaging. (A) MRI Lumbosacral spine sagittal view TW2 showing normal alignment (B) MRI Lumbosacral spine axial view TW2 showing non-compromised nerve roots bilaterally (C) CT Lumbosacral spine sagittal reconstruction bone window showing pars fracture L5 vertebrae.

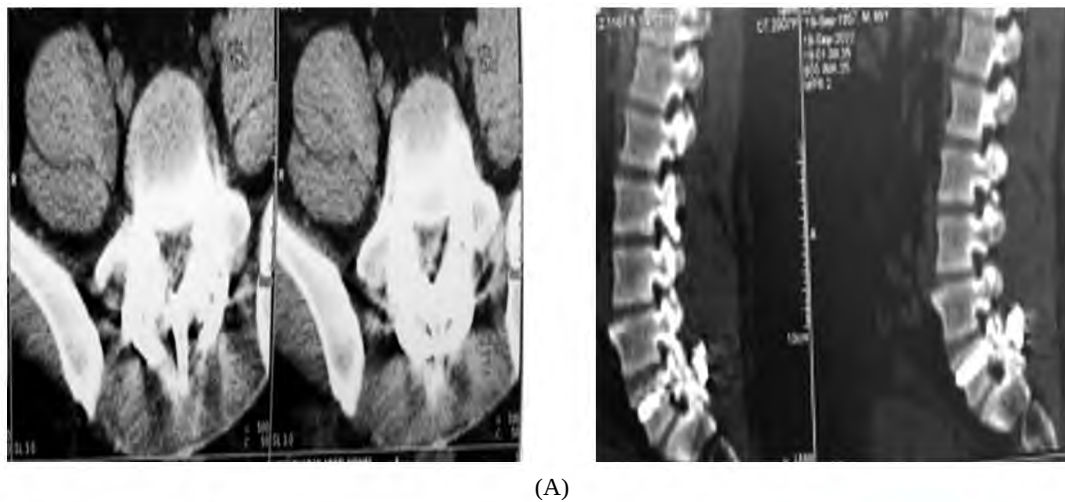


Fig. (7): Case (3): Intra and post-operative radiology and imaging. (A) CT Lumbosacral spine sagittal reconstruction and axial view showing placement of L5 pedicle screws with smiley face rod with bony fusion of pars interarticularis. (B) Plain X-ray lumbosacral spine AP and lateral views showing placement of L5 pedicle screws with smiley face rod technique. (C) Intra-operative images showing iliac crest bony chips placed on the pars interarticularis defect.

Discussion

Isthmic spondylolisthesis is thought to be a stress fracture of the neural arch's pars interarticularis. Activity-related back pain in young, active individuals is the clinical symptom. The most typical location for isthmic spondylolysis is L5 [46].

Males typically experience the condition earlier than females and at a higher prevalence due to participating in more demanding activities at a younger age.

The majority of patients are favorable to conservative treatment, which includes deep abdominal strengthening exercises, bracing, activity restriction, analgesic/anti-inflammatory medication given by physical therapists, muscle relaxants, and extension and flexion exercises. Depending on the severity of the spondylolysis, physical rehabilitation typically lasts between three and six months. Physical treatment aims to reduce movement at the unstable pars interarticularis defect [47].

Spondylolysis can be treated surgically in a number of ways, including pars repair or surgical fusion if disc degeneration is not immediately apparent.

Repairing pars can be done in a variety of ways. Kimura, in 1968, described bone grafting without internal fixation as a treatment for spondylolysis abnormalities. Although Scott's use of wire to complement bone grafting for the lytic deficiency began in 1968, it wasn't published until his findings 1986 [47]. Many writers employ the Scott wiring technique, while others have altered it to use cable or pedicle screws in place of wire [48].

Pedicle screws and rods used in multiple segment fixation have excellent success in stabilizing the spine, but they impact spinal flexion and axial rotation and may lead to degenerative changes in nearby normal segments.

Smiley face shaped rod technique is a new technique for treating isthmic spondylolisthesis that stabilizes the pars interarticularis of the same segment while preserving motion in the affected segment, axial rotation, and flexion of the spine, as well as preventing degenerative change in adjacent levels [44,49].

Our data shows that the sample consisted of 56.7% males and 43.3% females, with a mean age of 30.573.62 years and a mean weight of 75.873.69 kg. Of all the patients who experienced low back

pain, 53.3% had a pars defect in the L5-S1 region, 36.7% had one in the L4-5 region, and just one (or 10%) had one in the L3-4 region.

The mean VAS score for back pain prior to surgery was 7.43 0.50, and there was a statistically significant difference between this score and the VAS scores at all postoperative follow-up times (p 0.05). The mean Oswestry Disability Index (ODI) prior to surgery was 44.0 3.57, and it significantly decreased across post-operative follow-up time points (p 0.05).

The smiley face rod approach was successful as a direct repair technique for young athletes with isthmic spondylolisthesis, which is consistent with the findings of Yamashita et al., [44] study, Direct repair of isthmic spondylolisthesis utilizing the smiley face rod method in adolescent athletes. The smiley face rod technique was initially referred to as the "V-rod method".

As the screw head and rod on an anterior-posterior plain radiograph look like a smiling face, this technique has recently been dubbed the "smiley face rod method." Ulibarri et al., [50] found that the smiley face rod approach provided significantly greater stability of a spondylolytic defect than alternative direct repair operations. The rod pusher along with reduction utilized to properly reduce a slipping vertebra were both highly effective and easy to use.

There are two demanding steps in the process. The first is a suitable bending rod. The rod is set up from a midline wound and evenly bent into the shape of a "U". The other step is to firmly secure the rod into the inferior spinous process. At that point, a rod pusher is used to force the rod into the spinous process [51].

Radiographical examination of 46 athletes under the age of 18 who had spondylolysis at the L5 by Sairyo et al., [52] showed that the deformity was caused by the slippage.

Despite the case's brief follow-up period, it appeared to be adequate to demonstrate the smiley face rod method's efficacy. To determine how much sliding and disc degeneration this method's adaptation causes, studies with extended follow-up are required.

For patients with Grade I spondylolisthesis who have not responded to conservative treatment and symptomatic spondylolysis repair, several surgical options have been identified. Loose lamina and pars defects are exposed in Buck's straight pars defect repair method, and the defects are debrided

and decorticated. The defect is bridged with cortical bone screws [53].

The Scott wiring technique is used to decorate the transverse process, the lateral part of the superior facet, and the lamina on each side. Using a rod connected by a cephalic pedicle screw, a caudal laminar hook in addition to bone grafting, Kakiuchi, [54] found that 100% of pars defects are repaired.

Others authors have suggested using a rod hook or a V-shaped rod placed beneath the spinous process in conjunction with pedicle screws to stabilize the lamina [54].

Patients under 30 years old have been the primary focus of direct surgical repair of spondylolysis because their discs are less degenerative and therefore better candidates for direct repair. However, several writers have shown that younger patients do better than older ones. Kakiuchi et al., [54] has reported that more than 90% of patients had successful outcomes in their retrospective research using a hook screw system in 113 patients with 10.9 years of follow-up.

Nozawa et al., [55] has applied the Scott wiring method on 20 competitors, 13 of whom were under the age of 20. 86% of patients under the age of 20 reported excellent clinical outcomes, compared to only 70% of patients over the age of 20. Johnson and Thompson used a modified Scott technique, and they stated that all nineteen patients under the age of twenty-five received a satisfactory outcome comparing with two of three patients older than twenty-five years. Hefti et al., [56] found that using a laminar hook with a spring beside a screw put in the articular processes resulted in union rates between 56 and 82 percent.

Debusscher and Troussel, [57] used a pedicle screw hook method on 12 patients who were under 30 and 11 patients who were over 30. Only 73% of older patients in the cohort had an excellent outcome, compared to 100% of younger patients.

Salib and Pettine, [58] made alterations to the Scott wiring method by tightening a wire below the spinous process after wrapping it around cortical screws put into both pedicles. Yet, biomechanical tests showed that the device was just as rigid when the wire was fixed to the pedicle screw. In 1999, the first people to describe the pedicular screw-based constructions were Songer and Rovin, [59] they threaded a cable onto the screw and ran it across the other lamina. Osseous union occurred in all seven patients, and five of them had positive results.

Subsequent modifications included passing a curved rod or laminar hook under the spinous process to stabilize the pars defect instead of the spinous process alone. The "V rod method" quickly became known as the "smiley face rod method" due to the resemblance between the screw head and rod on an anterior posterior plain radiograph. As compared to alternative direct repair techniques, the biomechanical features were verified to be superior by Ulibarri et al. [50].

Conclusion: The Smiley face rod method for pars repair in patients with isthmic spondylolisthesis is an effective technique to manage pars defect if the disc is healthy, if there is no or minimal slippage of the vertebrae (<2mm), and efficient for preservation of the motion segment especially in adolescent athletes.

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تقييم اصلاح الجزء بين المفصلين باستخدام تقنية قضيبي الوجه المبتسم فى الانزلاق الفقارى النخاعى

- ١- معايير الاختيار لإصلاح الجزء بين المفصلين فى حالات الانزلاق الفقارى النخاعى مهمة للانصهار السليم.
- ٢- اصلاح الجزء بين المفصلين بتقنية قضيبي الوجه المبتسم للفقرات القطنية فى حالات الانزلاق الفقارى النخاعى يحافظ على جزء الحركة.
- ٣- إصلاح الانزلاق الفقارى النخاعى باستخدام تقنية قضيبي الوجه المبتسم فعاله فى تخفيف الأعراض.
- ٤- حققت تقنية قضيبي الوجه المبتسم إصلاحًا جراحياً مناسباً للجزء بين المفصلين للفقرات القطنية فى حالات الانزلاق الفقارى النخاعى.
- ٥- المرضى الذين خضعوا لإصلاح الانزلاق الفقارى النخاعى باستخدام تقنية قضيبي الوجه المبتسم كانوا أقل حاجة بكثير لتسكين الألم المخدر بعد الجراحة.
- ٦- المرضى الذين خضعوا لتقنية قضيبي الوجه المبتسم فى حالات الانزلاق الفقارى النخاعى للفقرات القطنية يقيمون مدة أقل فى المستشفى ويعودون إلى العمل فى وقت مبكر.