17

THE SURGICAL TREATMENT

of

SEVERE LUMBAR SPONDYLOLISTHESIS

Dissertation submitted for completion of Part III

Degree of Master of Medicine

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I would like to thank all my teachers over the past few years especially Dr. Guillaume du Toit.

DECLARATION

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Part 1. LITERATURE REVIEW

i. INTRODUCTION

Spondylolisthesis is defined as the slipping forward of one vertebra on another. The word is derived from the Greek words "spondylo" meaning vertebra and "olisthesis" meaning slip or to slide and refers to the displacement of one vertebral body on the one below. Lumbar spondylolisthesis usually occurs at L5 on S1 although L4 on L5 is common (Bradford 1987, Gaines 1988 and Nachemsen 1976).

A Belgian obstetrician, Herbiniaux in 1782, is recorded as the first person to have recognised this condition. (Boxall 1979, Bradford 1987). The first usage of the term "spondylolisthesis" is credited to Kilian in 1854. (Bradford 1987, Newman 1965).

The management of severe lumbar spondylolisthesis is controversial. After Meyerding's paper in 1932, a posterior fusion in situ was accepted as the treatment of choice. Subsequently an enthusiasm for reduction of the spondylolisthesis prior to fusion developed. It was felt that the reduction improved cosmesis and allowed a biomechanically more stable fusion. Severe problems with reduction have brought the technique into question.

At the same time problems with posterior fusion in situ, namely progression of the slip and no improvement in cosmesis, have been identified. Some authors even question whether surgery is always needed for symptomatic spondylolisthesis (Harris 1987).

The question of whether reduction is needed prior to fusion and what type of fusion is best, still rages forth in the literature.

ii. CLASSIFICATION.

Spondylolisthesis is classified according to the Wiltse, Newman and Macnab classification of 1976. They have classified spondylolisthesis into five types according to aetiological and anatomical factors (figure 1, page 8).

Type I: Dysplastic - This type is associated with congenital abnormalities of the upper sacrum and/or of the arch of L5.

Type II: Isthmic - Here the lesion is in the pars interarticularis. Three patterns are recognised.

a) Lytic-Fatigue fracture of the pars.

b) Elongated but intact pars.

c) Acute fracture.

Type III: Degenerative - Due to long standing intersegmental instability.

Type IV: Traumatic - Due to fractures in other areas of the bony hook other than the pars.

Type V: Pathological - Due to generalized or local bone pathology.

Severe spondylolisthesis is defined as a slip or forward translocation of more than 50% (Boxall 1979, Freeman 1989 and Peek 1989).

Spondylolisthesis

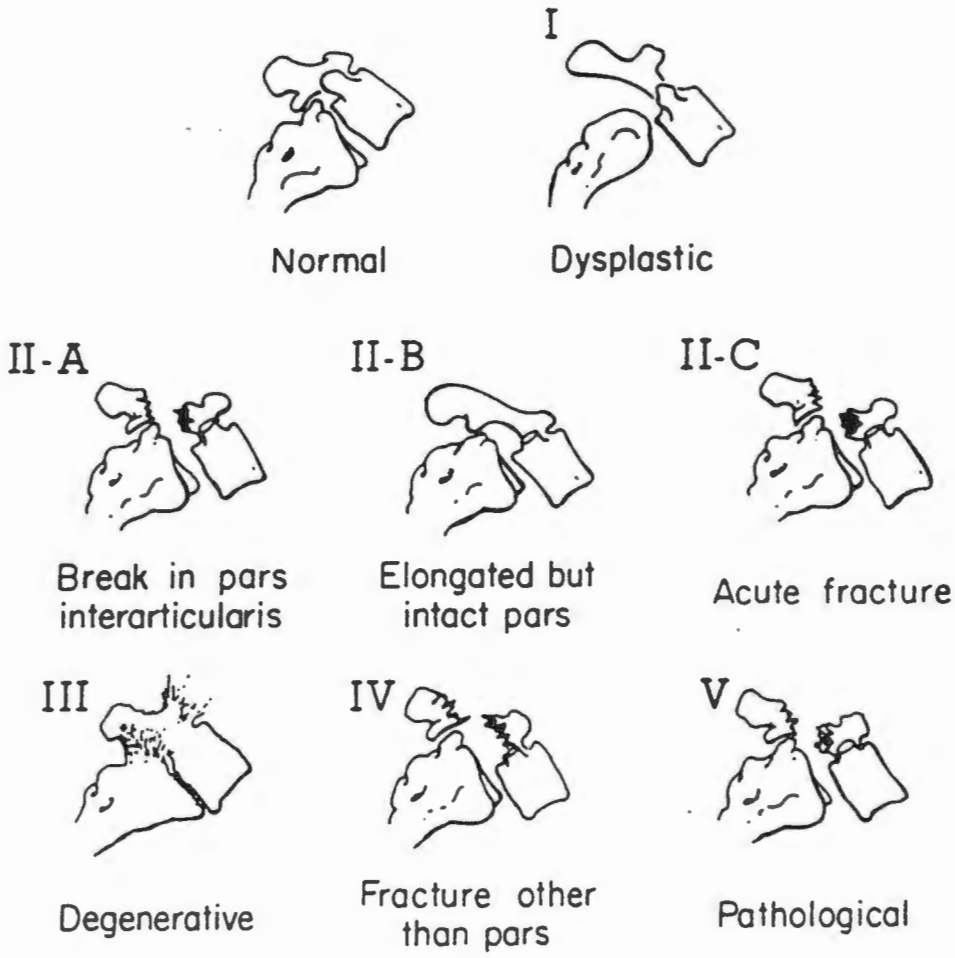


Figure 1: Classification of Spondylolisthesis.

(Wiltse et al: Clin Orth 1976; 117:23-29)

iii. AETIOLOGY\ INCIDENCE\ NATURAL HISTORY

The dysplastic type of spondylolisthesis is recognisable due to the bony abnormalities which later lead on to the subluxation. With the isthmic type of spondylolisthesis the defect is in the pars interarticularis. Furthermore, radiology of a patient with spondylolisthesis often reveals a combination of pathologies eg. pars elongation with lysis and an abnormal upper sacrum making categorisation difficult or very theoretical.

Many theories have been put forward to explain the pars defect. The earliest theory was that of Rambaud and Renault in the mid nineteenth century (Fredrickson 1984). They suggested that the fault was a failure of fusion of two separate ossification centres. In 1940, Hitchcock produced neural arch defects in fetal specimens by hyperextension of their backs. He suggested that birth trauma caused a fracture which subsequently went on to a non union. His theory was refuted in 1953 by Rowe and Roche. They dissected 500 infant cadavera and found no neural arch defects.

The current opinion is that a stress or fatigue fracture of the pars interarticularis following repeated trauma is responsible for the defect. (Bradford 1987, Gaines 1988, Hensinger 1989, Letts 1986 and Wiltse 1975). Wiltse (1975) feels that this fracture is secondary to a congenital weakness in the pars.

The incidence of spondylolisthesis in the general population, at the age of 5-7 years is accepted as 4-5% (Baker 1956, Fredrickson 1984, Hensinger 1989, Seitsalo 1988 and Wiltse 1976). This incidence increases by 1-2% until the age of 20 years then remains constant (Bradford 1987, Fredrickson 1984 and Wiltse 1975). (See figure 2).

This incidence of spondylolisthesis is for the Caucasion population. Different incidences are reported for other populations: In Eskimos the incidence is reported to be up to 50% (Kettlelamp 1971, Stewart 1953) whilst in the Black population it is less than 2% (Bradford 1987, Rowe 1953).

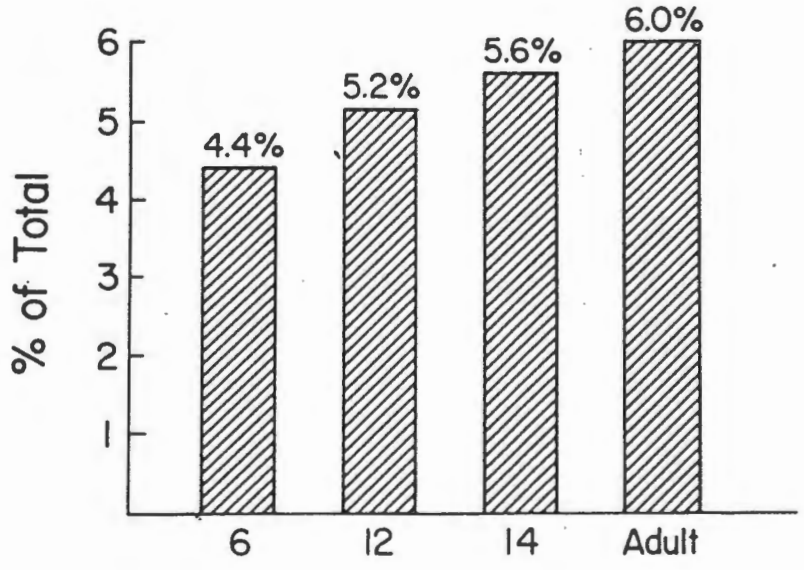


Figure 2: Bar graph showing the incidence of spondylolisthesis by age.

(Fredrickson et al: J Bone Joint Surg 1984; 66-A: 699-707)

The high incidence of spondylolysis among family members of affected people suggests a hereditary influence. The incidence of spondylolysis amongst close relatives being 27-69% as opposed to the 6-8% in the general population (Shahriaree 1979, Wynne-Davies 1979). Those with dysplastic lesions had a higher proportion of affected relatives (33%) compared to those with the isthmic type of spondylolisthesis (15%) (Wynne-Davies 1979).

An increased incidence of spondylolysis has been reported in young army recruits (Wiltse 1975) as well as in athletes participating in sport requiring severe flexion and extension. The incidence of spondylolysis in female gymnasts was found to be four times the expected rate (Goldberg 1980, Jackson 1976). Letts (1986) found increased incidences in hockey players as well as in gymnasts.

The incidence of spondylolisthesis as opposed to spondylolysis is uncertain. Fredrickson (1984) reported only 33 cases of olisthesis in the 500 patients he reviewed.
Neither spondylolysis nor spondylolisthesis have ever been reported in adults who have never walked (Rosenberg 1981).

An increased rate of sacral and lumbar spina bifida occulta as well as lack of development of the proximal sacrum and superior sacral facets is common in patients with spondylolysis (Dandy 1971, Jackson 1976, Meyerding 1932 and Wynne-Davies 1969).

There is no agreement on which sex has the higher incidence of spondylolysis and spondylolisthesis. Some authors feel that males have the higher incidence (Fredrickson 1984, Turner 1971, Wiltse 1975) while others feel that females are more frequently affected

(Blackburne 1977, Dandy 1971, Newman 1965). It is agreed that females with dysplastic features of their upper sacrum and L5 vertebra carry a worse prognosis for further slip than do males.

This increase in slip usually occurs around the adolescent growth spurt and is often accompanied by increasing symptoms such as back pain and hamstring tightness (Blackburne 1977, Seitsalo 1988). This increase in slip can however be asymptomatic (Fredrickson 1984, Wiltse 1961).

Most authors now agree on the features that carry a poor prognosis and therefore will probably need surgical intervention - see Table 1.

(Blackburne 1977, Boxall 1979, Bradford 1987, Hensinger 1989, Seitsalo 1988 and Turner 1971).

TABLE 1: Clinical and radiological risk factors for further slip.

Female sex
Age - Adolescent growth spurt
Dysplastic features of sacrum and L5
Presence of spina bifida
High grade slip
High slip angle
Low lumber index
Increased lumbar lordosis

However for the majority of patients spondylolisthesis appears to have a benign natural history (Fredrickson 1984, Harris 1987, Seitsalo 1988 and Wiltse 1961).

Fredrickson noted that after the age of 16 years there is seldom progression of the olisthesis in isthmic types of spondylolisthesis. They feel that a child, once past puberty, if asymptomatic, need not be routinely evaluated and should have no restrictions placed on their lifestyle.

Harris (1987), with a follow up of eighteen years, reported on 11 patients with grades III and IV spondylolisthesis who were treated non-operatively. He found only one patient with significant symptoms. None had disabling neurological deficits. They all led active lives and 5 of the 11 patients worked as manual labourers. They found that only 3 patients had progression of their olisthesis after maturity. They all had a full range of movement of their backs. None of the ladies had any problems with delivery of their children. He also found that the degree of spondylolisthesis did not influence the severity of symptoms.

Despite what appears to usually be a relatively benign condition the current recommended treatment is surgical stabilisation for patients with:

1. Dysplastic spondylolisthesis especially if pre-pubertal and female
2. Isthmic spondylolisthesis with slips of greater than 50%.

What type of surgery is needed is still the subject of much debate.

iv. CLINICAL FEATURES

Children and adults with spondylolysis and spondylolisthesis present with different problems. Although spondylolisthesis develops in late childhood, symptoms are relatively uncommon in children. (Bradford 1987, Hensinger 1989).

Teenagers are usually not symptomatic enough to seek medical attention (Hensinger 1989). Lafond (1962) found in his series of patients with spondylolysis or spondylolisthesis that 23% had symptoms prior to the age of 20 years. However only 9% had sought medical attention during childhood or adolescence. The onset of symptoms, if they occur, is usually during the adolescent growth spurt (Hensinger 1989).

Children tend to present with postural deformity or abnormal gait thought to be due to tight hamstrings (Hensinger 1976, Phalen 1961). Pain is the predominent complaint in adults. If a child presents with pain, it is usually one of two patterns:

1. Dull pain in the lower back. There may be mild radiation to the buttocks or posterior thighs. This discomfort is usually initiated or aggrevated by strenous activity especially sports involving repetitive flexion-extension movements such as gymnastics and tennis. This pain is relieved by rest or limiting the aggravating activity (Letts 1986). The pain is thought to be secondary to mechanical instability of the affected segment resulting in chronic muscle spasm (Gaines 1988).

2. Localised backpain with radicular pain into the lower extremities. This pain

seldom radiates into the calf or foot (Bradford 1987, Hensinger 1976, Hensinger 1989).

Bradford (1979) feels that the backache and radicular pain is associated with more dysplastic features and higher degrees of slip - grades III and IV. However, the severity of the pain does not always correlate with the degree of slip (Fredrickson 1984, Luskin 1965, Phalen 1961 and Wiltse 1961).

Children and adolescents, unlike adults, seldom have objective signs of nerve root compression such as motor weakness, changed reflexes and sensory deficits (Hensinger 1989).

The cause of the backpain is felt to be secondary to mechanical instability and chronic muscle spasm. The radicular pain arises from foraminal stenosis at the pars defect, callus at the pars fracture site, compression of the cauda equina or sacral root at the dome of the sacrum secondary to the L5 forward displacement, hypertrophy of the ligament flavum and possible disc herniation (Bradford 1987, Gaines 1988, Newman 1967 and Wiltse 1975).

Gait abnormalities are attributed to tight hamstring muscles (Boxall 1979, Hensinger 1989, Phalen 1961). The tight hamstrings restrict hip flexion by tilting the pelvis backwards. The child therefore cannot flex the hips with the knees extended and walks with a stiff-legged and short-stride gait - the so called pelvic waddle gait (Newman 1965) or Phalen-Dickson sign (1961) (figure 3, page 16). The child also has a positive straight leg raise test.

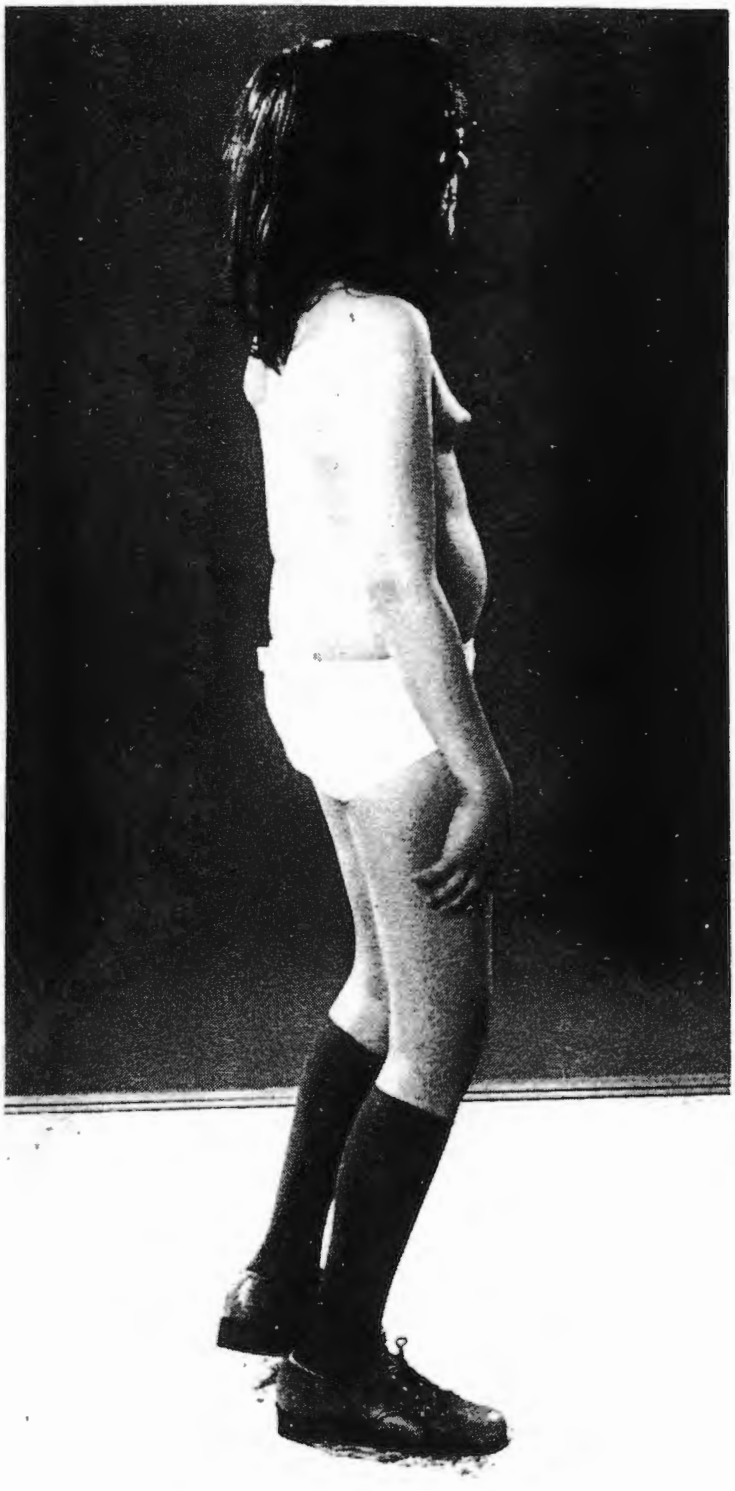


Figure 3: A patient demonstrating the Phalen-Dixon sign.

Eighty per cent of symptomatic patients are reported to have tight hamstrings. The cause of the hamstring tightness is unknown. Some authors feel it is a sign of nerve root irritation (Turner 1971). The hamstring tightness is seldom accompanied by neurological signs and some authors feel there is no evidence to support the cause being root irritation (Boxall 1979, Hensinger 1976, Hensinger 1989). This tightness does not appear to be influenced by the grade of slip and can be found with any grade of spondylolisthesis (Boxall 1979).

As the grade of slip increases, a palpable and often visible step-off at the lumbo-sacral junction can be felt. The lower back is usually tender to palpation. There is splinting of the lower back and restriction of movement.

As the slip and hence the lumbo-sacral kyphosis increases the body compensates by increasing the lumbar lordosis. The pelvis becomes more retroverted and verticalisation of the sacrum occurs. This distortion of the pelvis becomes apparent in the late grade II stage of spondylolisthesis.

Viewed from the front, the lower abdomen appears thrust forward with the anterior superior iliac spines higher than the posterior spines. There is a transverse abdominal crease at the level of the umbilicus. From behind the buttocks look "heart shaped" and flattened secondary to the sacral prominence. At this stage the patient often cannot put the knees underneath the trunk due to pelvic tilt and needs to stand with knees flexed and the thoracic\upper lumbar spine in extension.

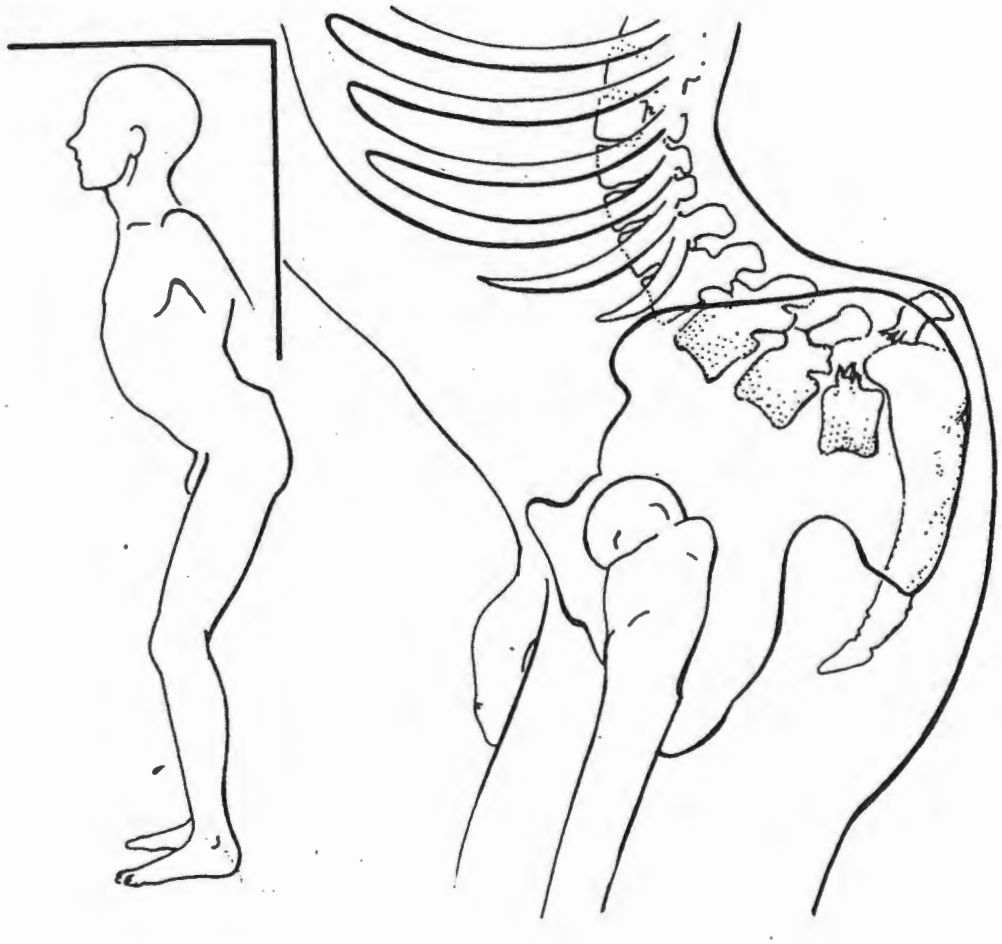


Figure 4: Sketch showing the changes occurring with regard to the pelvis and lumbar spine as the slip increases.

(Bradford: in Moe (ed): Textbook of Scoliosis and Other Spinal Deformities. 2nd ed. 1987: 403-434)

The forward slip can precipitate a "listhetic crisis" in which the spinal canal is totally occluded (Gaines 1988). Macnab (1977) describes the crisis as the sudden onset of severe backache with a rigid lumbar spine. There is often a spastic scoliosis. The anteriorly rotated pelvis results in a flat sacrum with severe hamstring spasm causing the patient to walk with bent knees. To relieve the nerve root tension the patient bends forward and often supports their weight on their knees.

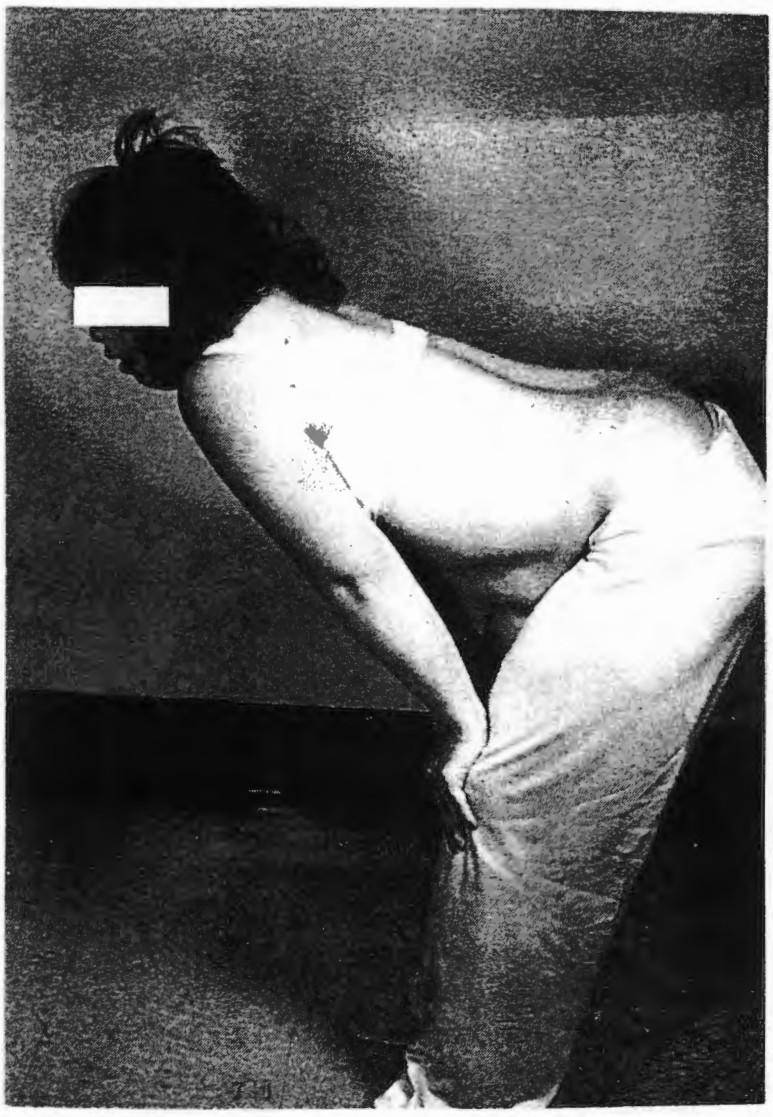


Figure 5: Characteristic position of a patient during a listhetic crisis.

(Gaines et al: in Chapman and Madison (eds): Operative Orthopaedics. 1988; 2005-2016)

Scoliosis is found in 23-48% of patients with spondylolisthesis but in only 13% of those with spondylolysis. This scoliosis is initially not structural, but secondary to lumbar muscle spasm (Boxall 1979, Fisk 1978, Hensinger 1976, Hensinger 1989, Laurent 1976 and McPhee 1979). Scoliosis is more common in patients with Type I (Dysplastic) spondylolisthesis (59%) than in patients with Type II (Isthmic) spondylolisthesis (42%). Female sex (61%) and patients with severe slip also show an increased incidence of scoliosis (Blackburne 1977, Bohlman 1982, Hensinger 1989 and Seitsalo 1991).

Idiopathic scoliosis can occur in association with olisthetic scoliosis. The incidence of spondylolysis or spondylolisthesis in patients with idiopathic scoliosis is higher, at 6,2%, than it is in the general population (Fisk 1978). When scoliosis and spondylolisthesis occur together it is recommended that they should be treated as separate problems. If the child is symptomatic early fusion of the spondylolisthesis is recommended (Fisk 1978, Seitsalo 1991).

v. RADIOLOGY

There are various imaging modalities available to investigate a patient with spondylolisthesis. These include X-rays, Myelograms, C.T.Scans and Magnetic Resonance Imaging. The most useful and generally used of these options is X-ray imaging.

1. X-RAYS

The basic x-rays needed are anteroposterior (AP) views of the lumbosacral spine and lateral views of the lumbosacral junction. If the defect is not obvious and spondylolysis is suspected then oblique x-rays should be taken looking for the pars defect.

Hensinger (1989) states that up to 20% of young patients with symptomatic spondylolysis are missed if oblique x-rays are not taken. The defect seen on the oblique views is known as the "Scotty dog sign of Lachepele" and appears as a defect in the collar of the dog's neck. However in severe spondylolisthesis the lysis is usually obvious if present.

Confusion can occur when the spondylolisthesis develops without any lysis such as in the Type I (Dysplastic) spondylolisthesis (Wiltse 1976). Up to one third of symptomatic patients can have spondylolisthesis without spondylolysis (Hensinger 1976).
Further difficulties arise when there have been adaptive changes and new bone formation in an attempt to stabilise the instability as this distorts the bony architecture.

All the x-rays for spondylolisthesis must be taken in the standing position as the olisthesis will often partly reduce with recumbency (Lowe 1976) (figure 6, page 22). However, the

degree of slip in adults, is not influenced by position as much as it is in children (Saraste 1987).

Stress X-rays are usually not needed in the assessment.

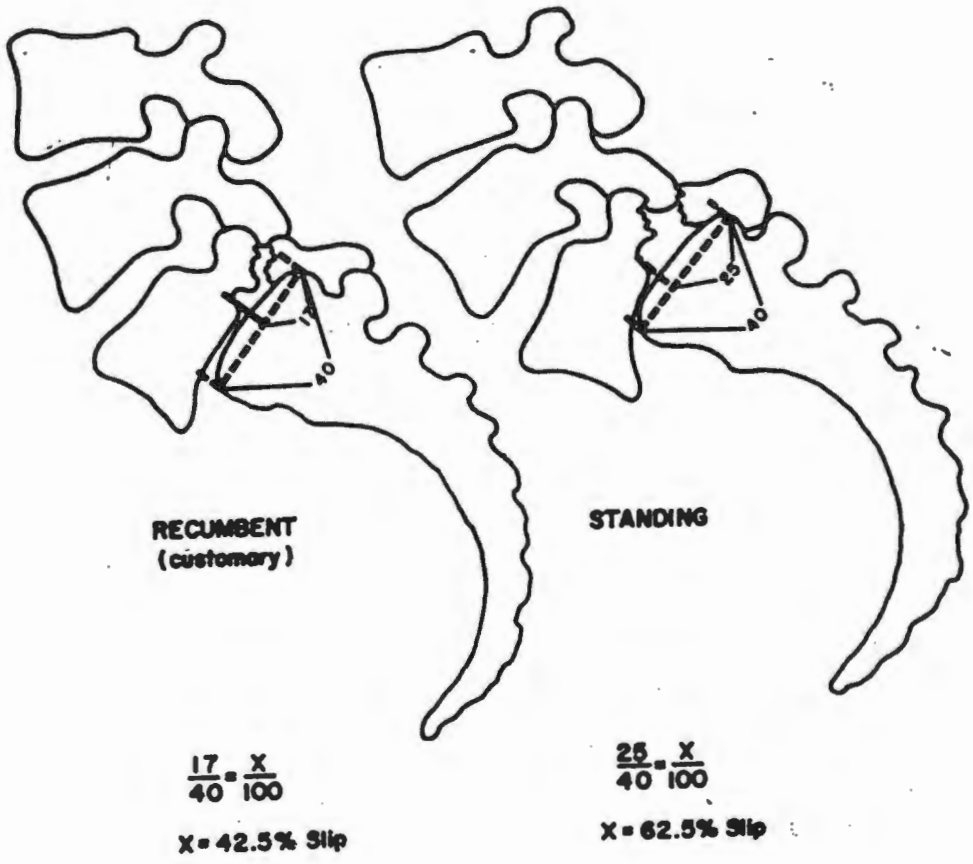


Figure 6: Sketch showing how positioning of patient affects the % of olisthesis.

(Lowe et al: Clin Orth 1976; 117: 80-84)

When assessing spondylolisthesis the posterior spinal elements and the vertebral bodies should be assessed separately.

POSTERIOR ELEMENTS.

Here one looks for pars interarticularis lysis or signs of dysplasia.

For a slip of greater than 25% to occur there must be pars elongation or lysis otherwise cauda equina paralysis will occur (Wiltse 1976). This attenuation of the pars has been called the "greyhound sign" by Hensinger (1976).

Other signs of dysplasia include poor L5\S1 facet joint development and spina bifida of L5 and/or S1. On the lateral x-ray the posterior neural arch of L5 as well as the spinous process appear to slide ventrally in the dysplastic lesions.

VERTEBRAL BODIES.

The forward subluxation of the vertebral body is best seen on the lateral X-ray. In the AP view severe olisthesis can be recognised by a tilting of the pelvis and seeing the body of L5 resembling a "upside down Napoleon's Hat".

There are two kinds of slip in spondylolisthesis (Hensinger 1989):

1. Tangential
2. Angular.

In addition to the above slips, the third observation needed is that of adaptive changes to the L5 vertebra, sacrum and lumbar spine.

1. Tangential Slip

This has also been called the grade of slip, percentage of slip and the anterior translation (Wiltse 1983). It measures the forward slip of L5 on the first sacral vertebra.

The methods used to measure slip are:

a. Meyerding Grade (1932)

b. Taillard Percentage Slip (1954)

c. Modified Taillard method (Boxall 1979)

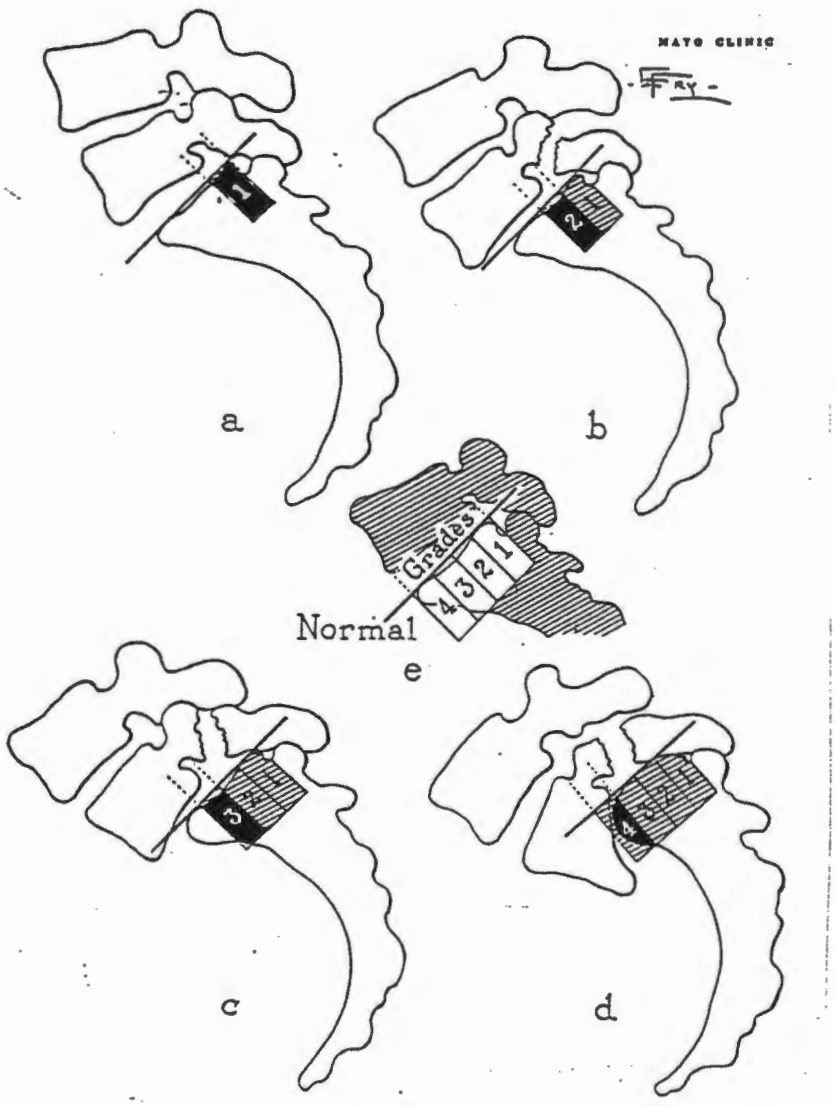
1a. Meyerding Grade

Meyerding divided the anteroposterior diameter of the first sacral vertebra into quarters and assigned these as Grades I-IV respectively. Subsequently a Grade V (Spondyloptosis) has been added and come to be universally accepted (Hensinger 1989).

This is an easy method for assessing the severity of the slip. The problem with this method is that addaptive changes may have occurred, making the first sacral vertebra indistinct.

Figure 7: Gradation of degrees of spondylolisthesis.

(Meyerding: Surg Gynaecol Obstet 1932; 54: 371-377)



1b. Percentage Slip

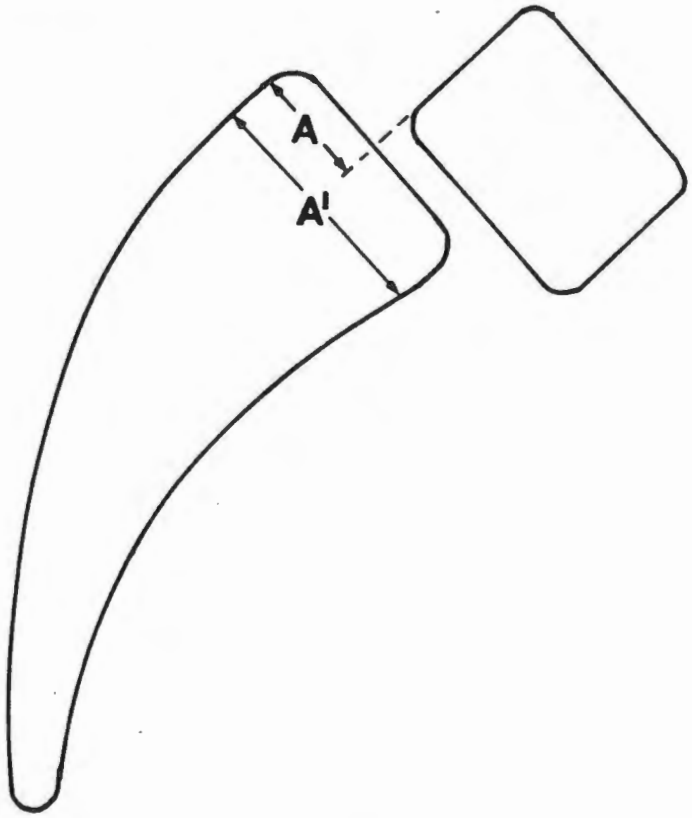
The Taillard method is the most commonly used method for quantifying the slip. This method is thought to be the most accurate method of measuring the slip (Laurent 1976, Wiltse 1983).

Boxall (1979) however feels it is not accurate as there can be adaptive changes to S1 as well as erosion of the L5 body. They have modified the method so that the % slip is the amount of slip of L5 on S1 measured from the back of S1 over the AP length of L5, converted to a percentage.

Figure 8: The most commonly used method for quantitating the % slip.

% slip = A/A' x 100/1.

(Wiltse et al: J Bone Joint Surg 1983; 65-A: 768-772)



2. Angular Slip

This measures the angular relationship between the fifth lumbar and first sacral vertebrae. It has been given many names: "Roll" (Newman 1965), "Sagittal Rotation" (Wiltse 1983), "Slip Angle" (Boxall 1979, Dandy 1971) and "Lumbosacral Kyphosis" (Bradford 1987, Burkus 1992).

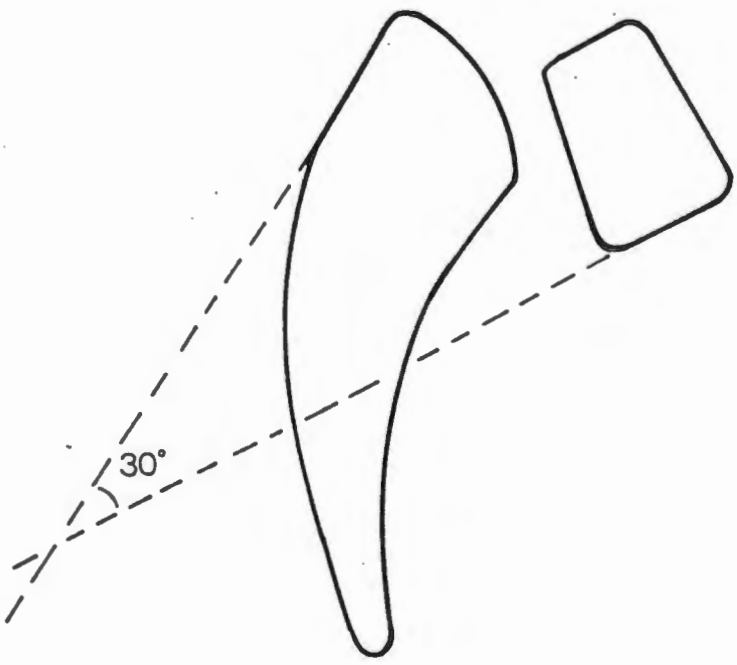
2a. Sagittal Rotation

This is measured by extending a line along the anterior border of L5 until it intersects with a line drawn down the posterior border of S1.

Once the sagittal rotation has reached 30 degrees it is thought that the slip will progress.

Figure 9: Measurement of sagittal rotation.

(Wiltse et al: J Bone Joint Surg 1983; 65-A: 768-772)



2b. Slip Angle

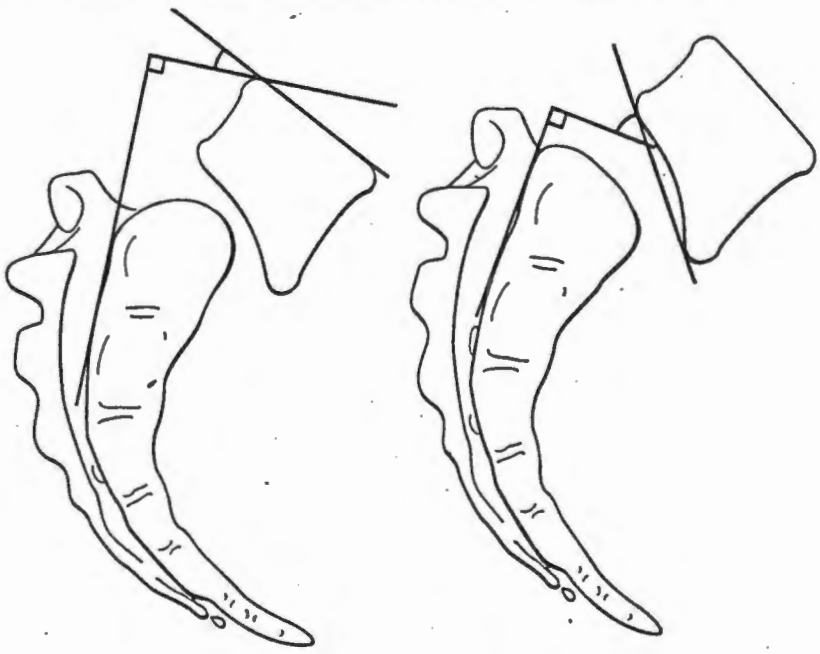
This is calculated by drawing a line perpendicular to the posterior border of the first sacral vertebra. The angle this perpendicular line makes with a second line drawn parallel to the L5 end plate is the slip angle. This angle can be measured using the inferior or superior L5 vertebral end plate.

Boxall (1979) prefers to use the inferior plate as he feels that the superior end plate is not a true reflection of slip when the body of L5 is positioned against the anterior sacrum. Burkus (1992) feels that the superior end plate is more accurate as the inferior end plate can become very distorted and indistinct.

The normal slip angle is O degrees (Bradford 1987). A slip angle (inferior end plate) of greater than 55 degrees is associated with a high chance of further slip (Boxall 1979).

Figure 10: Measurement of the slip angle by the Burkus (left) and Boxall (right) methods.

(Burkus et al: J Bone Joint Surg 1992; 74-A: 693-704)



3. Adaptive Changes

These measurements include:

a. Sacral Inclination\Tilt

b. Lumbar Index

c. Lumbar Lordosis

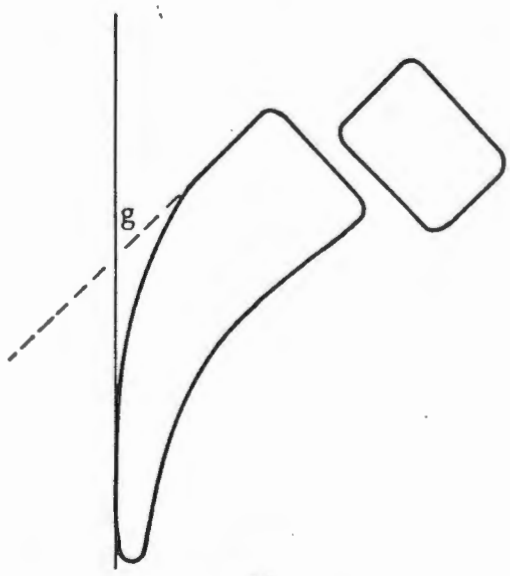
3a. Sacral Inclination

This refers to the relationship in the sagittal plane of the sacrum to the vertical. It is calculated by drawing a line down the posterior border of S1 and measuring the angle this line makes with a vertical line.

The normal sacrum is usually inclined forward by more than 30 degrees. As the slip becomes more severe the sacrum verticalises reducing the sacral tilt angle (Wiltse 1983).

Figure 11: Measurement of sacral inclination.

(Wiltse et al: J Bone Joint Surg 1983; 65-A: 768-772)



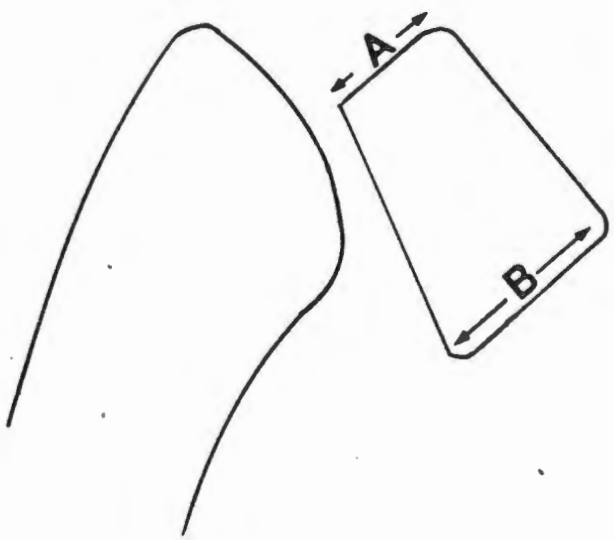
3b. Lumbar Index

This is a measurement of the wedging of the L5 vertebra. The index is calculated as a percentage. This percentage is determined by dividing the height of L5 posteriorly by the height of L5 anteriorly.

This trapezoidal shaping of L5 is thought to be adaptive to the olisthesis. It is felt that an index of less than 65% is predictive for further slip (Wiltse 1983).

Figure 12: Measurement of lumbar index.

(Wiltse et al: J Bone Joint Surg 1983; 65-A: 768-772)

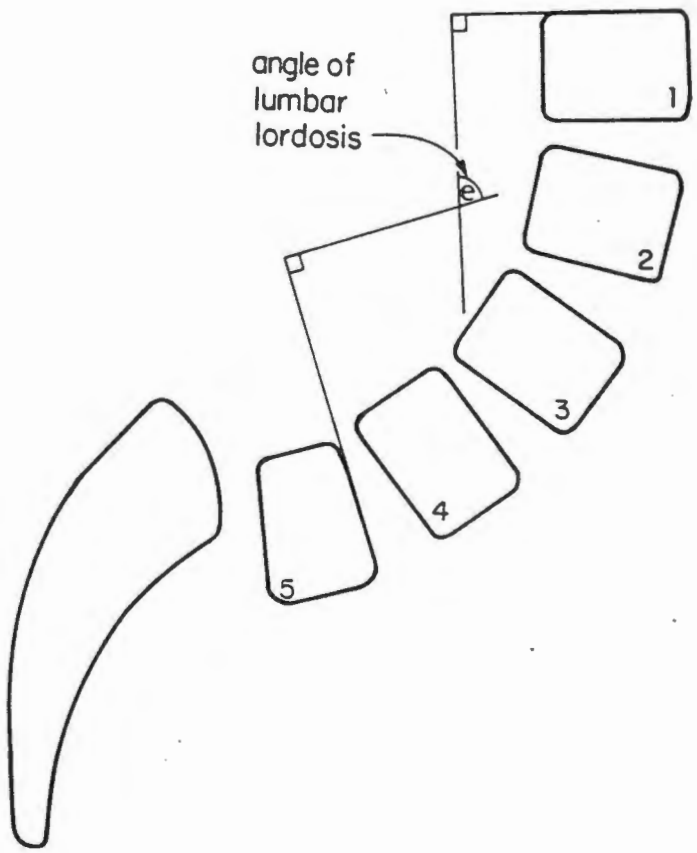


3c. Lumbar Lordosis

This is a compensatory phenomenon to the abnormal lumbosacral kyphosis. The lumbar lordosis tends to increase as the % slip and the slip angle increase.

Figure 13: Measurement of lumbar lordosis.

(Wiltse st al: J Bone Joint Surg 1983; 65-A: 768-772)



Other measurements can be made but are seldom used eg. rounding of the top of the sacrum, the sacrohorizontal angle and the lumbosacral joint angle (Bradford 1987, Wiltse 1983).

Boxall (1979) and Bradford (1987) feel that the slip angle is the most sensitive indicator of instability and the best indicator of progression of slip after fusion.
The other measurement commonly used to evaluate severity is the % slip. This has been found in a multivariate analysis to be prognostic for further slip (Saraste 1987).

2. MYELOGRAMS

Myelograms in children are not recommended and are seldom indicated as disc protrusion is uncommon in these patients (Bradford 1987, Hensinger 1989). Myelograms are recommended if other causes of adolescent backache eg. tumours are suspected. They may also be necessary if the patient's symptoms, regarding bowel and bladder, deteriorate. Bradford also recommends myelography if reduction is considered.
Myelograms have been superceded by C.T.Scans and Magnetic Resonance Imaging (MRI).

3. BONE SCANNING

Radionuclide scintigraphy using technetium-99m methylene diphosphonate is regarded as being the most sensitive method of diagnosing early spondylolysis or stress fractures in young patients and athletes presenting with low back pain (Grobler 1991, Papanicolaou 1985, Pennell 1985 and van den Oever 1987).
Bone scanning is of most use in the early stages when the x-rays are still normal (Jackson

1976, Papanicolaou 1985 and Wiltse 1975). Bone scanning is also useful to assess the age and potential healing of a spondylolytic lesion. As bone scanning is an indicator of bone remodelling (Papanicolaou 1985), a positive scan is regarded as a new lesion and one that has the potential for healing with immobilisation. A scan showing no activity indicates a long standing lesion with an established non-union (Jackson 1976, Papanicolaou 1985 and van den Oever 1987).

4. C.T. SCANS and MRI

C.T. scanning is useful in cases where the defect in the pars needs to be evaluated (McAfee 1982). This is especially in patients with severe neurological problems. The problem with C.T. scanning is that as the slip increases it becomes more difficult to scan the area and to interpret the scans.

MRI scanning is thought to be the best method of non-invasive investigation. The technique gives accurate sagittal and coronal views of the affected area. MRI scanning is recommended for investigation of deteriorating neurology and if some other cause for the pain, such as a tumour is suspected.

In summary, standing AP and lateral x-rays of the lumbosacral spine are the recommended first line of radiological investigation. The two most important measurements are the % slip and the slip angle. Dysplastic features must be looked for especially in the pre-pubescent child. Bone scanning is used in the young patient with backache to detect and age early spondylolysis. MRI scanning is the of choice if further investigations are needed.

vi. TREATMENT

The treatment of spondylolisthesis depends on various factors. The major factors being listed in Table 1, page 12.

The treatment of a patient with neurology is different in adults and children.
In children, it is accepted that unless there are symptoms of a cauda equina syndrome, surgery other than stabilisation of the lower spine is seldom needed (Boxall 1979, Nachemson 1976). Boxall (1976), Hensinger (1976) and Wiltse (1976) have all shown that children with severe neurology recover after a simple localised spinal fusion. They do not recommend the Gill Procedure (Gill 1955), partial laminectomy or the exploration laterally of nerve roots. It appears that once the spine is stable, the nerve roots adapt to their situation and recover. Should a Gill procedure be performed it must be accompanied by a spinal fusion or else the slip will progress in a high percentage of cases (Bradford 1987). Should the child have a cauda equina syndrome, then the necessary decompression and spinal fusion is needed (Boxall 1979, Hensinger 1976 and Verbiest 1979).

In adults, after spinal stabilisation, the nerve roots do not recover as well as in children. This is probably due to secondary degenerative spondylosis. In adults the recommended treatment for patients with incapacitating neurology is decompression and spinal fusion.

The major residual controversy regarding treatment of spondylolisthesisis is the question of reduction and type of spinal fusion.

a. What type of spinal fusion is needed? Should it be a posterior fusion, a posterolateral

fusion, an anterior fusion, a combined fusion or something else?

b. Is internal fixation needed?

c. Does the patient need to be braced and\or kept in bed and for how long after surgery?

d. Does the spondylolisthesis need reduction?

e. Is the degree of slip going to increase after fusion and how will it affect the patient?

It is accepted (Bradford 1987, Hensinger 1989) that for Meyerding Grade I and II slips , (< 50%), that posterolateral fusion in situ is adequate.

These patients do not need to be braced after surgery and can be mobilised when comfortable (Rombold 1966, Wiltse 1961). These patients do not need reduction of their spondylolisthesis and there is unlikely to be any further slip.

The controversy in the surgical management of spondylolisthesis concerns Meyerding Grades III\IV\V slips (>50%). The various surgical options and controversies will be discussed and compared.

A. FUSION in SITU

1. Anterior Fusion in Situ

Anterior fusion in situ was first suggested as a treatment for spondylolisthesis by Capener in 1932. He however did not feel that it was technically possible. The first anterior interbody fusion was performed by Burns in 1933 (Cloward 1981).

The rationale for anterior fusion is that the fusion mass is under compression and not tension as it is with posterior forms of fusion. This should decrease the pseudoarthrosis rate (Bohlman 1982, Smith 1990).

Surgical Methods

Various methods of doing an anterior fusion have been described.

The three major approaches are:

1. Transperitoneal (Freebody 1971, Jones 1988)
2. Retroperitoneal (Cheng 1989, Stauffer 1972)
3. Posterior Lumbar Interbody Fusion (Cloward 1981)

The common theme with all three approaches is a lumbar sacral interbody arthrodesis. This may be supplemented by a strut graft eg. fibula or rib anteriorly (Jones 1988).

Stauffer and Cheng both described a retroperitoneal approach to the lumbosacral junction,

disc excision and bone grafting with iliac crest bone. Due to crumbling of the iliac graft in Stauffer's series, the Mayo Clinic changed their technique to use fibula or rib instead of the iliac crest bone.

Cloward reported on his posterior lumbar interbody fusion (PLIF) in 1981. His procedure, via a posterior approach, consists of removing the complete posterior neural arch. The disc is then removed including the cartilaginous and cortical end plates. A vertebral spreader is then used and iliac bone plugs inserted to fill the gaps. No additional grafting is used. Post operative bracing was only used for one month in patients with severe slip. No attempt at reducing the slip was made.

Smith (1990) modified Cloward's procedure for severe olisthesis and completed the anterior fusion by driving a fibular graft through the sacrum into L5 via a posterior approach. They supplemented the fusion with a posterolateral fusion. No bracing was used.

Results

The reported results are very satisfactory.

Freebody (1971) reported that 84% of his 252 patients achieved a solid arthrodesis. He rated 92% of his clinical results good or better.

Good results have also been reported using the retroperitoneal approaches. Cheng (1989) reported 19 of 20 patients with excellent or satisfactory clinical results. However, only 75% of the patients were totally symptom free at 10 year follow up. Flynn and Hoque (1979)

reported 87% good results.

However, Stauffer and Coventry in 1972 reported the results from the Mayo Clinic. They found only 56% radiographic evidence of fusion and rated only 36% of their patients as having a good result.

Cloward (1981) admits that his posterior lumbar interbody fusion is a difficult operation, but reports 83% excellent results. His patients being free of any pain and physically unrestricted. He had a 94% radiographic fusion rate. Smith (1990) with his modification of this technique reported a 100% fusion rate and that all his patients had major or complete neurological recovery. His follow up was 2-12 years.

Complications

The complications for anterior fusion vary depending on whether an anterior or posterior approach has been used.

Anterior Approach

(Cheng 1989, Duncan 1965, Flynn 1984 and Stauffer 1972)

1. Damage to the pelvic vessels.
2. Damage to the presacral nervous plexus with resultant sexual dysfunction.
3. Cauda equina syndrome.
4. Damage to abdominal organs with the transperitoneal approach.

5. Difficulty with the retroperitoneal approach in obese patients.
6. Extrusion of the graft necessitating a second operation.
7. Pseudoarthrosis.
8. Fusion at the wrong level.
9. May need a second operation - posterior decompression of nerve roots.

The damage to the presacral sympathetic nervous plexus results in impotence, sterility and retrograde ejaculation. However with the increasing awareness of the anatomy and of this complication, the incidence is very low. Flynn quotes figures of 0,42% for retrograded ejaculation and of 0,44% for impotence and sterility.

The other complications such as cauda equina syndrome and damage to the abdominal organs are also rare.

Posterior Approach

(Cloward 1981, Smith 1990)

1. Dural tears.
2. Nerve root damage.
3. Pseudoarthrosis.

The dural tears were repaired and healed uneventfully. The nerve root damage also recovered.

2. Posterolateral Fusion in Situ

Meyerding (1932) suggested that a posterior fusion was adequate for the treatment of spondylolisthesis and that it prevented further deformity and disability. His operation was accepted as standard treatment for spondylolisthesis (Harris 1987). Other surgeons however found that while the operation did relieve symptoms, further slip did occur.

In 1960, Wiltse introduced his bilateral paraspinal muscle splitting approach to the lumbosacral spine. He felt the major advantage of this approach is that the interspinous supporting structures were not destroyed. There should therefore be less slip progression and the patient could be mobilised, brace free, immediately.

The other objection to posterolateral fusion in situ, is that the fusion mass is under tension and not compression, potentially leading to an increased rate of pseudoathrosis in addition to further slip (Boxall 1979, Bradford 1987).

Posterolateral fusion in situ also does not address the question of the child's appearance (Wiltse 1976).

The bilateral paraspinal muscle splitting approach of Wiltse (1976) is the accepted approach for bilateral posterolateral fusion in situ (see figure 14, page 42). In severe spondylolisthesis the recommended fusion is from L4 to S1 (Bradford 1987, Hensinger 1976, Pizzutillo 1986).

The initial Wiltse approach described two paraspinal skin incisions prior to splitting the sacrospinalis muscles. Today the operation is carried out via a single midline incision.

Once incised the skin is undermined laterally prior to cutting the fascia over the muscles.

The sacrospinalis is then split 3,5 cm lateral to the midline. The dissection is carried out through the sacrospinalis muscle. The top of the sacrum, the facet joints, transverse processes (L4\5), pars interarticularis and lamina to the bases of the spinous processes are exposed and prepared for bone grafting.

The graft is usually autograft from the iliac crest. The sacrospinalis muscle is then allowed to close over the graft to help keep it in position. The wound is closed in layers.

Interpedicular fixation (L4-S1) can be used to supplement the fusion in situ.

Post operative management is dependent on the surgeon. Wiltse (1976) and Rambold (1966) prefer no immobilisation whilst Turner (1971) uses a cast and Nachemson (1976) a lumbosacral corset.

Bradford (1987) and Hensinger (1976) use a body cast including one thigh with the hips extended. If there is any increase in deformity they keep the patient in bed for 3 months. This period is extended if the fusion still does not look solid.

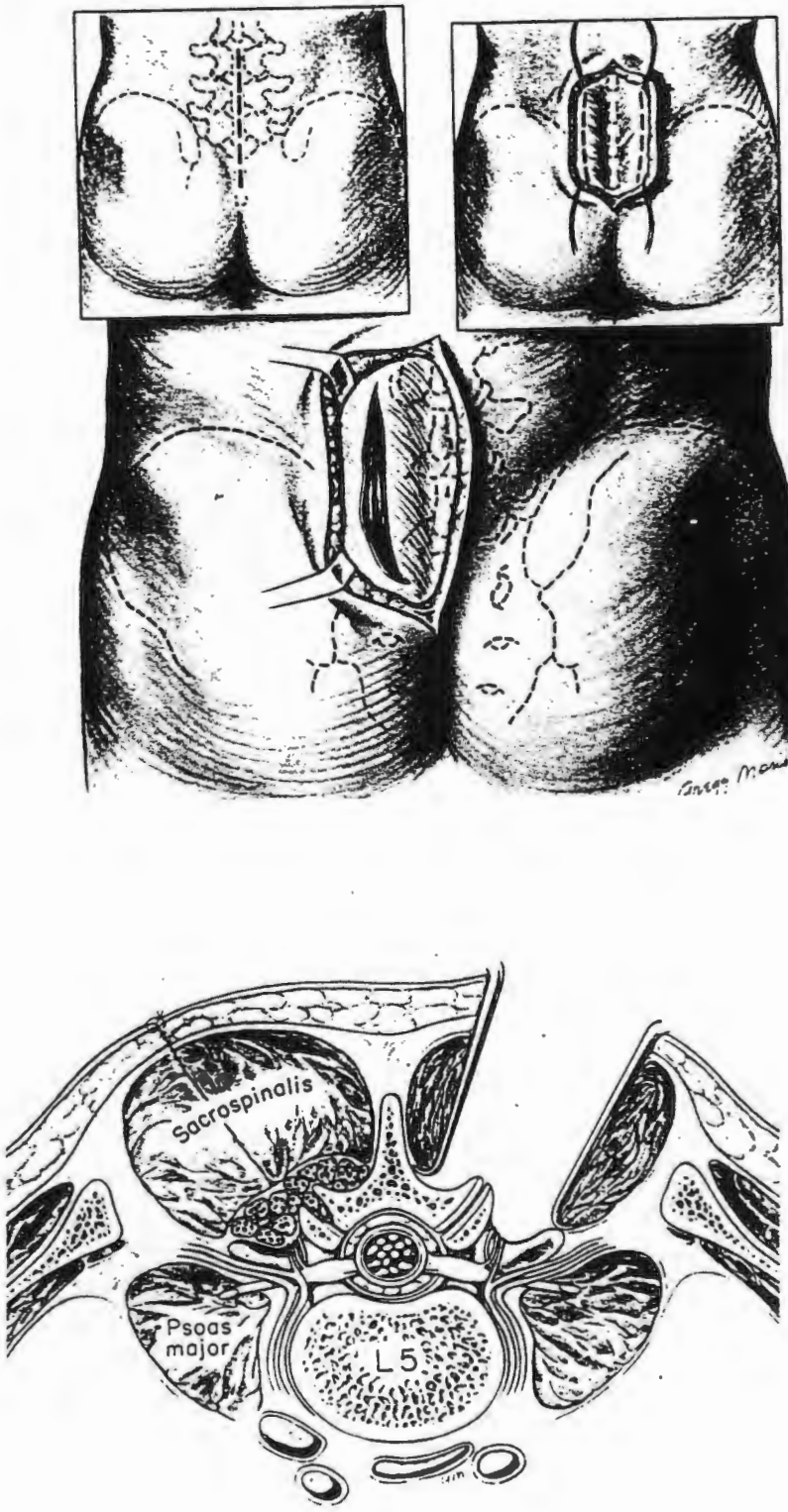


Figure 14: The bilateral paraspinal muscle splitting approach of Wiltse.

(Wiltse et al: Clin Orth 1976; 117: 92-100)

Results

Several long term studies of the results of bilateral posterolateral fusion in situ have been published - Burkus (1992), Fennered (1991), Freeman (1989), Harris (1987), Hensinger (1976), Johnson (1983), Riley (1986), Seitsalo (1991) and Sherman (1979).

The results show overwhelmingly that posterolateral fusion in situ is adequate for the stabilisation of severe spondylolisthesis. Bradford (1988) feels that posterolateral fusion in situ "has a predicatably favourable outcome". In the above named studies, a total of 583 patients were treated with posterolateral fusion in situ and only five patients are reportedly unhappy with their results. The average follow up in these series was 6,5 years (range 2-32 years). Even in the older series of Bosworth (1955) and Stauffer (1972) clinical success rates of 89% and 87% are reported.

Due to the success of posterolateral fusion in situ, Hensinger (1976) and Peek (1989) recommend that laminectomy\Gill procedure is seldom needed in the immature patient with neurological problems. In the adult patient with degenerative changes, nerve root exploration and laminectomy may be needed. However, in Peek's series on adults with severe sciatica, the preoperative neurological deficits all resolved once the spine was stabilised. For stabilisation of the spine, bilateral posterolateral fusion in situ was adequate.

The major drawbacks to posterolateral fusion in situ are pseudoarthrosis and further listhesis. The pseudoarthrosis rate is quoted as 0% to 26% by various authors. The older series of Boxall (1979) and Bosworth (1955) quote 25% and 26% rates respectively. The later series

quote figures of 0% to 6% (Fennered 1991, Freeman 1989 and Johnson 1983). The patients with pseudoarthrosis did not require further surgery. However, radiological detection of a pseudoarthrosis can be extremely difficult. Bradford (1987) reported 10 symptomatic patients thought radiologically to have solid in situ fusions, 7 of whom had a pseudoarthrosis at surgical exploration. Some authors feel the pseudoarthrosis rate is not influenced by laminectomy, immediate mobilisation or spina bifida occulta (Fennered 1991, Stauffer 1972 and Turner 1971). Boxall (1979) feels that pseudoarthrosis is also independent of preoperative slip. Bosworth (1955) and Wiltse (1976) feel that laminectomy does potentiate pseudoarthrosis.

Boxall (1979) feels that further olisthesis is inevitable even with solid fusion, if the preoperative slip angle is greater than 55 degrees. This tendency to further slip is more likely in the young patient than in the older patient (Hensinger 1976, Seitsalo 1991). Bradford (1987) feels that the increase in slip is about 10-37% of the original slip angle in only 30% of patients. Patients seldom complain of further neurology despite the further slip. This increase in slip is thought to be due to bending of the fusion mass. This slip is reported not to influence the birth process - normal vaginal delivery is still possible (Bradford 1987, Riley 1986).

Few patients are unhappy with their cosmetic appearance following posterolateral fusion in situ. Freeman (1989) and Johnson (1983) report four patients who were not satisfied with their appearance. Seitsalo (1990) reported 8 women, from a series of 87 patients, who considered their back deformity cosmetically disturbing. The other reports, whilst mentioning appearance as a possible drawback to posterolateral fusion in situ without

reduction, do not report any unhappy patients.

The overall result of bilateral posterolateral fusion in situ is good. Few patients complain of backache, most recover their neurological deficit and return to full active and unrestricted lives.

Complications

The major complications of posterolateral fusion in situ are pseudoarthrosis, further slip, cauda equina syndrome and the failure to correct cosmesis.

1. Pseudoarthrosis - this has already been discussed above.
2. Further slip - this has already been discussed above.

3. Cauda equina syndrome and other neurological problems.

Cauda equina syndrome, defined as loss of voluntary control of bowel and bladder, is rare following posterolateral fusion in situ. There have been only 13 reported cases in the English language literature since 1960 with an incidence of 3% (Schoenecker 1990).

The cause of the syndrome is unkown. Maurice (1989) feels that the cause is mechanical with the stretched nerve roots being sensitive to L5\S1 movement. This movement is increased during decortication by the mallet\osteotome blows. Schoenecker (1990) feels the cause is increased tension on the roots and not a mechanical cause. He feels that with the general anaesthetic and stripping of the lumbar muscles, the control and protective reflexes of L5\S1 are lost. This results in an increase slip and tension in the nerve roots.

The recommended treatment for cauda equina syndrome is immediate decompression of the nerve roots with possible discectomy. The cauda equina syndrome carries a poor overall prognosis.

Neurological problems other than cauda equina syndrome are rare unless decompression and nerve root exploration is performed. Fennered (1991) reported a reversible deterioration in four of sixty six patients. Seitsalo (1991) with 272 patients in his series reported no neurological deterioration.

4. Cosmesis. Wiltse (1976) state "the only reason for reduction is the hope that it will improve the child's appearance". From this literature review it appears that very few patients are unhappy with their appearance. Freeman (1989), Johnson (1983) and Seitsalo (1990) report a total of 12 patients who were unhappy. Bradford (1990) feels the cosmetic defect leads to severe psychological problems. However, the overall consensus in the literature is that very few patients are unhappy with their appearance and few have psychological problems.

Summary

Bilateral posterolateral fusion in situ, from the literature, appears to be a safe and predicatable procedure. The patient seldom has a long hospital stay and is usually rapidly mobilised. There are few complications. Despite these complications follow up of up to 32 years shows that most patients are relieved of their symptoms and can go back to a full, normal active life.

B. REDUCTION and FUSION

Many authors feel that reduction is needed prior to fusion. Two major reasons for reduction are suggested. Firstly, the fusion mass is under compression and not under tension (Bradford 1988). Secondly, reduction realigns the L5\S1 junction causing an improvement in appearance.

Matthias (1986) advocates the following as the cited reasons for reduction:

1 Normalisation of biomechanical function of the L5\S1 junction.

2 The reduced spine is less difficult to stabilise.

3 Elimination of neurologic complications.

4 Elimination of pain.

5 Increased mobility.

6 Improvement of appearance.

He feels that reduction is not always justified using these criteria.

Reduction was first described in 1921 by Scharb. The first description in the English literature was by Jenkins in 1936 (Bradford 1987).

Many techniques of reduction have been described.

Closed reduction is supplemented with a surgical procedure to fuse the spine (Bradford 1988, Scaglietti 1976). The surgical reduction can be via a posterior, anterior or combined approach. Gaines (1985) suggests that L5 vertebrectomy is required for a proper reduction in spondyloptosis (grade V slip).

Methods

Many techniques have been described for reducing spondylolisthesis. In Clinical Orthopaedics volume 117 (1976), three techniques are described - Scaglietti using corrective casting, Harrington using his rods and Snijder using wires attached to an external frame. Balderston (1985) also described his technique using spinal traction wires attached to a Hoffman pelvic external fixator. Bradford (1979) and McPhee (1979) used posterior fusion followed by anterior reduction. DeWald (1981) also uses circumferential fusion. Newer methods include the use of transpedicular screws (Sijbrandij 1983) and variable screw placement slotted plates (Steffee 1988). Gaines (1985) recommends vertebrectomy of L5 followed later by reduction and an anterior fusion.

Cast Techniques

The Scaglietti technique (1976) is well accepted (Bradford 1988). Using this method the patient is placed on a fracture table with the application of longitudinal traction with the hips slightly flexed. Once the traction has been applied, the hips are hyperextended. This reduces the slip and angulation and corrects the pelvic inclination. A plaster cast is applied with the patient in this position. Posterolateral fusion is then required to maintain the

reduction. A one thigh cast is applied for the first two months, whereafter successive plasters are applied for a total of 10 months. The patient is kept in bed for the initial four months.

Bradford (1988) modified this technique. He first subjected the patients to halo-femoral or halo-Hoffman traction. Thereafter he performed a posterolateral fusion followed 10 days later with the application of a plaster cast with the hips extended. The patient is kept in bed for four months. He has further modified his technique in that he now performs an anterior fusion secondarily - described further under surgical techniques.

Surgical Techniques

Balderston (1985) and Snijder (1976) both suggest the use of spinous process traction. Initially a posterolateral fusion is performed. At the same time traction wires are applied to the spinous processes of L (2),3,4 and attached to an external fixator. The wires are then tightened as needed to give increased translational reduction. Once adequate reduction has been obtained the wires are removed and a plaster cast is applied. The average time in bed is five months.

Harrington (1976) suggested using Harrington distraction rods to reduce the spondylolisthesis. It is reported that the use of these rods may actually increase the lumbosacral kyphosis and olisthesis. As the sacral structures are often dysplastic, fixation is difficult and fusion often has to be extended over several normal levels.

Combined approaches are suggested by Bradford (1979), Bradford (1990) and DeWald (1981). Bradford's (1979) suggested regime starts with halo-femoral distraction for two weeks. A pelvic sling to extend the hips is then added for a further two weeks. A Gill procedure and bilateral posterolateral fusion of L4 to S1 is then performed. After a further two weeks of traction, reduction and interbody fusion is carried out via a transperitoneal approach. The patient is then cast for 6-8 months and kept in bed for four months.
Hensinger (1989) feels this type of surgery should be reserved for patients with spondyloptosis or failed previous surgery.

Many surgeons prefer to incorporate a partial or complete L5 vertebrectomy and resection of the superior aspect of S1 (Balderston 1985, DeWald 1981 and Gaines 1985). This is an attempt to reduce the tension on the nerve roots during and after reduction of the olisthesis.

Newer reduction techniques using pedicular fixation are now being used (Ani 1991, Matthias 1986, Sijbrandij 1983 and Steffee 1988). These techniques also include some form of bony resection.
Sijbrandij reduced the olisthesis with Harrington rods and held the reduction (L5-S1) with Zielke sacral bars to avoid having to fix unaffected levels. Ani and Steffee both used variable screw placement (VSP) slotted plates and transpedicular screws.
Steffee fixes L4 to the sacrum and supplemented the pedicular fixation with cement. His technique is to first stretch the soft tissues at the L5\S1 level. This he does during surgery prior to doing his vertebrectomy. After filling L5 with bone cement he places pedicular screws into L4,5, S1,2. Using a straight plate on either side, a nut is put onto the L5 screws and tightened. This pulls the L5 body up to the plate aligning L5 in it normal position. The

plates are then removed, one at a time, and bent to the new position, replaced and then all the screws are tightened. The fixation is supplemented by copious amounts of bone graft. Spinal cord monitoring is used throughout the procedure.

Both Ani and Steffee admit that full reduction is not always possible and that it may be necessary to accept a less than perfect reduction.

Results

The overall results from reduction of spondylolisthesis are radiologically superb. However these superb results are overshadowed by a high incidence of neurological complications (up to 60% of cases - Bradford 1979). The neurological problems have been reported with both closed and open techniques.

The radiological results (% slip and slip angle) show improvement. Bradford (1988) using closed techniques reduced the % slip from 50% to 40% and the slip angle from 33 to 11 degrees.

Ani (1991) using the VSP system, reduced the % slip from 68% to 6%. The slip angles had improved from 98 to 83 degrees. These 20 patients were all followed up for more than 2 years. They were all rated as good to excellent results with regard to function and cosmesis.

Matthias (1986) using a similar technique on 50 patients reported superb results in pain and neurological improvement. However, 11 patients developed sensory problems and 12 motor problems. Only 50% of these recovered.

For salvage surgery Bradford (1987), reported 100% success in his 16 patients at a 4,5 year follow up. They had no pain, symptoms and all led an unrestricted life.

Ani (1991), Bradford (1990) and Steffee (1988) all feel that it is better to accept partial reduction as this tends to prevent neurological complications.

Complications

Complications are common with reduction and fusion. The major complication being neurological problems.

1. Neurological damage.

Neurological damage with reduction and transpedicular stabilisation has been reported as being as low as zero (Harms 1991, Poussa 1993) to as high as 60% (Bradford 1979, Peek 1989). These problems range from neuropraxia, loss of motor power and paraesthesia to cauda equina syndrome (Bradford 1979, Bradford 1990, DeWald 1981, Matthias 1986 and McPhee 1979).

The commonest problem is traction and paresis of the L5 nerve root. However paresis of L2,3,4,S1 and S2 nerve roots have also been reported (DeWald 1981, Harrington 1976, Matthias 1986 and Transfeldt 1989). Not all of the pareses have recovered after release of the reduction. Some of these pareses have occurred despite vertebrectomy.
Cauda equina syndrome has an incidence of 5% (Bradford 1990).

2. Loss of correction.

Unless instrumentaion is used the correction achieved by cast methods will usually be lost. However loss of correction has also been reported using instrumentation (Bradford 1979, McPhee 1979). Transpedicular fixation is thought to be the best fixation. This is unlikely to lose correction unless there is instrument failure (Ani 1991, Steffee 1988).

3. Pseudoarthrosis.

Reported delayed union and pseudoarthrosis rates range from zero (Hensinger 1976) and 1% (Harms 1991) to 21% (Bradford 1987, Bradford 1990).

4. Harrington Hooks and Rods.

These are difficult to fix to the sacrum and can slip with loss of correction (DeWald 1981). This instrumentation has also been shown to increase the lumbosacral kyphosis and the fixed flexion deformity of the spine (Harrington 1976).

5. Skin Irritation.

Irritation over the fixation has been reported being as high as 25% (Ani 1991).

6. Graft dislodging or fracturing (Bradford 1987).

7. Pin tract sepsis - 5% (Bradford 1990).

8. Severe Blood loss (Ani 1991, Gaines 1985).

9. Deep vein thrombosis (Bradford 1979 and 1987)

10. Prolonged immobilisation, spica wear and hospitalisation (Balderston 1985, Bradford 1988, Scaglietti 1976 and Snijder 1976).

11. Complications related to the anterior approach to the spine.

12. Need for a second procedure to remove the posterior instrumentation (DeWald 1981, Sijbrandij 1983).

Summary

Reduction of spondylolisthesis is feasible. It gives a good functional and cosmetic result. The cost, however, is prolonged hospitalisation and a very high risk of neurological damage.

The newer techniques along with a realisation that 100% reduction is not needed are giving good results with fewer complications.

Part 2. STUDY

i. ABSTRACT

A retrospective review of 16 surgically treated patients with severe spondylolisthesis was carried out at an average follow-up of 6,3 years (range 1-15 years).

All the patients had severe spondylolisthesis or severe dysplastic features of their lumbosacral junction. They were treated by bilateral posterolateral fusion in situ. No attempts were made to reduce the olisthesis.

14 patients were satisfied with the results of the surgery. Apart from occasional backache they were all happy specifically with their function, posture and gait.
4 patients had an increase of olisthesis, but this did not influence their outcome.

3 patients had postoperative neurological problems, 2 being permanent.

An analysis of the results is presented based on personal interview, physical and radiological examination.

ii. MATERIALS and METHODS

16 patients who were surgically treated for severe spondylolisthesis were reviewed retrospectively.

a- PATIENTS.

The patients were selected in a sequential order from the records of a local teaching hospital and a private hospital. In all cases pre-operative, operative and post-operative notes and appropriate x-rays were available.

There were 10 female and 6 male patients in the study. The mean age at surgery was 13 years for the females and 16 years for the males. The range was 10 to 42 years. The mean follow up was 6,3 years with a range of 1 to 15 years.

b- PRESENTATION.

Clinical: (See graphs 1 & 2, tables 1 & 2, pages 66-68).

13 patients presented with symptoms whilst the other 3 were detected incidently. The commonest presenting symptoms were severe backache (10 patients) and severe leg pain (8 patients). 3 patients presented with occasional backache and with occasional leg pain.

4 patients complained of sensory changes. No patients complained of any motor weakness,

however on examination two patients were found to have weakness of plantar flexion. 5 patients presented with gait abnormalities whilst hamstring tightness was found in 11 patients. 8 patients had scoliosis.

Radiological: (See table 3, page 69).

The classification of patients into dysplastic or isthmic spondylolisthesis was difficult and finally not done. This was due to there being features of both dysplastic and isthmic spondylolisthesis in most cases. 40% of the patients had spina bifida occulta. They all had rounded S1 vertebra and many had very curved sacrums. 12 patients had lysis of the pars interarticularis.

Except for slip angle, the x-rays were read according to Wiltse and Winter (1983).
The average olisthesis was 57% with a range from 41 to 100%. 3 patients were assessed as Meyerding Grade IV and 3 had spondyloptosis.
The average sacral inclination was 30 degrees whilst the sagittal rotation was 25 degrees (range 0-60 degrees).

The slip angle was measured according to both Boxall's (1979) and Burkus's (1992) methods. The values being 40 degrees (range 1-75 degrees) and 19 degrees (range 1-61 degrees) respectively.
The lumbar wedging index was 59% with an average lumbar lordosis of 52 degrees (range 24-70 degrees).

c- SURGERY.

The surgery was performed initially at the teaching hospital, but lately at the local private hospital. All the surgery was carried out by three qualified orthopaedic surgeons.

All the patients had bilateral posterolateral fusion in situ, 8 via a midline approach and 8 via the Wiltse muscle splitting approach. The level of fusion was L4 to S1 in 10 patients and L5 to S1 in 6.

3 patients had instrumentation - 2 with Zielke transpedicular fixation. The instrumentation of the third patient was abandoned due to inability to get adequate fixation. 5 patients had laminectomies.

d- POSTOPERATIVE MANAGEMENT.

5 patients were managed initially with orthoses, 3 with spicas, 2 with bed rest and the remaining 6 were mobilised when comfortable with no restrictions. One patient was treated with bed rest due to her size. A spica could not be fitted comfortably. The other patient was treated with bed rest following failed fixation. He was put into a one legged spica at 6 weeks after surgery for a further 6 weeks.

The orthoses\spicas were worn till fusion was seen - up to 6months.

e- EVALUATION.

All patients were evaluated by personal interview, physical and radiological examination. Most cases were seen and examined by the author. Patients living great distances from Cape Town were interviewed and examined by their local orthopaedic surgeon according to a strict proforma. All x-rays were examined by the author.

iii. RESULTS

Clinical. (See graphs 1 & 2, tables 1 & 2, pages 66-68).

The incidence of severe backache improved from 63% to 6% and severe leg pain from 50% to 6%.

All the patients with abnormal sensation recovered postoperatively. Unfortunately one patient, who presented with normal sensation, developed a cauda equina syndrome postoperatively and has been left with permanent saddle hypoaesthesia.

The patients who had motor abnormalities preoperatively recovered after surgery. 2 patients who were normal preoperatively developed motor weakness postoperatively. Only one has recovered motor function. The patient who did not recover is the only patient still with a gait abnormality.

Hamstring tightness recovered in 10 of the 11 patients.

Radiological. (See table 3, page 69).

According to Boxall (1979) the two most important X-ray readings are the % slip and the slip angle.

The % slip increased in 4 patients by an average of 3,5%. The average overall postoperative % slip was 59 degrees (range 35-100 degrees).

The average postoperative slip angles were 44 degrees (2-88 degrees) (Boxall) and 24 degrees (2-62 degrees)(Burkus).

The sagittal rotation deteriorated in 6 patients with the average deterioration from 25 to 29 degrees.

The average sacral inclination improved by 20% to 36 degrees. It improved in 7 patients, but deteriorated in 3.

The average lumbar lordosis increasesd by 27%, going from 52 to 67 degrees. In 2 patients the lumbar lordosis decreased whilst it increased in 9.

There was no radiological evidence of pseudoarthrosis.

Daily Living.

No patients found that their olisthesis had left them with an unacceptable deformity. They are all happy with their posture and except for the two patients with neurological complications, all lead active lives.

Except for those at school and one who is a housewife, they are all employed. Their jobs

range from panelbeating to teaching to being tellers and messengers for banks.
With regard to sport, one opens the bowling for his cricket team. None of the 14 patients have had to stop sport because of their spondylolisthesis.

Only one of the female patients has been pregnant since surgery. She is a small lady with grade IV spondylolisthesis. Her two children were delivered electively by caeserean section.

iv. COMPLICATIONS

There were four complications.

1. Cauda Equina Syndrome. A 14 year old girl, with grade III dysplastic spondylolisthesis, developed the syndrome after fusion and Zielke instrumentation (L4-S1). No laminectomy was performed. She had loss of sensation and bowel and bladder control. Her motor power remained normal.
Myelogram showed compression at the L5\S1 level. She was taken back to theatre on day five following her original surgery. She had an L5 laminectomy and the L5 and S1 nerve roots decompressed. She has not recovered.

2. Bilateral L5\S1 motor weakness. A 13 years old girl, with grade III spondylolisthesis developed this weakness after fusion of L4 to S1. Laminectomy of both L4 and L5 was performed and the left L5 nerve root was decompressed.
She initially needed bilateral orthopaedic boots with O'Gorman springs. She has shown some recovery and now copes with bilateral ankle foot orthoses.

3. Transient L5 motor weakness. A 12 years old girl with spondyloptosis had a L4 to S1 fusion. No laminectomy was performed.

She has recovered fully.

4. Superficial wound sepsis in one case.

v. DISCUSSION

Posterolateral fusion in situ is at present the most widely accepted method of treatment for spondylolisthesis (Bradford 1987). Despite satisfactory results in most patients, progression of slip is known to occur despite what appears to be a solid arthrodesis (Bradford 1987, Laurent 1976). Harris (1987) and Riley (1986) feel that this progression is of no consequence whilst Bradford (1987) feels the further slip is associated with deformity and pain. Posterolateral fusion in situ is not designed to improve cosmesis, but review of the literature does show that very few patients complain of their appearance (Freeman 1989, Johnson 1983).

This series reports on 16 patients treated with posterolateral fusion in situ. The long term clinical results are good and the patients are satisfied. The symptoms of severe backache and leg pain were relieved with only one patient complaining of frequent backache and one of frequent leg pain. In neither was the pain sufficient to cause them to seek further medical attention and they are coping well with their daily activities. This relief of symptoms is in keeping with the literature that stabilisation of the spine is usually sufficient to relieve the back and leg symptoms even in adults (Fennered 1991, Freeman 1989, Hensinger 1976,

Johnson 1983, Peek 1989, Seitsalo 1990 and Seitsalo 1991).

The incidence of neurological problems were disappointingly high in that 3 patients (19%) had post-operative problems with 2 (12%) being permanent. One of these patients had a laminectomy, nerve root exploration and fusion while the other patient, who developed a cauda equina syndrome, had no laminectomy, but did have transpedicular screw fixation. The operative notes of the first patient do not explain why she had the nerve root exploration, but she was from early in the series when most of the patients did have routine nerve root exploration. The reported incidence of neurological problems in patients treated with posterolateral fusion in situ is low. Seitsalo (1991) reported no neurological problems in 272 patients and Fennered (1991) reported a reversible deterioration in 6% of his series. Cauda equina syndrome is exceedingly rare after posterolateral fusion in situ. Schoenecker (1990) reports only 13 cases in the English language literature since 1960 with an overall incidence of 3%. Cauda equina syndrome following surgery for spondylolisthesis carries a very poor prognosis which is borne out in our patient's poor recovery.

Pseudoarthrosis was assessed radiologically in this series and all the patients appeared to have a solid fusion. Early series quote pseudoarthrosis rates of up to 26% (Bosworth 1955). Later series such as Hensinger (1976) and Johnson (1983) report a zero incidence of radiological pseudoarthrosis. The true rate of pseudoarthrosis following posterolateral fusion in situ is not known, but Edwards (1991) feels the true union rate is in the range of 60-70%. Bradford and Gotfried (1987) reported on 10 symptomatic patients thought to have solid fusions. At surgical exploration 7 of these patients had a pseudoarthrosis. Edwards feels that the true pseudoarthrosis rate even in those patients who are asymptomatic and have

radiologically solid fusions may be very high.

Progression of slip, despite apparently solid fusion, after posterolateral fusion in situ for spondylolisthesis is an acknowledged problem (Edwards 1991). Boxall (1979) felt that percentage slip and slip angle are the most valuable radiological measurements to make. In this series 4 patients (25%) had an increase in percentage slip by an average of 3,5 %. This increase is low compared to the literature where the range is between 11% (Laurent 1976) and 72% (Dandy 1971). The increase in slip angle in this series was 26% (Burkus method, 1992) and 10% (Boxall method, 1979). This increase in slip angle is within the range quoted in the literature of 10-37% increase of the original slip angle (Bradford 1987, Edwards 1991). Seitsalo (1990) felt that measuring sagittal rotation was a more accurate measure of progression than either slip angle or percentage slip. He found that 45% of patients in his series had further slip. Sagittal rotation increased in this series by 16% in 6 patients (37%). Seitsalo found for the same group of patients the slip angle changed in 57% as opposed to the 45% measuring sagittal rotation. In contrast, in this series, more patients showed an increase in sagittal rotation (37%) than in slip angle (25%).

The overall sacral inclination, in this series, improved whereas the lumbar lordosis deteriorated. In both measures, some patients improved whilst others deteriorated. I did not find these two measurements useful.

Measuring progression of slip is difficult. There are adaptive changes to both the vertebrae and sacrum which makes measuring angles very difficult. The preference of various authors for slip angle over sagittal rotation or vice versa makes one wonder as to how meaningful these post-operative measurements really are clinically, as further slip does not appear to

hinder most patients (Bradford 1987, Freeman 1989, Harris 1987, Johnson 1983 and Riley 1986).

This progression of the spondylolisthesis,in this series, does not appear to have adversely influenced the final outcome as the patients are happy with their results. I found no correlation between post-operative management and the increase in spinal deformity.

Bradford (1987) felt the increase slip was associated with further pain and in 1990, felt that this increase in slip led to cosmetic deformity with psychological problems. None of the patients in this series complained of pain severe enough to stop their daily activities and none complained of cosmetic deformities or had psychological problems.

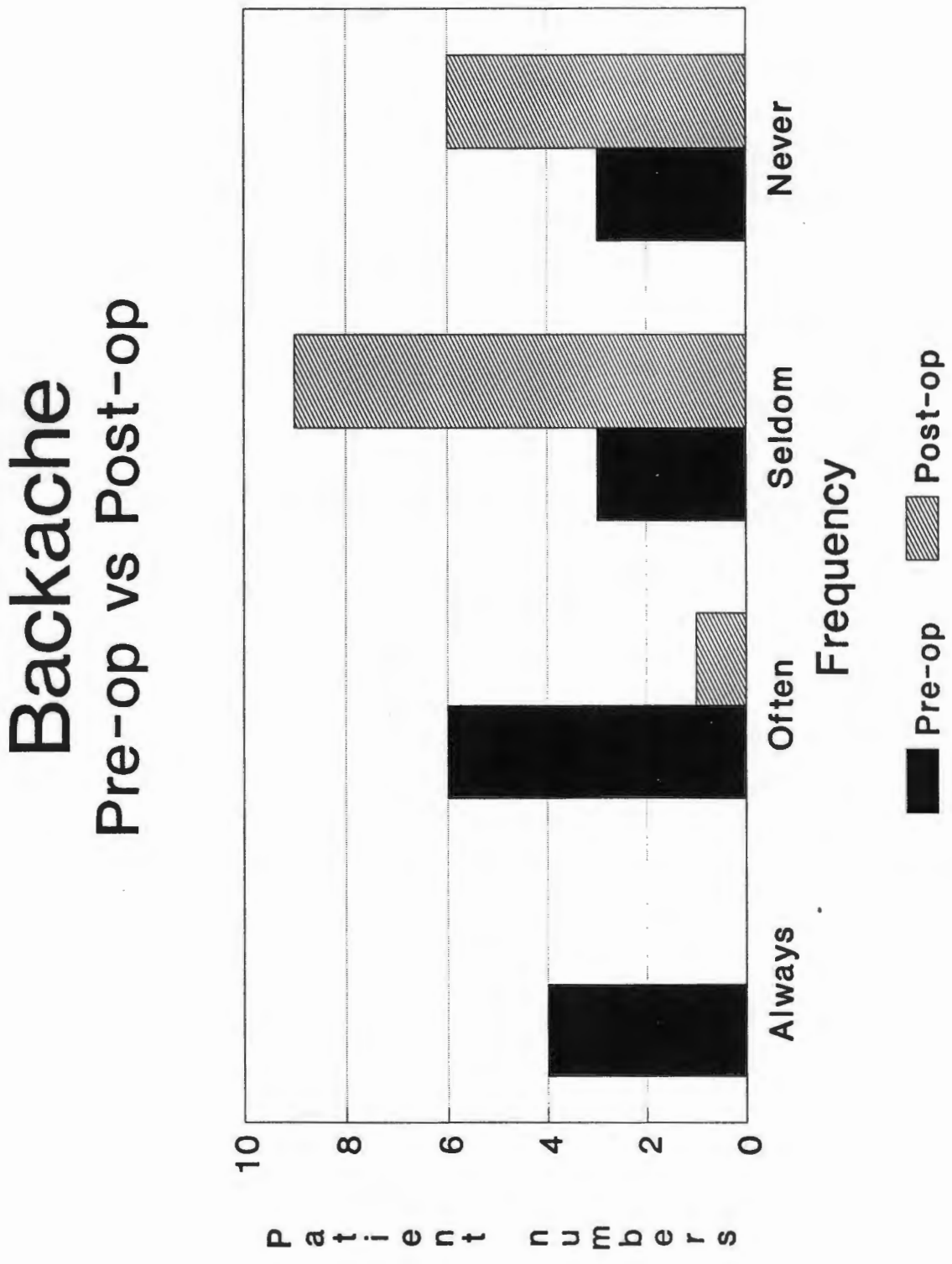
The patients in this series with the exception of the two girls with permanent neurological problems are happy and leading normal lives both socially and at work.

vi. CONCLUSIONS

Despite significant residual displacement and lumbosacral kyphosis, the patients were happy with the final outcome, both cosmetically and functionally. The complication rate of posterolateral fusion in situ is low although it can be devastating. There was minimal further slip or increase in slip angle proving that posterolateral fusion in situ is effective in stabilising the olisthesis.

Based on this study, I feel that posterolateral fusion in situ is a satisfactory procedure for all grades of spondylolisthesis.

Graph 1: Graph comparing pre-operative and post-operative backache.



Graph 2: Graph comparing pre-operative and post-operative leg pain.

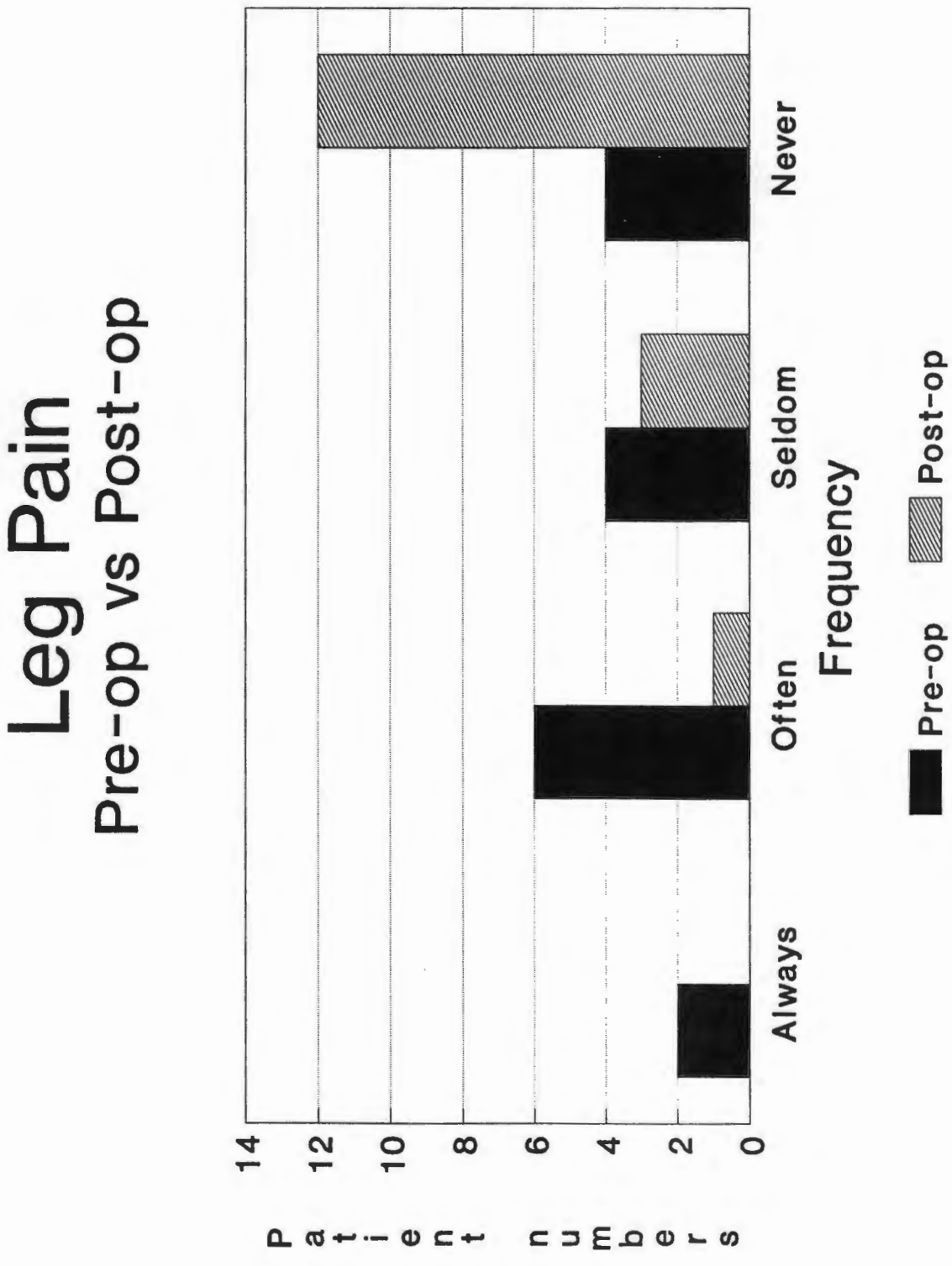


Table 1: Table showing pre-operative and post-operative sensation.

	PRE-OPERATIVE	POST-OPERATIVE	
		Normal	Abnormal
Normal	12	11	1
Abnormal	4	4	0

Table 2: Table showing pre-operative and post-operative weakness.

	PRE-OPERATIVE	POST-OPERATIVE	
		Normal	Abnormal
Normal	14	12	2
Abnormal	2	2	0

Table 3: Pre- and post-operative radiological assessment.

CRITERIA (Degrees)	PRE-OPERATIVE	POST-OPERATIVE
% Slip	57	59
Slip angle - Top L5	19	24
- Bottom L5	40	44
Sacral inclination	30	36
Sagittal rotation	25	29
Lumbar lordosis	52	67

Part 3. CONCLUSIONS

The results of the present study concur with the published literature on posterolateral fusion in situ.

The operation is relatively simple and carries a low morbidity. The results indicate great patient satisfaction. The symptoms are relieved and neurology improves and usually disappears. There maybe an increase in the olisthesis and slip angle as we also found in our study. However, this radiological deterioration did not appear to hinder the patients in any way. Few patients in the literature reviewed have been reported as being unhappy with their postoperative appearance. We did not find any patients, including those with spondyloptosis, unhappy with their appearance.

Anterior fusion in situ and Reduction with fusion, both give good results. However, the surgery is far more extensive than for posterolateral fusion in situ with a concomittent rise in morbidity especially neurological. Posterior lumbar interbody fusion also has a high morbidity.

With the newer transpedicular reduction techniques, the reported morbidity is lower. However, the same authors are recommending only a limited reduction resulting therefore in only a limited cosmetic improvement.

Wiltse and Jackson (1976) said "the only reason for reduction is the hope that it will improve the child's appearance". I agree with this statement. I do not feel the increased olisthesis

with posterolateral fusion in situ causes a problem and therefore feel it does not warrant reduction. I feel that with the excellent cosmetic results from posterolateral fusion in situ that reduction with its high morbidity is not justified for cosmesis alone.

As a result of reviewing the literature and this study I feel that posterolateral fusion in situ gives a satisfactory result for all grades of spondylolisthesis in the hands of the average spinal surgeon. However, some authors are now reporting consistently good results with more aggressive techniques and in their hands reduction techniques are acceptable.

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Part 4. REFERENCES

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