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Surgical Treatment of Spondylolisthesis without Spine Fusion

A Long Term Follow-up of Operated Cases

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Eight years ago, in association with *Manning,* the authors reported a group of eighteen patients treated for symptomatic spondylolisthesis by excision of the loose lamina and decompression of the nerve roots without spine fusion (5). The patho-mechanics of this condition, the surgical technique, the findings at surgery, and the methods of post-operative care were described at that time.

The present paper is a long term follow-up study of our operated cases, in which we shall pay particular attention to the question of postoperative progression of displacement and our results.

Our series now consists of fifty-two patients between the ages of fourteen and fifty-seven years. The two children in the group were fourteen years of age. Forty-three patients (twenty-one males and twenty-two females) were treated initially by the decompression operation. Two women had a combined decompression and fusion, and seven women were treated by the decompression procedure after previous fusion operations had failed to relieve their symptoms. Of the latter, six had pseudarthroses, but one had persistent symptoms despite a solid fusion.

The present length of follow-up on all of our patients extends from four to 146 months and averages sixty-four months. Twenty-nine cases have been followed over sixty months. Sixteen cases were lost after follow-up periods of four to thirty-seven months. Ten of these have not been seen since our initial publication. Therefore, their radiographs have not been included in this article (Cases 1, 6, 8, 9, 10, 11, 12, 17, 19 and 20).

EVALUATION OF DISPLACEMENT

Most of our early x-rays were obtained with the patients reclining. All of the follow-up x-rays were taken in the upright position. Comparisons between the reclining and upright films obtained on the same date show no essential change in the position of the involved vertebra.

We used *Taillard*'s method (9, 10) of expressing the displacement of the spondylolisthetic vertebra as a per cent of the width of the vertebra below. This is illustrated in Table 3. The description of the degree of displacement follows *Meyerding*'s basic classification but is more detailed and is described in footnotes on Tables 1-E and 2-E.

PROGRESSIVE FORWARD DISPLACEMENT IN THE CHILD

Friberg (3) reported that progressive forward displacement occurred over a relatively short period of time in a very few children in his series, and in these cases spondyloptosis resulted.

Taillard showed that progressive forward slipping occurred in twelve of the fifty cases in his series and only in patients under the age of twenty-five years. He believed that he could accurately predict rapid and complete forward displacement in those patients having both a decrease in the posterior vertical height of the fifth lumbar vertebra of 30 per cent or more in relation to the anterior height and a rounding of the superior border of the sacrum. He reduced the deformity by Scherb's method, obtained satisfactory repositions in seven of the thirteen cases attempted, and performed postero-lateral fusions in these cases. Of these seven cases, six subsequently showed complete forward displacement. He concluded that successful arthrodesis was ineffective in preventing progressive displacement.

In our original paper we were aware that rapid forward displacement occurred in some children, and we advised against the decompression procedure in children. *Margo* (7) later reported the case of a young boy with considerable displacement whose symptoms were temporarily relieved by the decompression operation but who then showed additional displacement and developed more symptoms. *Marmor & Bechtol* (8) reported an almost identical case. In both of these cases fusions were performed after the slipping had progressed, but, unfortunately, the lengths of follow-up were brief.

Taillard's criteria would have indicated the probability of progressive displacement in these two patients. In our opinion, removal of the arch contributed nothing to the increased displacement, nor, in most hands, would initial fusion have prevented it.

One of the two children in our series (Case 51) showed the typical changes mentioned by *Taillard*. This boy had low back and leg pain and was treated with exercises until spondyloptosis occurred. At sur-

gery solid healing of the defect on the left and evidence of partial healing on the right were found. In addition there was a spontaneous fusion of the inferior facet of the fifth lumbar vertebra to the sacrum on the left. The decompression operation was performed and resulted in complete relief of symptoms. He had some recurrence of difficulty fifteen months after surgery, following an automobile accident, but symptoms quickly subsided.

The other child (Case 50) did not show the progressive displacement criteria of *Taillard*. She was treated conservatively, however, for twenty-eight months, and no progression occurred. At surgery no defect was demonstrable in either pars interarticularis or pedicle. The lower end of the dural sac and the sacral nerve roots were compressed by a tight arch of the fifth lumbar vertebra. A simple laminectomy was performed, and the inferior facets were left intact. She had relief of symptoms after surgery. For nine months there was no further displacement, but x-rays twenty-four months after surgery revealed a 22 per cent progression of displacement. The patient was entirely asymptomatic, however, and the clinical examination was completely negative.

In our experience most children become asymptomatic on a vigorous program of straight-leg-raising and toe-touching exercises. However, if symptoms are persistent and severe, we feel that the decompression operation may be done for relief of pain in most children, since only one child out of ten is likely to show progressive displacement and since it now seems probable that we can predict which children will continue to slip.

We believe there are two alternatives in those children who do have x-ray findings indicative of continuing displacement. If both arthrodesis and arrest of displacement could always be achieved, then one would certainly be justified in doing a combined decompression and fusion operation, particularly in females. However, if one could not be certain either of arresting displacement or of obtaining solid fusion, as we cannot, then one should inform the parents that further progression is likely and that surgery should be delayed until maximum displacement is reached. We recommend deferring surgery because in some cases of severe displacement it is also necessary to excise the lamina above the spondylolisthetic vertebra to achieve a thorough decompression.

PROGRESSIVE DISPLACEMENT IN THE ADULT

Twenty-nine of our fifty adult patients have shown no postoperative progression of forward displacement after an average follow-up of fifty-nine months. The remaining twenty-one adults have shown varying amounts of progressive displacement during an average follow-up period of eighty-one months. (See Tables 4 and 5). The average postoperative increase in displacement in all of our patients, including the children, is 5 per cent.

Although this series of cases is too small to be of statistical value, it is at least interesting to note that essentially the same percentage of men and women showed progression of displacement after surgery. In the group showing progression, the average increase was 5.9 per cent in males and 16 per cent in females. Among the women, Cases 2, 5, 16, 18, 25, 29 and 50 showed the greatest progression, and all but one were young. Case 5 had two children before surgery and three afterward. Case 16 had three children after surgery, and Case 18 had one before the decompression and one afterward. Cases 5 and 18 reported much easier pregnancies and deliveries after the decompression operation. None of these women had any back difficulty during pregnancy or any complications with delivery.

In the adults showing increase in slipping there were 90 per cent satisfactory results and 10 per cent failures, whereas there were 82.7 per cent satisfactory cases and 17.3 per cent failures in the group who showed no progression. These figures substantiate our opinion that there is no correlation between symptoms and the degree or progression of displacement in adults with spondylolisthesis.

Case 5, a woman who has been followed for 123 months, is of particular interest to us because she has shown considerable progression of displacement (27 per cent) and because we obtained follow-up x-rays on her at close enough intervals to learn when the progression occurred. Tracings of the x-rays appear in Table 3. Progression was first noted thirty-eight months after surgery and was associated with narrowing of the lumbosacral disc. The progression and narrowing continued over the next forty-three months until the disc collapsed completely. Displacement has not progressed in the past three years but seemingly has regressed 6 per cent. During the period of increasing displacement this patient had no symptoms. After the disc collapsed and displacement stopped, she began to have episodes of back and leg discomfort after lying in bed for several hours. She could obtain relief

by getting up and exercising. This patient certainly did not fit the typical clinical picture of so-called instability, since the erect position and activity relieved the symptoms which she had.

Aside from Case 5, x-rays were not taken at the proper intervals to show precisely when progression of displacement occurred in the other adults. It would appear, however, from the patients whom we have followed for a long period of time (Cases 2, 4, 5, 13, 15, 16, 28 and 29), that progression of displacement after the decompression operation is generally mild, occurs in association with narrowing and degeneration of the lumbosacral disc, and, in itself, does not cause symptoms.

Adkins (1, 2) described two patients who showed some increase in forward displacement after excision of the arch. In each case he removed the posterior annulus of the disc in order to perform an interbody fusion which then could not be done because of deterioration in the patient's condition during surgery. He felt that removal of the posterior annulus might have been the cause of the additional displacement which later occurred.

The preservation of the posterior annulus may, therefore, be important to the maintenance of stability in this condition. Also the build-up of bone along the anterior-superior portion of the sacrum which is frequently seen in patients with spondylolisthesis may well be due to the stripping away of the annulus from this portion of the sacrum.

SPONTANEOUS HEALING OF THE DEFECT

Several cases listed on Table 1-C had a build-up of bone about the defects in the pars interarticularis which seemed to indicate attempted healing, and in four patients we found evidence of complete healing.

In Case 24 the defect on the right showed healing by bone. In Case 42, although the appearance by x-ray was characteristic of a typical first degree spondylolisthesis, at surgery both defects were found to be completely filled in with bone. Symptoms in this case were obviously caused by the massive bone formation which compressed the fifth lumbar roots at the sites of the healed defects. This patient also had a spontaneous fusion of the inferior facet of the fifth lumbar vertebra to the superior facet of the sacrum on the left.

Case 50 had the typical appearance of spondylolisthesis, but at surgery no defects were found in the arch, and the symptoms appeared to be due to compression of the sacral nerve roots and the dural sac by the tight arch.

Despite the rapid occurrence of spondyloptosis before surgery in Case 51, the defects in the fifth lumbar vertebra were found to be healed completely on the left and partially on the right. This patient also had a spontaneous unilateral fusion of the inferior facet of the fifth lumbar vertebra to the sacrum on the left.

A spontaneous and very solid fusion of both inferior facets of the fifth lumbar vertebra to the sacrum was also found in an adult with spondyloptosis (Case 28).

DEVELOPMENT OF PSEUDARTHROSIS FOLLOWING SOLID FUSION

We have found that patients with spondylolisthesis may develop pseudarthrosis even many years after apparent solid fusion is present.

Case 3 was treated initially in 1949 by a *Hibbs'* fusion from the fourth lumbar vertebra to the sacrum without decompression. Fourteen months later, because of persistent left leg pain, a re-exploration was carried out for removal of the fibrocartilaginous mass which was felt by that time to be the cause of her symptoms. The fusion was found to be heavy and solid. A hole was drilled through the one-inch-thick fusion mass on the left side at the fourth lumbar interspace to gain exposure of the defect. Seventy-four months following the initial fusion a pseudarthrosis developed at the lumbosacral interspace. Interestingly enough, however, the fusion remains solid at the fourth lumbar level.

Another patient (Case 27) had two unsuccessful fusions in 1939 and 1940. A third fusion in 1942 was reported to be solid from the third lumbar vertebra to the sacrum. She continued to have constant pain for several years and then intermittent symptoms for an additional period of time until we saw her in 1955. At surgery pseudarthroses were present at the third and fifth lumbar interspaces.

An interesting study would be a long term follow-up and search for pseudarthrosis in the apparently successful fusions for spondylolisthesis by those medical centers where arthrodesis has long been the standard treatment for this condition. By this study also more information could be gained about the secondary development of defects in the pars interarticularis of the vertebra above the fusion area. Incidentally, we have never seen such a defect occur following excision of the loose arch alone.

ASSOCIATED DISC PATHOLOGY

Most patients with spondylolisthesis have degeneration of the fifth lumbar disc, and usually the nuclear material is displaced anteriorly rather than posteriorly.

In our fifty-two cases, one-third of the patients had disc pathology which may have accounted for the onset of symptoms. We found four herniations and ten protrusions of the fourth lumbar disc, and at the fifth lumbar level we found one herniation and three protrusions. In some of these cases the disc pathology rather than the spondylolisthesis appeared to be the sole cause of symptoms.

Therefore, the prevalent concept that onset of symptoms following injury in patients with spondylolisthesis merely represents an aggravation of a pre-existing condition is no longer valid, and in these cases serious consideration should always be given to the coexistence of disc pathology.

REOPERATION FOLLOWING THE DECOMPRESSION PROCEDURE

a. Unsuspected or Recurrent Disc Pathology.

A herniation of the fourth lumbar disc was found in Case 40 at the time of the initial decompression. Symptoms persisted, and upon re-exploration three months later a herniated disc was also found at the third lumbar interspace.

In Case 42 discography two years postoperatively showed a new protrusion of the fourth lumbar disc and a protrusion of the third lumbar disc. Symptoms, however, have not been sufficient to warrant re-exploration, and the patient continues to perform extremely heavy work.

In those patients with involvement of the patellar reflex, discography at the third lumbar interspace should be done prior to surgery.

Case 36 was found to have a herniation of the fourth lumbar disc at the time of initial surgery. He had a perfect result until he was involved in an automobile accident thirty-four months postoperatively and again developed symptoms. Re-exploration revealed a reherniation of the fourth lumbar disc.

Case 37 developed recurrence of symptoms one month after surgery as a result of a fall. Seventeen months later a herniated disc was found and excised. A reherniation at the same level occurred after numerous subsequent injuries and was removed thirty-one months after the

initial surgery. This patient often exhibits classical symptoms of conversion hysteria. Although she is classified as a failure, there are times when she gets along quite well.

b. Meningocele.

Recurrence of local symptoms in the back and coccygeal area necessitated re-exploration in two other patients in whom meningoceles were found.

In Case 11 re-exploration was performed nineteen months after the decompression operation and resulted in considerable relief of symptoms.

In Case 49 the original decompression had been done elsewhere and had completely relieved symptoms for over five years. Local back pain recurred, however, and upon re-exploration seventy-one months after the original surgery a very large meningocele was found and excised. The patient developed a postoperative staphylococcal infection which resulted in a spinal fluid fistula. This closed spontaneously after a period of bed rest in the head-dependent position. He returned to work four months after surgery and has been doing heavy welding work for the past three years without symptoms.

It is probable that these meningoceles resulted from needle holes in the dura following myelography or discography. At the time of surgery small dural defects should be sought and carefully closed with fine arterial silk.

c. Extraneural Scarring.

Extraneural scarring may occur after surgery for spondylolisthesis as well as after any lumbar disc excision.

Case 5, described previously, developed left first sacral root findings nine and one-half years after the orignal decompression. Upon re-exploration the first sacral root was found to be tented and bound down by scar, and the root was released. While being driven home from the hospital, the patient was involved in an automobile accident, she was thrown out on the road, and the wound was torn open. The wound healed nicely again, but the patient has shown little, if any, improvement. However, there may understandably be a large element of psychic trauma as a result of this accident.

Case 44 was re-explored for scarring about the fifth lumbar root and

obtained some relief, but this patient's symptoms are difficult to evaluate because of a coexistent, severe plantar fasciitis.

Extraneural scarring may occur for several reasons. Re-exploration of patients after disc surgery has shown that incomplete excision of the ligamentum flavum results in its becoming bound down to the dura and emergent nerve roots. For this reason there should be complete excision of ligamentum flavum from areas adjacent to the nerve roots.

A second cause for scar formation results from the use of cottonoid as a packing and sponging material. Reports of microscopic sections of extraneural scar frequently stated that suture material was present in the scar. Since none had been used in the area it was obvious that the excessive scar was due to irritation from minute pieces of cottonoid. For the last several years we have substituted polyvinyl sponge (*Ivalon*) in our cases. This material is more resilient, tougher than cottonoid, and suction through it is superior to cottonoid.

A third reason for extraneural scar, we believe, lies in the individual. Patients with dark complexions tend to form excessive scar about the dural sac and emergent nerve roots. This deep scar is almost always associated with visible keloid in the skin wound. Patients with dark complexions have, therefore, been given deep x-ray therapy beginning on the third postoperative day.

d. Intraneural Scar.

Intraneural scar can exist prior to surgery as a result of prolonged root irritation and compression at the defect. It can also be caused by undue trauma at the time of surgery. These patients may have persistence of back and leg symptoms despite the presence of free straight-leg-raising. It is our practice, therefore, to divide the sheath carefully if the root appears scarred at the time of surgery. Neurolysis seems to give relief in about half of the cases attempted. We find it impossible to predict, however, which patients may continue to have symptoms caused by intraneural scar formation.

e. Fusion after Arch Excision.

Of the forty-three patients treated initially by decompression we have subjected only two to attempted fusions later because of the persistence of symptoms following the decompression operation. Interbody fusion was performed elsewhere in a third patient.

The first patient (Case 21) had an attempted decompression operation elsewhere. When we explored him eleven months later we found that the lateral portions of the arch and the cartilaginous mass had not been removed on either side, and there was considerable scar formation about the roots. Radicular pain continued after our decompression, so five months later, following discography which showed a protrusion of the fourth lumbar disc and marked degeneration of the fifth disc, evacuation of these two disc spaces was attempted. This procedure did not relieve symptoms either. Therefore, an *Adkins'* fusion was attempted and resulted in fusion of the fourth to the fifth lumbar vertebrae but not of the fifth lumbar vertebra to the sacrum, even though very little motion remained at this level. The patient was improved by this procedure and was able to obtain a job as a swimming pool maintenance man. Five years later he suddenly complained of an increase in sciatic pain and also had an episode of delirium tremens. We refused to subject this man to further surgery, but a month later another fusion operation was attempted elsewhere. This too failed to relieve his symptoms. We do not know whether solid fusion was obtained on the last occasion.

The second patient (Case 41) had severe right sciatica and marked right fifth lumbar root findings. At the initial surgery the fifth lumbar root was found to be impaled upon a spur arising from the right lateral portion of the loose lamina of the involved vertebra. Relief of pain followed the decompression. However, there was recurrence of severe right leg pain and some back pain, and nine months later an *Adkins'* fusion was attempted. The right leg pain was not relieved, so after another nine month interval the sensory component of the right fifth lumbar root was divided under local anesthesia. Symptoms were diminished for two years, but the patient again returned because of low back and right leg pain. The fusion was then reinforced over the facet area. At surgery we found no motion between the fifth lumbar vertebra and the sacrum, but some was evident between the fourth and fifth lumbar vertebrae. This procedure did not relieve symptoms or result in fusion of the fourth to the fifth lumbar vertebrae. One and one-half years later we again explored the patient but were still unsuccessful in relieving her symptoms. This woman is overweight and has been having severe personal difficulties, and these factors may play some part in the persistence of her symptoms.

Case 31, a cerebro-spastic palsy victim with spastic paralysis of the lower extremities and a marked lumbar lordosis, had the decompres-

sion operation performed for low back and left sciatic pain. Although she was improved moderately by the surgery, the leg pain continued. Four years later, at a local clinic, an anterior interbody fusion at the fourth and fifth lumbar levels was unsuccessful. Three months later a re-exploration also failed to relieve her symptoms. After these two operations the patient was confined to a wheel chair. We re-explored the site of the decompression a year later. Considerable scar was resected, and the patient was placed on an active postoperative course of exercises and swimming. She returned to college, was ambulatory without crutches, and was able to carry out the activities which she had been incapable of performing following the attempted fusion.

Our experience with the fusion operation for various types of low back conditions indicates that it will not relieve radicular pain.

OTHER COMPLICATIONS OF SURGERY

a. Wound Infections.

Wound infections occurred in two patients (Cases 40 and 49) but fortunately did not adversely affect the final results.

b. Thrombophlebitis and Pulmonary Embolism.

One case of thrombophlebitis occurred in this series (Case 3). This patient had a conventional fusion operation in 1949 and developed a thrombophlebitis during the postoperative period. She continues to have some swelling of the involved leg.

Case 1, who initially had a combined decompression and fusion operation, developed a mild pulmonary embolism after a secondary decompression operation was done for removal of bony fragments which had sunk in on the dural sac.

In general, however, our entire series of cases seems to be singularly free from the complications of thrombophlebitis or pulmonary embolism, and we believe this is because of the early exercise and ambulation permitted by the decompression procedure.

c. Poor Patient Selection.

Poor patient selection is another cause of poor results after any operative procedure. In this series we have four patients who show definite evidence of conversion hysteria (Cases 30, 33, 37 and 41). Two other patients were extremely neurotic, and one, we learned later, was

a chronic alcoholic. If any overt emotional problems are apparent in a patient we do not believe that he is a candidate for any type of back surgery.

We also feel that this procedure should be used with caution in patients who have litigation pending. For example, Case 33, who was noted above to have a conversion hysteria, had an industrial injury and claimed no improvement after surgery, although there were no positive findings at the time we last saw him. Three other patients, however, were involved in accidents and subsequent litigation, and all showed prompt relief of symptoms following surgical treatment (Cases 11, 16 and 36).

RESULTS

Our cases were analyzed according to *Barr*'s criteria except that those cases which required reoperation were not automatically considered failures. This change was necessary, in all fairness, because many of our patients sustained injuries after surgery and because excellent results by the fusion method are reported in many papers, but two or more operations were often necessary to achieve the reported results.

a. Initial Decompression.

Of the forty-three cases of initial decompression, 86.1 per cent are considered satisfactory, and 13.9 per cent unsatisfactory. Eighteen or 41.8 per cent are asymptomatic; twelve or 28 per cent are good; seven or 16.3 per cent are fair; and six or 13.9 per cent are failures. If one considers only the twenty-four cases in this group who have been followed over five years the results are very little different: twelve or 50 per cent are asymptomatic; four or 16.7 per cent are good; three or 12.5 per cent are fair; and five or 20.8 per cent are failures.

b. Combined Arch Excision and Fusion.

In our group there were only two patients who had combined arch excision and fusion as one operative procedure. The first (Case 1) did well for a period of time but then developed a pseudarthrosis and recurrence of symptoms. She was markedly improved following a second decompression procedure but was finally lost from further follow-up. She was considered to have a fair result.

The second patient (Case 2) developed recurrence of back and leg pain soon after the initial surgery. Re-exploration showed that the grafts had slipped medially causing irritation and pressure on the lower dural sac and necessitating removal of the bony material. Re-fusion with rib grafts was attempted, but, although solid fusion was obtained, it did not result in complete relief of symptoms. However, the patient does quite well at this time and is considered to have a fair result.

c. Decompression after Previously Attempted Fusion.

The six remaining patients in this series were treated by the decompression operation after attempted fusion had failed to relieve their symptoms. One is considered to have a good result; four patients are classified as fair; and one is a failure.

Case 18 had three unsuccessful fusions and was finally advised to seek psychiatric care before we first saw her. While under our care she has had four additional operations, the last over three years ago when a new protrusion of the fifth lumbar disc was removed. She has a fair result but feels much better and now is able to participate in sports such as water-skiing and bowling. She also holds a full-time job in addition to doing her housework and caring for her two children.

Case 27 had three fusion operations, was able to work for fifteen years, and then became completely disabled. Following the decompression she has been able again to do her regular work and is listed as a fair result.

Case 30 shows evidence of a classical conversion hysteria but actually has a fair result following the decompression operation.

Case 9, a good result, and Case 25, a fair result, were improved after the decompression but have been lost from further follow-up. Case 17 was classified as a failure on the basis of her complaints, although all physical, neurological and x-ray examinations were normal.

Although our results in this group of cases are not striking, they do illustrate that patients who are completely disabled following attempted fusion operations can be rehabilitated by the decompression procedure.

CONCLUSIONS

Our experiences gained from treating symptomatic spondylolisthesis by the techniques which we have developed over the past thirteen years are briefly summarized as follows:

1. These patients should first be treated with an active exercise pro-

gram consisting of straight-leg-raising and sitting toe-touching exercises. The use of a brace or any type of support has usually only aggravated symptoms.

2. Surgery is considered necessary in those patients who, despite the treatment outlined above, continue to have severe symptoms or in those who are prevented from enjoying normal lives because of recurrent episodes of disability.

3. From our limited experience, it appears that the decompression operation may also be used in children whose symptoms are persistent and severe. In those who show the progressive displacement criteria of *Taillard*, treatment should only be undertaken after a thorough discussion with the parents regarding the probability of further forward displacement.

4. Anterior displacement of varying degrees occurs in a few adults after the decompression operation. This begins as a narrowing of the disc below the involved vertebra, is limited, and does not necessarily lead to onset of symptoms. The same percentage of men and women showed postoperative progression of displacement, but a greater degree of displacement occurred in women. Most of the women were within the child-bearing age, and three had from one to three children following the decompression operation. In our opinion, removal of the arch neither causes further forward displacement nor influences its amount.

5. Aside from the usual degenerative changes at the fifth lumbar disc, disc protrusion or herniation at other levels is present in one-third of the cases. It most commonly occurs at the interspace above the spondylolisthetic vertebra where the greatest stress is placed because of the small amount of motion present between the involved vertebra and the one below.

6. Results of the decompression operation, we feel, are satisfactory under the following conditions:

a. The procedure must be performed thoroughly by complete removal of the arch and decompression of the involved roots past the pedicles.

b. Disc pathology should be recognized and dealt with at the time of surgery.

c. The postoperative care must consist of the prompt initiation of straight-leg-raising exercises and, later, toe-touching exercises in order to insure free nerve root excursion. Complications such as thrombophlebitis and pulmonary emboli will also thus be avoided.

7. If patients develop recurrence of symptoms following surgery one should not hesitate to reoperate after employing the usual diagnostic methods of thorough neurological examination plus myelography and/or discography.

8. In our experience attempts at fusion after arch excision because of persistent radicular symptoms will not relieve pain arising from nerve root involvement. In addition, fusion is difficult to achieve.

TABLE

Synopsis of Cases of Spondylolisthesis Originally Treated

Case	Sex	Age	Occupation	Onset with injury	Duration of symptoms	Length of conservative treatment
4	M	41	Physician	No	5 years	5 years
5	F	30	Housewife	No	5 years	4 years
6	M	37	Salesman	No	2 years	18 months
7	F	23	Housewife and secretary	No	2 weeks	None
8	M	37	Laundryman	No	9 years	9 years
10	F	44	Housewife	No	14 years	10 years
11	F	27	Secretary	Yes	16 months	16 months
12	F	27	Housewife	No	4 years	1 year
13	M	35	Floor covering contractor	Yes	Many years, worse last 15 months	4 months
14	M	19	Clerk and laborer	Yes	4 months	1 month
15	F	24	Housewife	No	2 years	18 months
16	F	25	Clerk and housewife	Yes	7 months	7 months
19	M	23	Medical student	No	Several years	10 months
20	M	40	Teamster	No	2 years	1 year
21	M	32	Carpenter	No	2 years	2 years
22	M	52	Marine electrician	No	All of life, worse last 7 years	7 years
23	F	41	Clerk	Yes	9 months	9 months
24	M	51	Janitor	Yes	24 months	24 months
26	F	47	Bookkeeper	Yes	Many years, worse last 2 months	2 months

1—A

by Excision of the Loose Arch and Decompression Alone.

Level and degree of displacement	Associated anomalies	Degree of preoperative disability*
Lumbar 5 first	Upper lumbar curve, left	Total
Lumbar 5 first	Mild thoraco-lumbar curve, left	Total
Lumbar 5 first	Bifid lamina lumbar 5 with fusion to spinous process of sacral 1. Spina bifida occulta of sacral 1.	Total
Lumbar 5 first	Upper lumbar curve, right	Total
Lumbar 5 first	Spina bifida occulta, sacral 1	Total
Lumbar 5 first	None	Moderate
Lumbar 5 first	Thoraco-lumbar scoliosis, left	Total
Lumbar 5 first	Bifid lamina, lumbar 5. Spina bifida occulta, sacral 1	Total
Lumbar 5 first	Spina bifida occulta, sacral 1, with fusion spinous processes, lumbar 5 and sacral 1	Total
Lumbar 5 first	None	Moderate
Lumbar 5 second	None	Total
Lumbar 5 first	Mild upper lumbar curve, left	Total
Lumbar 5 first	Spina bifida occulta, sacral 1	Total
Lumbar 5 first	Lumbar curve, right	Moderate
Lumbar 5 first	Upper lumbar curve, left	Total
Lumbar 4 first	"Reverse" spondylolisthesis, lumbar 5	Total
Lumbar 5 spondylolysis	Unilateral defect lumbar 5, left. Bifid lamina lumbar 5	Total
Lumbar 5 first	Spina bifida occulta sacral 1 with fusion spinous processes lumbar 5 and sacral 1. Healing of defect lumbar 5, right, found at surgery	Total
Lumbar 5 first	Mild right thoraco-lumbar curve	Total

TABLE

Case	Sex	Age	Occupation	Onset with injury	Duration of symptoms	Length of conservative treatment
28	F	38	Bookkeeper and housewife	No	16 years	11 years
29	F	47	Shipping clerk and housewife	No	4.5 years	4 years
31	F	21	Student	Yes	5 years	11 months
32	M	51	Janitor	No	10 months	10 months
33	M	49	Painter	Yes	1 year	1 year
34	M	37	Grocery clerk	Yes	1 month	1 month
35	M	36	Teacher	No	2.5 years	5 months
36	M	38	Truck driver	Yes	1 year	8 months
37	F	40	Waitress and housewife	No	3 years	1 year
38	F	38	Waitress	Yes	20 years	Several years
39	M	45	Banker	Yes	Several years	8 months
40	F	36	Housewife and magazine sales	Yes	1 year	4 months
41	F	30	Maid and housewife	Yes	3 years	3 years
42	M	47	Construction worker	No	5 years	4.5 years
43	F	57	Assembly worker	No	9 weeks	5 weeks
44	F	55	Housewife	No	14 years	13 years
45	F	57	Housewife	No	5 years	4 years

1—A (cont.)

Level and degree of displacement	Associated anomalies	Degree of preoperative disabiliiy*
Lumbar 5 fourth	Fusion of facets, lumbar 5 to sacrum, found at surgery	Total
Lumbar 5 first	Spina bifida occulta, sacral 1	Moderate
Lumbar 5 first	Cerebro-spastic palsy	Questionable because of palsy
Lumbar 5 first	None	Total
Lumbar 5 spondylolysis	None	Questionable
Lumbar 5 first	Mild thoraco-lumbar curve, left. Fusion spinous processes, lumbar 5 and sacral 1	Total
Lumbar 5 first	Bifid lamina lumbar 5	Total
Lumbar 5 first	Mild mid-lumbar curve, left. Bifid lamina lumbar 5. Spina bifida occulta, sacral 1	Total
Lumbar 5 first	Porphyrinuria diagnosed after surgery	Total
Lumbar 5 first	Right lumbar, left thoracic scoliosis	Total
Lumbar 5 first	Mild left lumbar curve. Bifid lamina lumbar 5. Spina bifida occulta sacral 1	Total
Lumbar 5 first	Left thoraco-lumbar scoliosis. Sustained compression fractures of thoracic 9 and lumbar 1 65 months after initial surgery	Total
Lumbar 5 first	Slight left upper lumbar curve. Spike of bone down from right lamina of lumbar 5 to nerve root found at surgery	Total
Lumbar 5 first	Right thoraco-lumbar scoliosis. Fusion inferior facet lumbar 5 to superior facet sacral 1, left, and bilateral healing of defect, lumbar 5, found at surgery	Total
Lumbar 5 first	Right lower thoracic curve	Total
Lumbar 5 first	Right mid-thoracic curve. Chronic plantar fasciitis. Negative for rheumatoid arthritis	Moderate
Lumbar 5 first	Right mid-thoracic, left low-thoracic curve, mild	Total

TABLE

Case	Sex	Age	Occupation	Onset with injury	Duration of symptoms	Length of conservative treatment
46	F	29	Brushmaker and housewife	No	7 years, worse last 10 months	10 months
47	M	57	Automobile painter	Yes	6.5 years	6 years
48	F	46	Housewife	Yes	8 years worse last 1 year	8 years
49	M	48	Welder	No	10 months	9 months
50	F	14	Student	Yes	4 years	28 months
51	M	14	Student	No	27 months	26 months
52	M	52	Farmer	Yes	Many years, worse last 6 weeks	6 weeks

* Total = Unable to carry out any activities. Severe back and (or) lower extremity pain.
Moderate = Unable to carry out most activities. Moderate back and (or) lower extremity pain.
Mild = Able to carry out most activities. Mild pain in back or lower extremities.

1—A (cont.)

Level and degree of displacement	Associated anomalise	Degree of preoperative disability*
Lumbar 5 first	None	Total
Lumbar 5 first	Spina bifida occulta sacral 1. Fusion spinous processes lumbar 5 and sacral 1	Total
Lumbar 5 first	None	Total
Lumbar 4 first	Mild left mid-lumbar curve	Total
Lumbar 5 first	Left lumbar curve. Spina bifida occulta, sacral 1	Total
Lumbar 5 fourth	Osteochondritis. Mild left lumbar curve. Progression of forward displacement from second to nominal fourth degree allowed to occur before surgery	Total
Lumbar 4 first	Right upper lumbar curve. Transitional fifth lumbar vertebra	Total

TABLE

Comparison of Symptoms and

	Preoperative			
Case	Back pain	Area of radicular pain	Abnormal physical findings	Nerve roots involved
4	Moderate	Left sciatica, severe	Flexion 18 in. of floor. SLR*80 right, 35 left	Lumbar 5, sacral 1, left, moderate
5	Moderate	Calves, severe	Extension restricted and painful	Lumbar 5, left, moderate
6	Mild	Buttocks. Left sciatica, severe	Flexion 6 in. of floor. Extension restricted and painful. SLR 80 right, 60 left	Lumbar 5, sacral 1, left, moderate
7	Moderate	Buttocks, severe	Flexion 4 in. of floor. Extension restricted and painful	Lumbar 5, right, moderate
8	Severe	Right buttock, severe	Flexion 18 in. of floor. Right list. Extension restricted and painful. SLR 10 right, 60 left	Lumbar 5, sacral 1, right, moderate
10	Moderate	Coccyx and right sciatica, moderate	Extension restricted and painful. SLR 60 right, 90 left	Lumbar 5, sacral 1, right, moderate
11	Mild	Left sciatica, severe	Flexion 10 in. of floor. Extension restricted and painful	Lumbar 5, sacral 1, left, moderate
12	Severe	Left sciatica, severe	Extension restricted and caused increase in radicular pain and neurological findings	Lumbar 5, left, moderate
13	Severe	Right buttock and sciatica, moderate	Extension restricted and caused increase in radicular pain and neurological findings	Right lumbar 5, moderate, sacral 1, mild
14	Moderate	Sciatica, moderate. Right buttock	Extension restricted and caused increase in radicular pain and neurological findings	Lumbar 5, bilateral, moderate. Sacral 1, right, mild
15	Severe	Posterior thighs, severe	Flexion 18 in. of floor. SLR 80 right, 70 left. Extension restricted and painful	Lumbar 5, bilateral, severe. Sacral 1, right, moderate

1—B
Findings before and after Surgery.

Postoperative (most recent examination)			
Back pain	Area of radicular pain	Abnormal physical findings and remarks	Nerve roots involved
Occasional ache	Occasional left sciatica	Carries out full practice including long periods in surgery daily	Lumbar 5 sacral 1, mild
Occasional ache	Occasional left sciatica	Touches floor. 2 pregnancies postoperatively. Reoperated. See Table 1—D	Sacral 1, left
None	Occasional right calf, mild	Flexion to 4 in. of floor. Examination negative	None
None	None	3 pregnancies postoperatively. Examination negative	None
None	None	Flexion to 3 in. of floor. Examination negative	None
Occasional mild	None	Flexion 2 in. of floor. Examination negative.	None
None	Right thigh and buttock, moderate	Flexion 12 in. of floor. SLR 60 right, 75 left. Reoperated. See Table 1—D	None
None	None	Touches floor. Examination negative	None
None	None	Acute flare-up 8.5 years after surgery. Findings indicated possible disc protrusion. Subsided in 1 week. Again asymptomatic, and examination negative	None
None	None	Examination negative except for recent right peroneal palsy caused by habit of sitting with right leg crossed over left during prolonged periods of studying	None other than right peroneal palsy
Occasional catching	Occasional left calf ache	Touches floor	Lumbar 5, left, mild

TABLE

Case	Preoperative			
	Back pain	Area of radicular pain	Abnormal physical findings	Nerve roots involved
16	Moderate	Lateral right calf, severe	Extension restricted and painful	Lumbar 5, right, moderate
19	Mild	Sciatica, right, severe	Flexion 2 in. of floor. SLR 60 right, 80 left	Sacral 1, right, moderate
20	Moderate	Left buttock, moderate	None	Lumbar 4 and 5, left, mild
21	Severe	Sciatica, bilateral, moderate	Extension restricted and painful and caused increase in radicular pain and neurological findings	Lumbar 5, bilateral, sacral 1, right, moderate
22	Severe	Severe right sciatica	Moderate spasm. Flexion 15 in. of floor. SLR 60 right, 70 left	Lumbar 4 and 5, bilateral, moderate
23	Mild	Severe right sciatica	Extension restricted and painful. Slight spasm. SLR 60 right	Lumbar 5, sacral 1, bilateral: moderate, left; severe, right
24	Only on hyper-extension, severe	Left sciatica, severe	Flexion 7 in. of floor. SLR free but painful. Extension reproduced left sciatic pain	Lumbar 5, bilateral, worse on left. Left sacral 1, severe
26	Severe	Inner thighs, moderate	Two-stage recovery from flexed position. Spasm	Lumbar 5, right, moderate
28	Severe	Posterior thighs and calves, severe	Flexion 6 in. of floor. SLR free. Extension painful. Unexplained urinary incontinence	Lumbar 5, sacral 1, bilateral, severe
29	Moderate	Bilateral sciatica, moderate	Flexion free. Pain on extension	Lumbar 5, right, moderate. Sacral 1, left, mild

1—B (cont.)

Postoperative (most recent examination)			
Back pain	Area of radicular pain	Abnormal physical findings and remarks	Nerve roots involved
None	None	Touches metacarpal heads to floor. Examination negative. 3 pregnancies postoperatively	None
None	None	Flexion 4 in. of floor. SLR 80 bilaterally	None
None	None	Touches floor. Examination negative	None
Occasional, severe	Occasional left great toe, severe	No abnormal clinical findings. Neurologic examination shows objective left sacral 1 findings, but only subjective left lumbar 5 findings. Reoperated. See Table 1—D	Sacral 1, left
None	None	Flexion 6 in. of floor. Examination negative	None
Stiffness	Cramping in calves worse on right	Flexion 1 in. of floor. SLR 90 bilaterally	Bilateral lumbar 5, sacral 1, mild
Rare catch of pain	None	Touches floor. Extension slightly restricted	None
Moderate	None	Examination negative. Touches floor	None
None	None	Urinary incontinence disappeared	Bilateral lumbar 5, mild
None	Very mild buttock pain on right	Flexion to hands flat on floor. Examination negative	None

TABLE

Preoperative				
Case	Back pain	Area of radicular pain	Abnormal physical findings	Nerve roots involved
31	Severe	Sciatica, left, severe	Flexion only to knees due to spasticity. Neurological evaluation difficult because considerable paralysis	Lumbar 5, left, suggestive
32	Severe	Coccyx, severe; both legs to heels, worse on left	Flexion 16 in. of floor. Little lumbar motion. SLR 70 right with leg pain and 50 left with back pain	Sacral 1, left
33	Constant dull ache	Constant in right lateral thigh	Industrial injury. Slight left list. Flexion 2 in. of floor. No spasm or two-stage recovery. Compromise and release recommended initially on basis of definite exaggeration of complaints	Lumbar 5, right, mild
34	Severe	Right sciatica, moderate	Right list. Back motions restricted and painful. SLR 60 right, positive Lasegue. SLR 80 left	Lumbar 5, bilateral, moderate, worse on right
35	Moderate	Left calf, severe. Right leg, intermittent	Flexion to 8 in. of floor. SLR 70 bilaterally	Lumbar 5, left, moderate
36	Left, moderate	Left sciatica, severe	Left list. Deviation to left on flexion. SLR 80 right with pain left back. SLR 45 left	Lumbar 4, sacral 1, left, mild
37	Severe	Right sciatica, severe	Flexion mid-way between knees and ankles. SLR 45 right, 90 left	Lumbar 5, sacral 1, right, moderate
38	Severe	Right thigh	Extension restricted and painful. SLR tight bilaterally and painful on right	Sacral 1, right, mild
39	Severe	Both buttocks. Both legs	Rigid back. Flexion to knees. Right list. SLR 80 right. Tender over loose arch	Lumbar 5, right, moderate

1—B (cont.)

Postoperative (most recent examination)			
Back pain	Area of radicular pain	Abnormal physical findings and remarks	Nerve roots involved
Moderate	Left leg, moderate	SLR free. Touches toes. No two-stage recovery from flexion. Reoperated. See Table 1—D	Difficult to evaluate
None	None	Flexion to 3 in. of floor. Examination negative	None
Morning stiffness	Left sciatica	Camptocormia. Stocking hypesthesia entire right lower extremity and left leg below knee. Normal back motion. SLR past 90 bilaterally. Only positive finding was right heel jerk depression	Sacral 1, right, mild
Tired feeling with over-activity only	Some tenderness, dorsum of right foot	Touches floor. Slight left list which increases with fatigue but is not associated with any pain. SLR 85 right, 90 left.	Lumbar 5, right, mild
None	None	Touches floor. Examination negative	None
None	None	Touches floor. Had re-injury after surgery. See Table 1—D. Completely asymptomatic and doing everything	None
Constant. Varies in degree and location	Both legs intermittent, worse on right	SLR slightly restricted and causes back and leg pain. Flexion good from sitting position. Atrophy of 0.25 in. right calf, 1 in. left thigh	Lumbar 4, right, and lumbar 5, bilateral, mild
None	None	Flexion to palms flat on floor. Examination negative	None
None	None	Clinical examination negative. Only neurologic finding is slight depression both heel jerks	Sacral 1, bilateral, slight

TABLE

	Preoperative			
Case	Back pain	Area of radicular pain	Abnormal physical findings	Nerve roots involved
40	Severe	Coccyx, left buttock, entire right leg, severe	Left list. Flexion and right bend restricted and painful. SLR 70 right with pain. SLR 90 left with tightness	Lumbar 5, right, moderate
41	Severe	Severe right sciatica into all toes	Rigid back. Unable to straighten up. SLR 15 right, 45 left. Loss of dorsiflexor power right foot	Lumbar 5, right, severe
42	Severe	Both hips and legs, worse on right	Flexion restricted and painful. SLR 70 right, 80 left	Lumbar 5, bilateral, moderate, worse on right
43	Severe	Right hip, thigh and ankle, moderate	Acute tenderness right sciatic notch. Flexion caused right leg pain. SLR 80 right	Lumbar 5, right, severe
44	Moderate	Right thigh, moderate	Flexion to 4 in. of floor. SLR 70 bilaterally	Lumbar 5, right, moderate
45	Moderate	Left sciatica into great toe, severe	Good back motions. SLR free	Lumbar 5, left, moderate
46	Moderate	Left leg, severe. Right leg, mild	Flexion to 6 in. of floor. SLR tight. Tender over loose arch	Lumbar 5, sacral 1, right, moderate
47	Severe	Left calf, severe	Back motions restricted. SLR 70 left	Lumbar 5, sacral 1, left

1—B (cont.)

Postoperative (most recent examination)			
Back pain	Area of radicular pain	Abnormal physical findings and remarks	Nerve roots involved
None	Right calf, mild	No low back discomfort. Some pain over fracture site above. Touches floor. Numerous re-injuries. Reoperation. See Table 1—D	None
Intermittent ache varying intensity	Persistent severe right sciatica	Prompt return lumbar 5, right, nerve function. Flexion 12 in. of floor. Severe home problems. Nail biter. Reoperated. See Table 1—D	None
Mild. Occasional	Right leg, mild	Flexion to 3 in. of floor. Some discomfort on extension. Works 15 hrs. per day on maintenance heavy highway equipment. Back discomfort on lifting more than 150 pounds	Lumbar 5, sacral 1, left, mild
None	None	Slight tenderness right sciatic notch. Abdominal discomfort. SLR free. Symptoms probably due to coexistent arteriosclerotic vascular disease	None
Constant. Moderate	Right calf. mild	Touches floor, but complains of pain on bending. Acute plantar fasciitis. Reoperated. See Table 1—D	Sacral 1, bilateral, mild
None	Right buttock, occasionally	Asymptomatic until a fall 2 years after surgery. Now has some pain on hyperextension. Right buttock pain only after prolonged inactivity	None
Mild ache	None	Flexion to 6 in. of floor. Had re-injury	None
Stiffness only	Both legs, mild	Only symptom was slight back stiffness after long inactivity until injured in auto accident 15 months after surgery. Recent x-ray evidence of increased spurring at lumbar 3 disc	None

TABLE

Case	Preoperative: Back pain	Preoperative: Area of radicular pain	Preoperative: Abnormal physical findings	Preoperative: Nerve roots involved
48	Aching, severe	Both thighs, intermittent, severe	Good back motions. SLR 70 bilaterally with pain. Tender over loose arch	Lumbar 5, bilateral, mild. Sacral 1, left, moderate
49	Severe	Left buttock and posterior thigh; both calves	Initial decompression elsewhere. Previous examiner reported spasm, restriction all back motions, and SLR 50 bilaterally. See Table 1—D	None reported
50	Severe	Both legs to heels, worse on right	Extension painful. SLR 50 right, 85 left	Lumbar 5, sacral 1, right
51	Severe, only present on jarring motions	Both legs, worse on left, present only after prolonged walking	Marked lordosis. Flexion restricted and caused leg pain bilaterally. Unable to walk on toes of left foot	Lumbar 5, bilateral, worse on left, Sacral 1, left, mild
52	Severe	Both legs, severe	Marked left list. Marked restriction SLR with pain. Rigid back	Lumbar 4, sacral 1, bilateral; lumbar 5, left

* SLR = Straight-leg-raising.

1–B (cont.)

Postoperative (most recent examination)			
Back pain	Area of radicular pain	Abnormal physical findings and remarks	Nerve roots involved
None	None	Completely negative in all respects	None
None	None	Flexion to 1 in. of floor. Asymptomatic	Lumbar 5, left, mild
None	None	Flexion to 4 in. of floor. Examination negative. Asymptomatic	None
Occasional, mild	None	Injured in auto accident 15 months after surgery. Had recurrence of symptoms and findings. Subsided in 1 month. Some back pain now when working long hours under his car	Lumbar 5, right, mild
None	Right thigh, mild	Flexion 4 in. of floor	Lumbar 4, bilateral

TABLE

Correlation of Surgical Findings with

Case	Preoperative neurological findings	Surgical	
	Nerve roots involved	Mobility of free lamina	Fibrocartilaginous mass
4	Lumbar 5, sacral 1, left, moderate	Marked	Bilateral
5	Lumbar 5, left, moderate	Moderate	Bilateral, larger on left
6	Lumbar 5, sacral 1, left, moderate	Marked	Bilateral, larger on left
7	Lumbar 5, right, moderate	Marked	Bilateral, larger on right
8	Lumbar 5, sacral 1, right, moderate	Marked	Bilateral, larger on right
10	Lumbar 5, sacral 1, right, moderate	Marked	Bilateral, larger on right
11	Lumbar 5, sacral 1, left, moderate	Marked	Bilateral, larger on left
12	Lumbar 5, left, moderate	Marked	Bilateral, larger on left
13	Right lumbar 5, moderate, sacral 1, mild	Marked	Bilateral, larger on right
14	Lumbar 5, bilateral, moderate. Sacral 1, right, mild	Marked	Bilateral
15	Lumbar 5, bilateral, severe. Sacral 1, right, moderate	Slight	Bilateral, larger on right
16	Lumbar 5, right, moderate	Marked	Bilateral
19	Sacral 1, right, moderate	Marked	Bilateral, larger on right
20	Lumbar 4 and 5, left, mild	Slight	Bilateral, larger on left
21	Lumbar 5, bilateral, sacral 1, right, moderate	Marked	Bilateral, larger on left
22	Lumbar 4 and 5, bilateral, moderate	Slight	Bilateral, larger on right
23	Lumbar 5, sacral 1, moderate left, severe right	None right but marked left	(Unilateral defect.) Left, small
24	Lumbar 5, bilateral, worse left. Sacral 1, left, severe	None	Left, small and posterior

1—C

Preoperative Neurological Findings.

findings

Loose ossicle at site of pseudarthrosis	Disc pathology
Left	None
None	None
None	Protrusion lumbar 4, left
Left	None
None	Protrusion lumbar 4, right
None	None
None	None
None	None
None	None
None	None
None	None
None	None
None	None
Left	Questionable. Disc material not removed.
Bilateral	None
None	Herniation lumbar 4, right
Pseudarthrosis healed on right. Loose ossicle present on right	None

TABLE

Case	Preoperative neurological findings	Surgical	
	Nerve roots involved	Mobility of free lamina	Fibrocartilaginous mass
26	Lumbar 5, right, moderate	Moderate	Bilateral
28	Lumbar 5, sacral 1, bilateral, severe	None	Bilateral, marked
29	Lumbar 5, right, moderate. Sacral 1, left, mild	Moderate	Bilateral
31	Lumbar 5, left, suggestive	None	Bilateral, moderate
32	Sacral 1, left	Marked	Bilateral, more on right, but not compressing roots
33	Lumbar 5, right, mild	Moderate	Bilateral, compressing root on right
34	Lumbar 5, bilateral, worse on right.	Moderate	Bilateral compressing both lumbar 5 roots
35	Lumbar 5, left, moderate	Marked	Bilateral, larger on left
36	Lumbar 4 and sacral 1, left, mild	Marked	Bilateral, moderate
37	Lumbar 5, sacral 1, right, moderate	Marked	Bilateral, larger on right
38	Sacral 1, right, mild	Moderate	Bilateral, small, not compressing roots
39	Lumbar 5, right, moderate	Marked	Bilateral, not compressing roots
40	Lumbar 5, right, moderate	Marked	Bilateral
41	Lumbar 5, right, severe	Moderate	Bilateral
42	Lumbar 5, bilateral, worse on right	None	None. Defects healed bilaterally

1—C (cont.)

findings

Loose ossicle at site of pseudarthrosis	Disc pathology
None	Lumbar 4 soft and soggy but not bulging. Material excised
Right. Spontaneous fusion of lumbar 5 inferior facets to sacrum	None
None	None
None	None
No loose ossicle but considerable pile-up of bone at defect on right	Protrusion lumbar 5 with adherence of sacral 1 root, left.
No loose ossicle. Spur near sacral 1 root, right, removed to avoid cause for future symptoms	Mild protrusion lumbar 4. Excised
None	None
None	None
None	Protrusion lumbar 4, left
No loose ossicle. Lumbar 5 root, right, compressed by spur	None
None	Protrusion lumbar 4 and 5, left
Left	Herniation lumbar 4, right, with right lumbar 5 root bound down to it
None	Complete herniation nucleus of lumbar 4, with fragments bilaterally slightly away from the midline.
No loose ossicle. Sharp spur down from lamina of lumbar 5 directly impaled right fifth root	Lumbar 4 soft and protruded in midline. Annulus of lumbar 5 tight
No loose ossicles. Build-up of bone at healed defects compressed both lumbar 5 roots, worse on right. Spontaneous fusion lumbar 5 and sacral 1 facets, left	None at this surgery. Discogram 20 months later showed degeneration lumbar 3 disc and posterior herniation lumbar 4

TABLE

Case	Preoperative neurological findings	Surgical	
	Nerve roots involved	Mobility of free lamina	Fibrocartilaginous mass
43	Lumbar 5, right, severe	Moderate	Bilateral, not compressing roots
44	Lumbar 5, right, moderate	Slight	Bilateral
45	Lumbar 5, left, moderate	Marked	Bilateral, very large on right
46	Lumbar 5 and sacral 1, right, moderate	Marked	Bilateral, small
47	Lumbar 5 and sacral 1, left	Marked	Marked on left. None on right
48	Lumbar 5, bilateral, mild. Sacral 1, left, moderate	Moderate	Bilateral, small
49	None reported	Marked	Bilateral
50	Lumbar 5 and sacral 1, right	None	None. No defects demonstrable. Dural sac compressed by tight lamina of lumbar 5. Lamina of lumbar 5 excised, but inferior facets left intact
51	Lumbar 5, bilateral, worse on left. Sacral 1, left, mild	None	Bilateral, small, not compressing roots
52	Lumbar 4 and sacral 1, bilateral. Lumbar 5, left	Marked	Bilateral

1—C (cont.)

findings

Loose ossicle at site of pseudarthrosis	Disc pathology
None	Herniation lumbar 4, right, from which material had traveled downward about 7 mm. Lumbar 5 disc normal.
None	Bilateral protrusion lumbar 4
None	Protrusion lumbar 4, left
No loose ossicle. Large pile-up of bone at defect on right	Lumbar 4 soft but not protruding
None	Protrusion lumbar 5, right
None	Herniation lumbar 5, left. Mild protrusion lumbar 4, right
None	None
None	None
No loose ossicle. Right lumbar 5 root adherent at hop-off between lumbar 5 and sacral 1. Solid fusion of facets, lumbar 5 to sacrum	None
Right	Herniation lumbar 4, right

TABLE 1—D
Reoperation.

Case	Months after decompression	Indications for reoperation	Operation and surgical findings	Result and remarks
5	115	Back discomfort and left sciatica returned when lying in bed. Loss of left ankle jerk	Exploration. Kinking left sacral 1 root by scar. Bony over-growth, inferior facet, lumbar 4, left	Thrown from car ninth postoperative day. Wound torn open. Sutured. Healed per primam. Nervous since. Improvement moderate only
11	19	Developed coccygeal and right buttock pain. SLR 70 right. Left ankle jerk depressed	Exploration. Meningocele 2 × 2 mm in size removed. External neurolysis. Marked scar about right lumbar 5 root	Flexion to level of knees. Some pain behind right knee. No back pain. Good result
21	1. 11	1. Initial excision of arch elsewhere, incomplete. Catching pain in back	1. Excision of fragments of loose lamina. External neurolysis, sacral 1 root, left	1. Recurrent catching pain in back with associated clicking feeling and noise
	2. 15	2. Catching in back. Left sacral 1 findings	2. Excision degenerated lumbar 4 disc. Adherent lumbar 5 root, left	2. Improved
	3. 39	3. Persistent back and left leg pain. Sacral 1 findings, left	3. No abnormal findings. *Adkins'* fusion lumbar 4 to sacrum attempted	3. Marked improvement but continued to have some left leg pain
	4. 99	4. Back pain and left leg radiation. .5 in. atrophy left calf. Left heel jerk depressed	4. Done elsewhere. Fusion not solid between lumbar 5 and sacrum	4. Mild sacral 1 findings and left lumbar 5 pain

31	1. 48	1. Done elsewhere for back and left leg pain	1. Anterior interbody fusion lumbar 4 and 5	1. Failure of fusion
	2. 52	2. Done elsewhere for back and left leg pain	2. Re-exploration of lumbosacral area	2. Failure. Patient now confined to wheel chair after this procedure
	3. 63	3. Inability to carry out many former activites because of wheel chair confinement. Marked restriction SLR bilaterally. Persistent back pain and stiffness	3. Exploration laminectomy wound. Excision of considerable scar about dural sac and nerve roots	3. Patient again ambulatory without crutches and back in college. Able to swim. Marked improvement in back and leg pain, back motions, and SLR. Difficult to evaluate neurologically because of the considerable spastic paralysis of lower extremities
36	52	Re-injury to back in rear-end auto collision 32 months after surgery. Developed pain left low back and left thigh, numbness left foot, and some left calf atrophy. No improvement after exercise program	Excision of reherniated lumbar 4 disc, left, and some scar about the root	Last seen 78 months after original surgery. Asymptomatic. Neurologically negative
37	1. 18	1. 1 month after surgery had a fall. Restriction SLR and flexion. Lumbar 5 neurologic findings, right. Discogram 17 months later showed herniation lumbar 4 disc.	1. Excision of a central protrusion, lumbar 4 disc	1. Improved
	2. 31	2. 23 months after initial surgery had second injury. Limitation SLR and back motion. Stocking hypesthesia right leg. Numerous other injuries	2. Excision of reherniated lumbar 4 disc, right. Lumbar 5 and sacral 1 roots bound down by scar	2. Failure. Left leg pain. SLR 75 right, 70 left, with back pain. Stocking hypesthesia right leg. Porphyrinuria diagnosed. Conversion hysteria. Attempted suicide. Under psychiatric care

TABLE 1—D (cont.)

Case	Months after decompression	Indications for reoperation	Operation and surgical findings	Result and remarks
40	5	Developed constant back and right leg pain. Catching pain in back on arising. SLR and flexion free. No neurologic findings. Discography of lumbar 3 advised and performed	Excision of herniated lumbar 3 disc	Good result. Symptoms relieved after this procedure. Has had numerous injuries since, including rear-end auto collisions. Sustained compression fractures thoracic 9 and lumbar 1 65 months after initial surgery. Has had some recurrence right low back and right calf pain, but no positive neurologic findings. Touches floor
41	1. 9	1. Persistent severe right sciatica. Local tenderness. Neurologically negative. Extremely nervous	1. Bilateral *Adkins'* fusion attempted with iliac bone, lumbar 4–5 and lumbar 5–sacral 1	1. Persistent right leg pain. No definite neurologic findings
	2. 18	2. Persistent right sciatica. Traction on right lumbar 5 root at surgery (under local anesthesia) reproduced pain	2. Exploration revealed intra- and extraneural scar, right lumbar 5 root. Section of sensory branch, right lumbar 5 root, attempted	2. Improved for several months, but then had recurrence right leg pain. Developed intermittent stocking hypesthesia right leg

	3. 39	3. Non-union *Adkins'* fusion at lumbar 4–5 level. Complained of severe right sciatica. Slight lumbar 5 motor deficit. Slight sacral 1 sensory deficit	3. Exploration. *Adkins'* fusion solid at lumbar 5–sacral 1 level. Lateral *Hibbs'* fusion lumbar 4 to sacral 1 attempted	3. Unimproved. Persistent right leg pain
	4. 59	4. Severe radicular pain down right sacral 1 distribution	4. Re-exploration right lumbar 5–sacral 1 roots. Sacral 1 root clear. Lumbar 5 root scarred considerably. Fusion solid lumbar 5–sacral 1 but not at lumbar 4–5	4. Symptoms unimproved. Inconstant stocking hypesthesia entire right leg and left leg below knee
44	19	Persistent right sciatica and left low back pain. Able to touch floor. Neurological examination negative.	Exploration. Ring of scar about right lumbar 5 root cuff excised	Failure. Continues to have constant back pain. Mild sacral 1 findings bilaterally. Persistent pain probably due to intraneural scar formation
49	71	Asymptomatic for 5 years after initial decompression elsewhere and then developed low back ache and catching pain. No recurrence of leg pain	Exploration. Large meningocele found, dissected free and closed. Some ectopic bone formation present. Disc material excised at lumbar 3 and 4. Developed wound infection postoperatively	Complete relief of symptoms. Examination negative

TABLE
Synopsis of

Case	Occupation	Length of disability (months)*	Ability to resume former occupation	Length of follow-up (months)	Further forward displacement and per cent of increase**
4	Physician	1	Complete	144	Early first to mid first degree, 9 per cent
5	Housewife	7*	Complete	123	Early first to late first degree, 27 per cent
6	Salesman	1	Complete	37	Early first to mid first degree, 6 per cent
7	Housewife and secretary	1.5	Complete	118	None
8	Laundryman	1	Complete	34	None
10	Housewife	2	Complete	33	10 per cent progression of mid first degree
11	Secretary	10*	Complete	32	None
12	Housewife	1	Complete	31	None
13	Floor covering contractor	6	Complete	112	5 per cent progression of early first degree
14	Clerk and laborer	1.5	Complete	108	3 per cent progression of early first degree
15	Housewife	2	Complete	109	9 per cent progression of early second degree
16	Clerk and housewife	1.5	Complete	118	Early first to late first degree, 33 per cent
19	Medical student	1	Complete	20	None
20	Teamster	2	Complete	16	None
21	Carpenter	45*	Complete	97	None
22	Marine electrician	9	Complete	97	None
23	Clerk	2	Complete	9	None
24	Janitor	4	Complete	95	None
26	Bookkeeper	5	Complete	5	None

1—E
Results.

Result	Remarks
Fair	Able to spend long periods in surgery daily
Fair	Thrown from car ninth day after last surgery. Wound torn open. Sutured. Healed per primam. Nervous since. Moderate improvement only
Good	Lost from further follow-up
Asymptomatic	
Asymptomatic	Lost from further follow-up
Good	Lost from further follow-up
Good	Lost from further follow-up
Asymptomatic	Lost from further follow-up
Asymptomatic	Performs all duties connected with installation of floor covering
Asymptomatic	
Good	
Asymptomatic	3 pregnancies postoperatively
Asymptomatic	Lost from further follow-up
Asymptomatic	Lost from further follow-up
Failure	Now employed as swimming pool maintenance man. Work is equally arduous, according to the patient
Asymptomatic	
Fair	Lost from complete follow-up
Good	
Fair	Lost from complete follow-up

TABLE

Case	Occupation	Length of disability (months)*	Ability to resume former occupation	Length of follow-up (months)	Further forward displacement and per cent of increase**
28	Bookkeeper and housewife	7	Complete	85	None
29	Shipping clerk and housewife	4	Complete	70	Early first to mid first degree, 24 per cent
31	Student		Complete	87	None
32	Janitor	2	Complete	74	None
33	Painter	7.5	Complete	9	None
34	Grocery clerk	3	Complete	7	3 per cent progression of mid first degree
35	Teacher	3	Complete	79	6 per cent progression of mid first degree
36	Truck driver	4*	Complete	78	5 per cent progression of mid first degree
37	Waitress and housewife	See remarks	See remarks	81	Early first to mid first degree, 3 per cent
38	Waitress	9	Complete	77	None
39	Banker	4	Complete	75	None
40	Housewife and magazine sales	8*	Complete	75	Early first to mid first degree, 8 per cent
41	Housewife and maid	20*	Partial	60	None
42	Construction worker	5	Complete	72	None

1–E (cont.)

Result	Remarks
Asymptomatic	Does own housework and laundry. Holds full-time job and drives 100 miles daily
Good	Developed keloid after surgery. Symptoms persisted for some time but cleared after x-ray therapy. Able to perform work requiring lifting and wrapping of heavy packages
Failure	Classified as failure now because of operative procedures 1 and 2 on Table 1—D. Markedly improved after last surgery, however
Asymptomatic	73 months after surgery had recurrence of symptoms. Prescribed exercise program resumed. Again became asymptomatic
Failure	Felt to have a conversion hysteria. Industrial litigation. Obvious psychosexual abnormality. Under psychiatric care. Lost from complete follow-up
Fair	Lost from complete follow-up
Asymptomatic	Does heavy labor during summer months
Asymptomatic	
Failure	Felt to have a conversion hysteria. Disability difficult to evaluate because of psychiatric problems
Asymptomatic	Under treatment before and after surgery for numerous non-related medical problems which were cause of prolonged disability
Asymptomatic	
Good	Good result after second decompression. Many postoperative injuries caused recurrence of symptoms, but patient now has minimal complaints and is again considered a good result
Failure	Ability to resume occupation was complete 4 months after initial surgery but only partial after other procedures
Fair	Returned to lighter work 5 months after surgery but later resumed regular job. 17 months after surgery had onset of new symptoms. Disc excision advised but patient has not wished surgery. Does extremely heavy work 15 hrs. per day

TABLE

Case	Occupation	Length of disability (months)*	Ability to resume former occupation	Length of follow-up (months)	Further forward displacement and per cent of increase**
43	Assembly worker	4	Complete	57	None
44	Housewife	8*	Complete	68	9 per cent progression of early first degree
45	Housewife	3	Complete	56	None
46	Brushmaker and housewife	4	Complete	40	None
47	Automobile painter	5	Complete	34	Early first to mid first degree, 9 per cent
48	Housewife. Very athletic	2	Complete	32	None
49	Welder	8*	Complete	96	7 per cent progression of mid first degree
50	Student	3	Complete	24	Mid first to late first degree, 22 per cent
51	Student	2	Complete	23	Nominal fourth to true fourth degree after surgery
52	Farmer	See remarks	See remarks	4	None

* Asterisk indicates those patients who had operative procedures following the initial decompression. Disability indicated is accrued total resulting from all operative procedures.

** Definition of terminology describing degree of displacement:

Spondylolysis = No measurable degree of displacement

First degree = Slipping from 1 to 50 per cent
- Early = 1 to 17 per cent
- Mid = 18 to 35 per cent
- Late = 36 to 50 per cent

1–E (cont.)

Result	Remarks
Good	Herniated disc probable sole cause of symptoms. 2 years after surgery developed right lower quadrant pain. History of intermittent claudication. Aorta calcified. Myelogram and discogram not remarkable 27 months after surgery
Failure	Persistent pain in low back and right calf. Unimproved following second operation
Good	Asymptomatic and dismissed from care 3 months after surgery. Fell 31 months after surgery and had recurrence of mild back and left leg pain. Now classified as good because of the occasional right buttock pain which appeared subsequent to this injury
Good	Rear end auto collision 13 months after surgery. Developed mild backache after this injury
Fair	Good result until auto accident 15 months after surgery. Now considered fair
Asymptomatic	2 months after surgery had acute recurrence after swimming with flippers. Symptoms subsided completely after rest and caudal injections. Continues to be very athletic now
Asymptomatic	
Asymptomatic	
Good	Has occasional mild backache after working under his car for prolonged periods of time
Good	Patient had not returned to work when last seen. No financial need to do so. Lost from complete follow-up

Second degree = Slipping from 51 to 99 per cent
Early = 51 to 68 per cent
Mid = 69 to 86 per cent
Late = 87 to 99 per cent

Third degree = Slipping of 100 per cent

Fourth degree = Slipping of 100 per cent plus resting of the inferior aspect of the body of the involved vertebra against the anterior aspect of the vertebra below

TABLE

Synopsis of Patients with Previous Fusion Treated

Case	Sex	Age	Occupation	Duration of symptoms (years)	Level and degree of displacement
1	F	21	Waitress and housewife	6	Lumbar 5 first
2	F	42	Bookbinder and housewife	11	Lumbar 5 first
3	F	21	Secretary and housewife	10 worse past 3 years	Lumbar 5 first
9	F	37	Housewife	23	Lumbar 5 first
17	F	34	Housewife	7	Lumbar 5 first
18	F	24	Secretary and housewife	12	Lumbar 5 first
25	F	26	Housewife	Many years	Lumbar 5 first
27	F	37	Mail house order clerk and housewife	Several years	Lumbar 5 first
30	F	32	Maid and housewife	4	Lumbar 4 first

2—A

by Excision of the Loose Arch and Decompression.

Previous surgery	Degree of disability before decompression
Excision of loose arch alone and fusion with iliac bone by Dr. Gill in 1949	Total
Excision of loose arch and decompression lumbar 5 nerve roots bilaterally followed by fusion with iliac bone, lumbar 4 to sacrum by Dr. Gill in 1950. Patient had had no back surgery prior to this	Total
Hibbs fusion with iliac bone, lumbar 4 to sacrum, by Dr. Gill. Thrombophlebitis was postoperative complication	Moderate
First fusion, 1950, failed. Coccygectomy, 1950. Second fusion, 1951, failed. All done elsewhere	Total
First fusion, 1949, failed. Second fusion, 1951, failed. Both done elsewhere.	Total
Exploration and fusion, lumbar 4 to sacrum, 1950, failed. Second fusion, 1951, failed. Third fusion, 1952, failed. All done elsewhere	Total
First fusion, 1951, failed. Second fusion, 1952. Done elsewhere. Did fairly well for 7 or 8 months after second fusion but had recurrence of symptoms after moving furniture	Total
3 attempted fusions, lumbar 3 to sacrum, done elsewhere 1939, 1940, 1942. Last fusion reportedly successful	Total
Fusion of lamina of lumbar 4 to spinous process and lamina of lumbar 5, 1952. No apparent attempt at fusion between lumbar 3 and 4. Done elsewhere	Total

TABLE
Comparison of Symptoms and Findings

	Preoperative			
Case	Back pain	Area of radicular pain	Abnormal physical findings	Nerve roots involved
1	Constant, severe	Both calves, severe on right	Flexion to 6 in. of floor. Extension limited and painful	Lumbar 5, sacral 1, bilateral, moderate
2	Constant, severe	Right lower extremity, severe	Flexion to 6 in. of floor with pain in right low back. SLR to 65 on right and 30 on left. Tenderness to palpation, lumbosacral junction.	Lumbar 5, sacral 1, left, moderate
3	Moderate	Left leg, moderate	Some restriction SLR. Tender over loose arch. Pain on extension	None
9	Constant, moderate	Coccyx, moderate; left sciatica, severe	Flexion to 5 in. of floor. SLR 90 right, 70 left	Lumbar 5, left, moderate
17	Constant, severe	Both thighs and calves, moderate	Flexion to 5 in. of floor with reproduction of right sciatica. Extension limited and painful	Lumbar 5, bilateral, marked on right
18	Constant, severe	Right buttock and sciatica, severe	Flexion to knees. Extension restricted and extremely painful, causing right sciatica. SLR 70 bilaterally	Lumbar 5, bilateral, marked on right. Sacral 1, right, moderate
25	Constant, severe	Left leg	Tender over graft donor site. Flexion to 8 in. of floor. Extension restricted. Stocking hypesthesia entire left leg.	Lumbar 5, left, moderate

2—B
before and after Decompression Operation.

Postoperative (most recent examination)			
Back pain	Area of radicular pain	Abnormal physical findings and remarks	Nerve roots involved
Mild, only after heavy work. Morning stiffness, relieved by exercise	Right calf, occasional, mild	Slight tightness of SLR on right	Sacral 1, right, mild
Aching, mild	Coccyx and right leg, mild	Limitation of flexion to level of knees. Neurological examination negative. Fusion solid	None
Aching after heavy work	Occasional left calf pain	SLR free. Some back tenderness and discomfort on extension. Flexes to touch floor. X-ray evidence of degeneration and posterior calcification at lumbar 4 disc. Fusion solid at lumbar 4. Pseudarthrosis at lumbar 5.	None
Tired feeling after prolonged sitting	None	Touches floor. Examination negative	None
Feeling of weakness	Right calf, mild	Extension slightly painful. Touches metacarpal heads to floor	None
Mild, occasional	Right sciatica, mild, occasional	Touches floor. SLR free. Back and leg discomfort now are associated mainly with menstrual periods. Some tightness in back at end of day. Re-operated. See Table 2—D	Sacral 1, right, mild
Tender over operative area	Right leg	Doing well until 2 weeks prior to last examination when she fell on buttocks. See Table 2—E	Lumbar 5, bilateral, mild

TABLE

Preoperative				
Case	Back pain	Area of radicular pain	Abnormal physical findings	Nerve roots involved
27	Severe	Aching left leg. Severe pain right leg	Marked restriction and pain on SLR. Flexion to 10 in. of floor. Had large, adherent stellate scar over sacrum from pressure of cast worn after the fusion	Lumbar 4, right. Lumbar 5, sacral 1, bilateral
30	Constant	Coccyx and both legs, severe	Walked in flexed position with upper lumbar area hyperextended. Generalized hypesthesia right leg	Lumbar 5, bilateral, mild

2—B (cont.)

Postoperative (most recent examination)			
Back pain	Area of radicular pain	Abnormal physical findings and remarks	Nerve roots involved
Dull ache on left	Aching in left leg	Flexion to 2 in. of floor. SLR 90 bilaterally. Plastic correction of scar strongly advised. See Table 2—D	Sacral 1, left, mild
Catching, occasionally	None	Reoperated. See comments on Table 2—D. Was asymptomatic and negative 4 days prior to injury described on Table 2—D. Recently developed catching in back. Flexion free but slight two-stage recovery	Sacral 1, left, mild

TABLE

Correlation of Surgical Findings with

Case	Preoperative neurological findings	Surgical	
	Nerve roots involved	Level of pseudarthrosis	Amount of motion at defect in pars interarticularis of involved vertebra
1	Lumbar 5, sacral 1, bilateral, moderate	Lumbar 4 and 5. Lumbar 5 and sacral 1	Perceptible only after removal 0.25 in. of bone
2	Lumbar 5, sacral 1, left, moderate	None	Marked
3	None	Fusion solid	None
9	Lumbar 5, left, moderate	Lumbar 4 and 5. Lumbar 5 and sacral 1	Barely perceptible
17	Lumbar 5, bilateral, marked on right	Lumbar 4 and 5. Lumbar 5 and sacral 1	Barely perceptible
18	Lumbar 5, bilateral, marked on right. Sacral 1, right, moderate	Lumbar 4 and 5. Lumbar 5 and sacral 1	Barely perceptible only after removal 0.25 in. of bone
25	Lumbar 5, left, moderate	Frank nonunion at lumbar 4–5 and lumbar 5–sacral 1 with overgrowth of bone above lamina of lumbar 4 which buttressed against spinous process of lumbar 3. Numerous fragments of bone over surface of fusion mass	Barely perceptible
27	Lumbar 4, right. Lumbar 5 and sacral 1, bilateral	Nonunion at lumbar 3. Questionable nonunion at lumbar 5. Little motion present however	Barely perceptible
30	Lumbar 5, bilateral, mild	Lumbar 4–5	Barely perceptible

2—C

Preoperative Neurological Findings.

findings

Fibrocartilaginous mass	Disc pathology and dural compression
Bilateral, larger on right	Fusion mass extended over lamina of lumbar 4 and compressed dura
Bilateral, compressing both lumbar 5 roots	No disc pathology
Present on left	None noted
Bilateral, larger on left	None noted
Bilateral, larger on right, with adhesions to lumbar 5 root, right	Dura compressed by sinking in of fusion mass
Bilateral, larger on right	Dura compressed by mass of ligamentum flavum below lamina of lumbar 3
Bilateral, larger on left, with compression left lumbar 5 root. Right lumbar 5 root clear	Adhesions under graft to dura. Considerable ligamentum flavum present. Lumbar 5 disc markedly collapsed. Impossible to remove disc material. Lumbar 4 disc normal
Bilateral and compressing both lumbar 5 roots	Lumbar 3 disc degenerated, boggy and bulging. Lumbar 4 and 5 discs normal
Bilateral	Lumbar 4 disc prominent on right. Lumbar 5 disc collapsed

TABLE 2—D

Reoperations.

Case	Months after decompression	Indications for reoperation	Operation and surgical findings	Result and remarks
2	1. 5	1. 3 months after surgery developed severe pain over operative area with radiation to right buttocks and coccyx. X-rays showed shifting of grafts toward midline over dura	1. Exploration. Excision of thick scar between dura and graft. Excision of bone chips compressing terminal end of spinal theca	1. Relief of coccygeal and right leg pain for about six weeks
	2. 14	2. Recurrence of coccygeal and right leg pain	2. Exploration. Excision of thick scar over dura. Excision of adhesions between right sacral 1 root and wall of canal, also between pedicle of lumbar 5 and right fifth lumbar nerve root. Refusion with rib grafts lumbar 4 to sacrum	2. Fusion solid. Right leg pain disappeared. Neurological examination continued to be normal
	3. 38	3. Recurrence of coccygeal pain	3. Exploration. Fusion solid. Excision thin scar about dura and right sacral 1 root. Small dural arachnoid cyst found	3. Patient had spinal fluid fistula for 4 to 5 weeks after surgery. Temporary relief of symptoms only, although neurological examinations have remained negative
18	1. 8	1. Aching in back and local soreness. Some pain right buttocks. No leg pain. X-ray evidence of new bone formation about previous fusion site	1. Exploration. Excision of osseous proliferation in scar overlying dural sac	1. Much improved. Free back motion. No radicular pain. 1 month after surgery was struck in back by doorknob. Developed soreness over sacrum and later radicular pain into right buttock and leg

	2. 13	2. Persistent backache with radiation to coccyx. Sacral 1 findings, left. Slight spasm on back motion	2. Exploration. Excision of scar about dura and right lumbar 5 and sacral 1 roots. Excision of degenerated disc material at lumbar 4	2. Improved. Continued to have some back and right leg pain. Became pregnant 7 months later. Had some increase in back pain but pregnancy and delivery much easier than with other child. Did very well afterward. Essentially lost back pain and had only mild right leg discomfort
	3. 68	3. 4 months previously slipped and twisted back. Had recurrence of back and right leg pain. Mild lumbar 5 and sacral 1 findings, right. Discogram showed protrusion at lumbar 5, right	3. Exploration. Freeing of right lumbar 5 root which was bound to annulus of lumbar 5 disc by scar. Excision of disc material at lumbar 5	3. Improved, but continued to have some back and right leg discomfort. Injured 3 years later while water-skiing. Had some increase in symptoms. Mild lumbar 5 findings present on right
	4. 110	4. 3 months before surgery had belly-flop while water-skiing. Developed more right leg pain. Later developed .5 in. atrophy right calf and some right lumbar 5 neurologic changes	4. Reherniation lumbar 4 disc right	4. Last seen 3.5 months after surgery. Calves equal. No sensory changes. Right heel jerk diminished. Much improved. Considered as fair result
27	31	Unhealed ulcer and large adherent stellate scar over sacrum caused by pressure of cast worn after fusion	Biopsy of scar. No malignancy. No infection. Scar excised. Transposition of gluteal skin flap performed. Done elsewhere at our recommendation	Excellent
30	1. 15	1. 7 months after decompression fell on buttocks. Developed inability to straighten back and paresthesias in feet. Bizarre posture. SLR free. Flexion to 2 in. of floor. Neurologically negative	1. Exploration done elsewhere. Adhesions reported	1. Developed wound infection. Seen by us 2.5 years later. Had stocking hypesthesia left leg. No reflex or motor abnormality. No atrophy. SLR free. Diastasis of spinalis muscles. Considerable back stiffness

TABLE 2—D

Case	Months after decompression	Indications for reoperation
30 (cont.)	2. 53	2. Apparent diastasis of spinalis muscles. Back and leg pain. SLR 70 bilaterally. No definite neurologic changes
	3. 53.5	3. Cerebro-spinal fluid fistula

2—E
Results.

Result	Remarks
Fair	Had second child after decompression procedure. Pregnancy and delivery much easier than with first child. Lost from further follow-up
Fair	Continues to have mild aching in back, coccyx and right leg but carries out all activities. Fusion remains solid. Patient tends to form considerable scar
Fair	Occasional back and leg pain. Carries out all activities. Two pregnancies since decompression. Fusion solid at lumbar 4. Pseudarthrosis at lumbar 5
Good	Occasional mild back pain. Carries out all activities. Lost from further follow-up
Failure	Lost from further follow-up
Fair	Carries out all activities
Fair	7 months after surgery patient stated she had a completely new outlook on life. Had very little back pain. Some right buttock and posterior right leg pain. Mild right lumbar 5 and sacral 1 neurologic deficit was only abnormal physical finding. Fell 2 weeks prior to last examination and had tenderness over operative area with radicular pain to right leg. Mild bilateral lumbar 5 root findings present. Lost from complete follow-up
Fair	Has had occasional flare-ups of back pain. Not disabling. Symptoms clear when exercises are resumed. Patient states the more active she is, the better she feels
Fair	Does well except during recurrent apparently hysterical episodes when her sons leave for sea duty

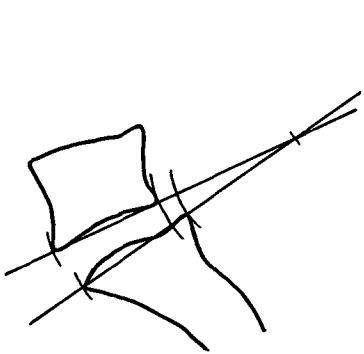
Second degree = Slipping from 51 to 99 per cent
Early = 51 to 68 per cent
Mid = 69 to 86 per cent
Late = 87 to 99 per cent

Third degree = Slipping of 100 per cent

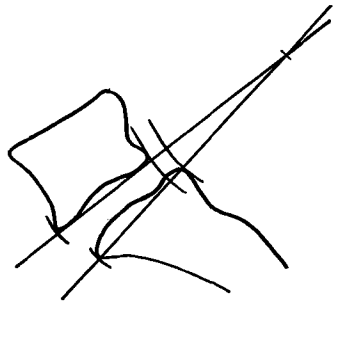
Fourth degree = Slipping of 100 per cent plus resting of the inferior aspect of the body of the involved vertebra against the anterior aspect of the vertebra below

TABLE 3

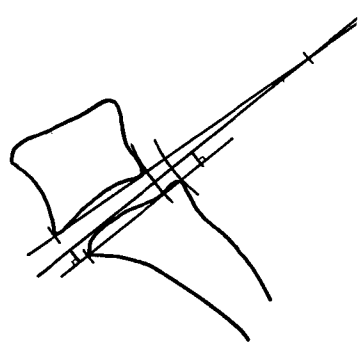
Case 5. Female. Birth Date 6-18-21. *Date of Surgery 11-5-51.*



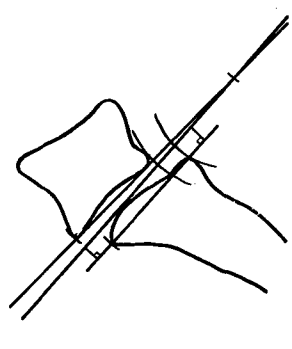
8-26-46 17 %



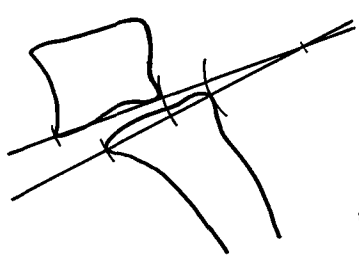
6-30-53 14 %



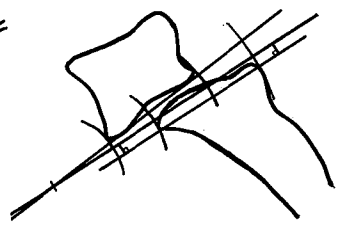
11-5-53 18 %



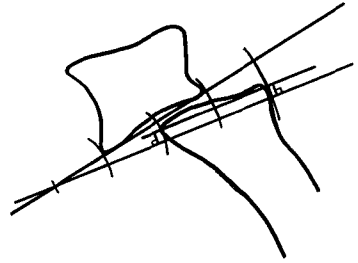
1-4-55 23 %



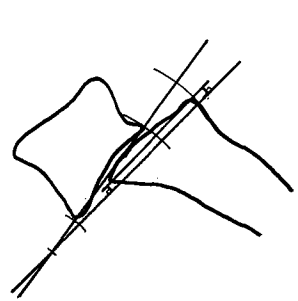
8-23-55 38 %



7-10-56 46 %



8-12-58 50 %



11-16-61 44 %

TABLE 4

Postoperative Progression of Displacement According to Age.

Age at surgery (years)	Number of Patients		Average postoperative progression of displacement	
	(Males)	(Females)	(Males)	(Females)
25 or under	1	4	3 %	19 %
26 to 30	0	2	0 %	23 %
31 to 35	1	0	5 %	0 %
36 to 40	4	3	5 %	5 %
41 to 45	1	2	9 %	17.5 %
46 to 50	1	1	7 %	24 %
51 to 55	0	1	0 %	9 %
56 to 60	1	0	9 %	0 %

TABLE 5

Postoperative Progression of Displacement According to Sex.

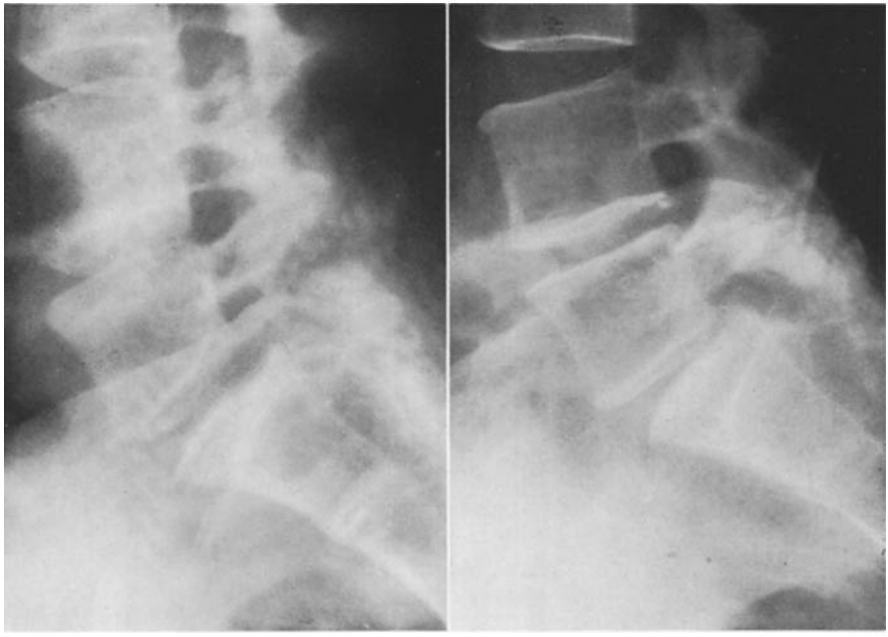
	Number of patients	
	Males	Females
Sex of patients	21 (40.4 %)	31 (59.6 %)
Patients with postoperative progression of displacement	9 (42.8 %)	13 (41.9 %)
Average displacement in patients with post-operative progression of displacement	9 (5.9 %)	13 (16.0 %)
Average follow-up in all patients	21 (62 months)	31 (65 months)
Average follow-up in patients without post-operative progression of displacement	12 (51 months)	18 (56 months)
Average follow-up in patients with post-operative progression of displacement	9 (77 months)	13 (79 months)

A B

Fig. 1. Case 2.

A: Roentgenogram four months before a combined decompression and fusion in a forty-two year old female.

B: Roentgenogram 114 months after surgery shows a 25 per cent progression of the first degree spondylolisthesis.

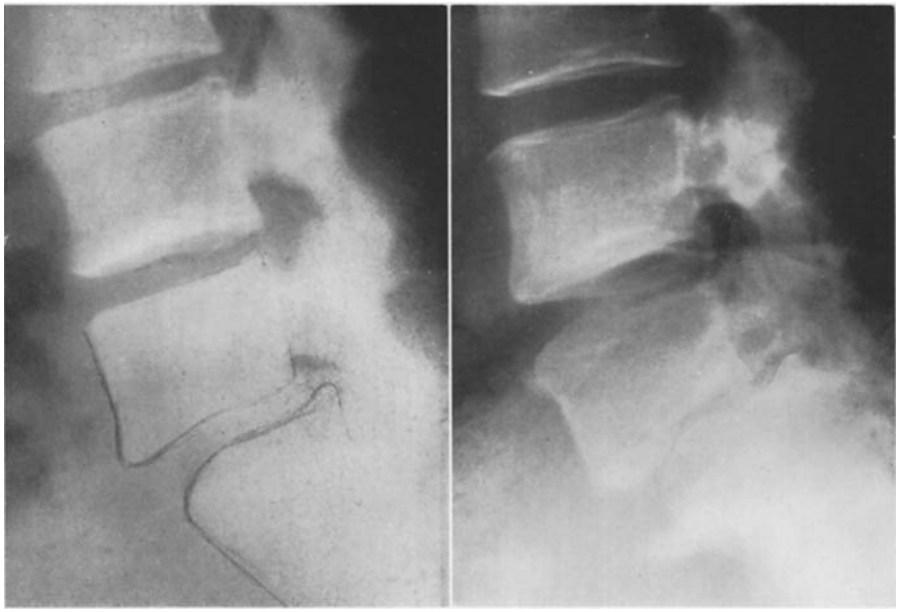


A B

Fig. 2. Case 3.

A: Roentgenogram ten months prior to the decompression operation in a twenty-one year old female. Re-exploration because of persistent symptoms showed solid fusion from lumbar 4 to the sacrum, and a decompression was done on the left. (The roentgenogram has been retouched.)

B: Roentgenogram 146 months after the decompression procedure. There has been no progression of displacement despite the pseudarthrosis at the 5th lumbar interspace.



A B

Fig. 3. Case 4.

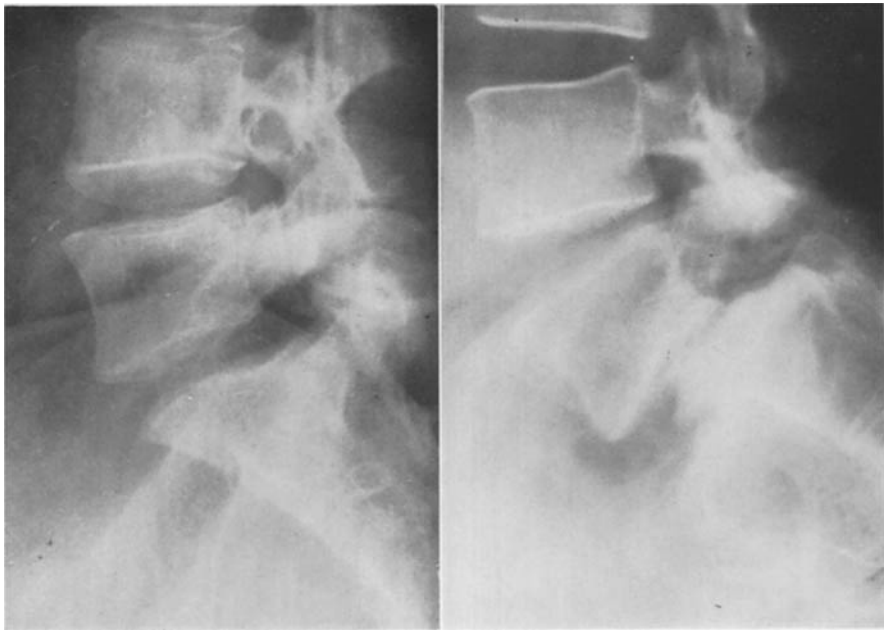
A: Roentgenogram eleven months before the decompression operation in a forty-one year old male. (The roentgenogram has been retouched.)

B: Roentgenogram 144 months after surgery shows a 9 per cent progression of the first degree spondylolisthesis. (The roentgenogram has been retouched.)

Fig. 5. Case 7. →

A: Roentgenogram immediately prior to the decompression operation in a twenty-three year old female. (The roentgenogram has been retouched.)

B: Roentgenogram 118 months after surgery shows no progression of displacement. (The roentgenogram has been retouched.)



A B

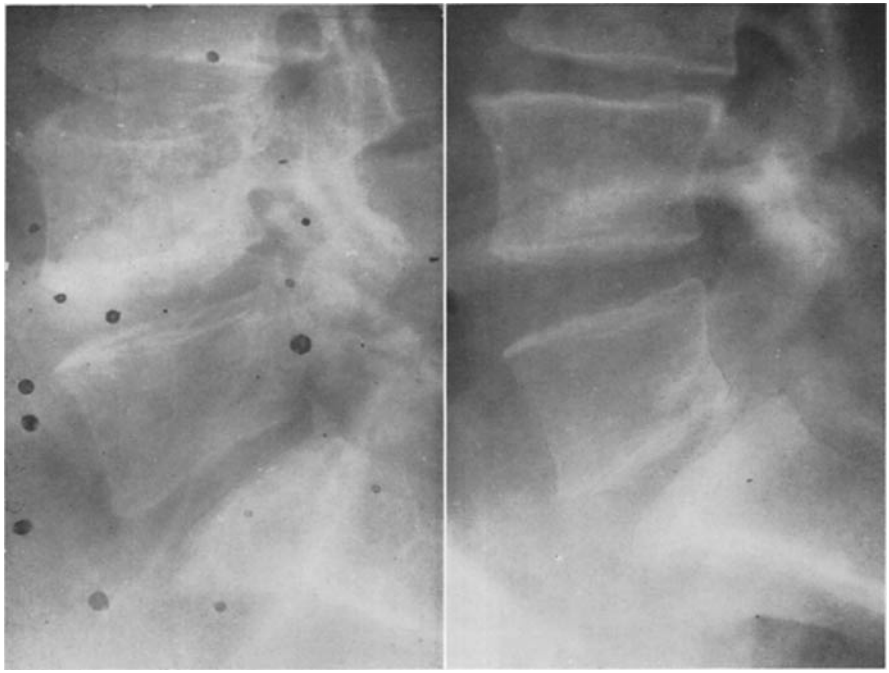
Fig. 4. Case 5.

A: Roentgenogram sixty-two months before the decompression operation in a woman thirty years of age at the time of surgery.

B: Roentgenogram 123 months after surgery shows a 27 per cent progression of the first degree spondylolisthesis.

A B

Fig. 5. Case 7.

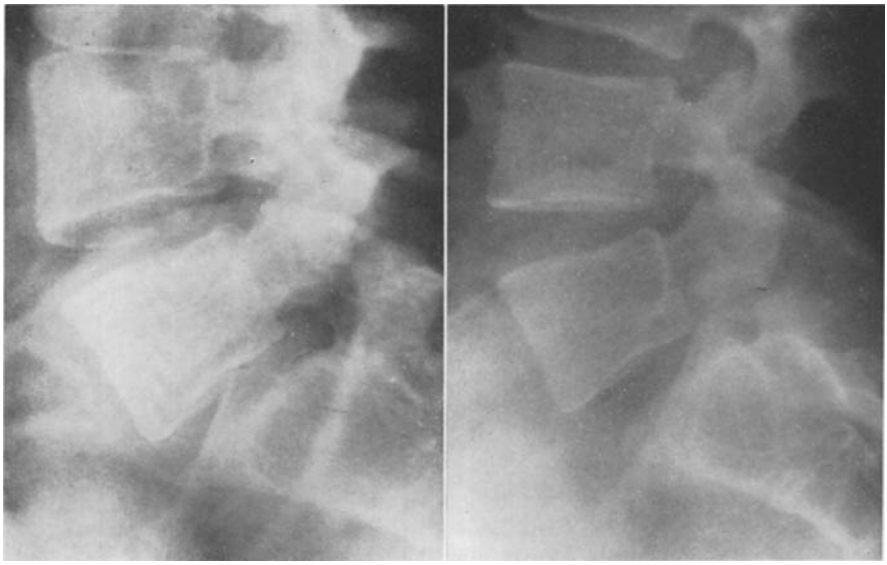


A B

Fig. 6. Case 13.

A: Roentgenogram fourteen months before the decompression operation in a male who was thirty-five years of age at the time of surgery. (The roentgenogram has been retouched.)

B: Roentgenogram 112 months after surgery shows a 5 per cent progression of the first degree spondylolisthesis. (The roentgenogram has been retouched.)

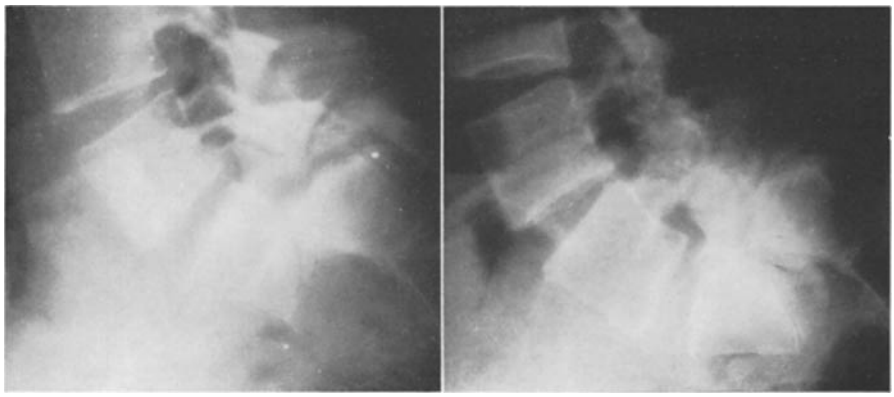


A B

Fig. 7. Case 14.

A: Roentgenogram immediately prior to the decompression operation in a nineteen year old male. (The roentgenogram has been retouched.)

B: Roentgenogram 108 months after surgery shows a 3 per cent progression of the first degree spondylolisthesis.

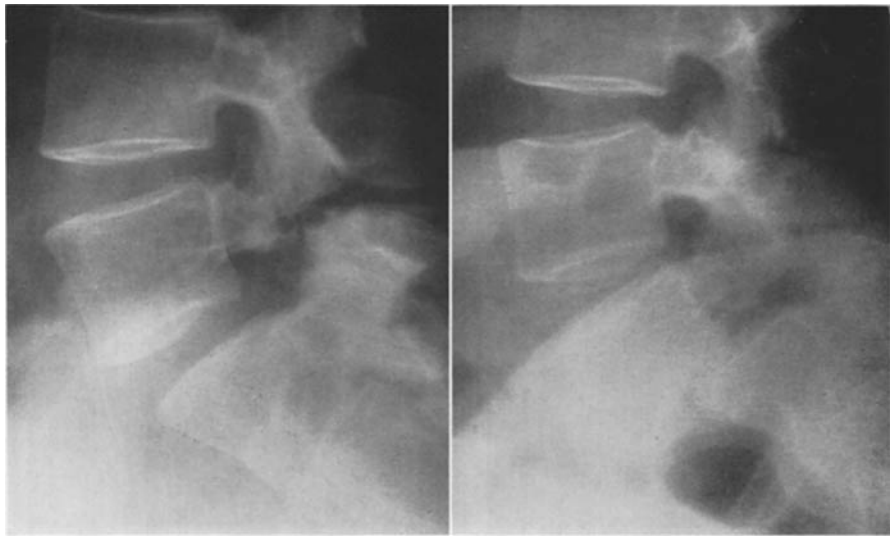


A B

Fig. 8. Case 15.

A: Roentgenogram five weeks before the decompression operation in a twenty-four year old female. (The roentgenogram has been retouched.)

B: Roentgenogram 109 months after surgery shows a 9 per cent progression of the second degree spondylolisthesis. (The roentgenogram has been retouched.)

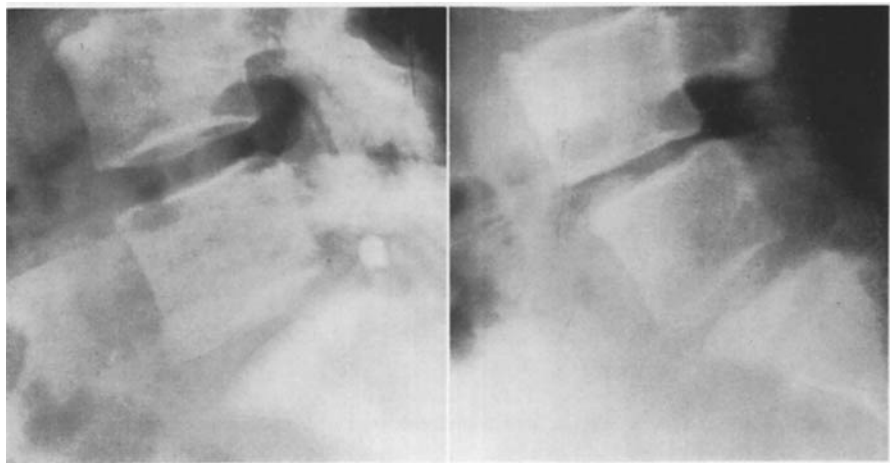


A B

Fig. 9. Case 16.

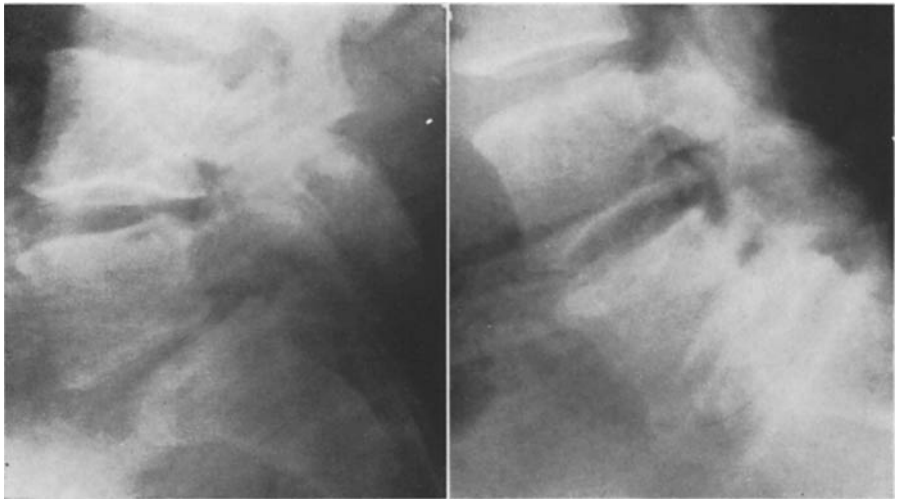
A: Roentgenogram six months before the decompression operation in a twenty-five year old female. (The roentgenogram has been retouched.)

B: Roentgenogram 118 months following surgery shows a 33 per cent progression of the first degree spondylolisthesis.



A B

Fig. 10. Case 18.



A B

Fig. 11. Case 21.

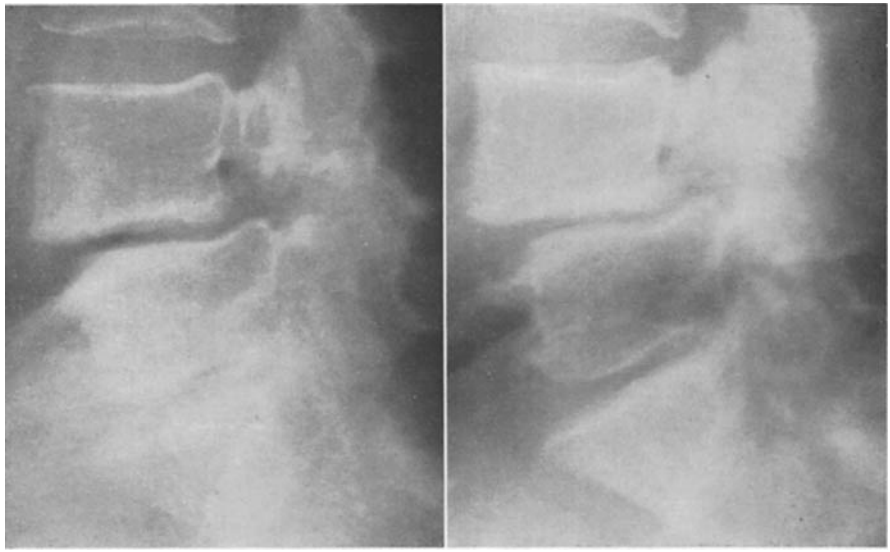
A: Roentgenogram thirty-seven months after the decompression operation in a male who was thirty-two years of age at the time of surgery. Preoperative roentgenograms were not available. (The roentgenogram has been retouched.)

B: Roentgenogram ninety-seven months after surgery shows no progression of displacement. (The roentgeonogram has been retouched.)

← *Fig. 10. Case 18.*

A: Roentgenogram three months before the decompression operation in a twenty-four year old female. Pseudarthroses are present at lumbar 4 and 5 following three previously attempted fusion operations elsewhere. (The roentgenogram has been retouched.)

B: Roentgenogram 113 months after the decompression operation shows a 15 per cent progression of the first degree spondylolisthesis.



A B

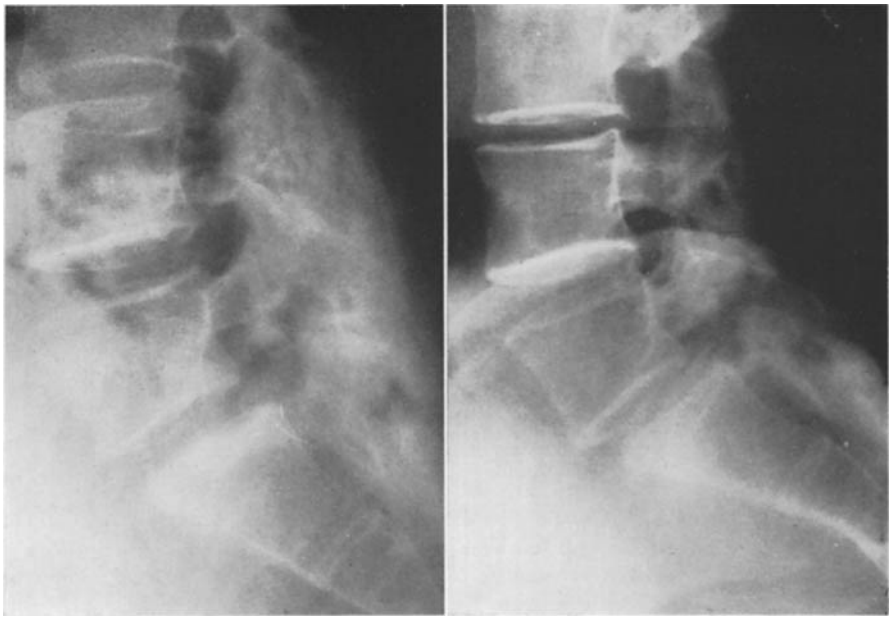
Fig. 12. Case 22.

A: Roentgenogram five months before the decompression operation in a fifty-two year old male shows a spondylolisthesis of the fourth lumbar vertebra.

B: Roentgenogram ninety-seven months following surgery shows no progression of displacement.

A B

Fig. 13. Case 23.



A B

Fig. 17. Case 27.

A: Roentgenogram immediately prior to the decompression operation in a thirty-seven year old female. Fusions from lumbar 3 to the sacrum were attempted elsewhere sixteen, fifteen and thirteen years previously. At surgery pseudarthroses at the third and fifth lumbar interspaces were found. (The roentgenogram has been retouched.)

B: Roentgenogram ninety-five months following the decompression procedure shows a 4 per cent progression of the first degree spondylolisthesis.

A B

Fig. 18. Case 28.

A: Roentgenogram before the decompression operation in a thirty-eight year old female. (The roentgenogram has been retouched.)

B: Roentgenogram eighty-five months following surgery shows no progression of displacement. (The roentgenogram has been retouched.)

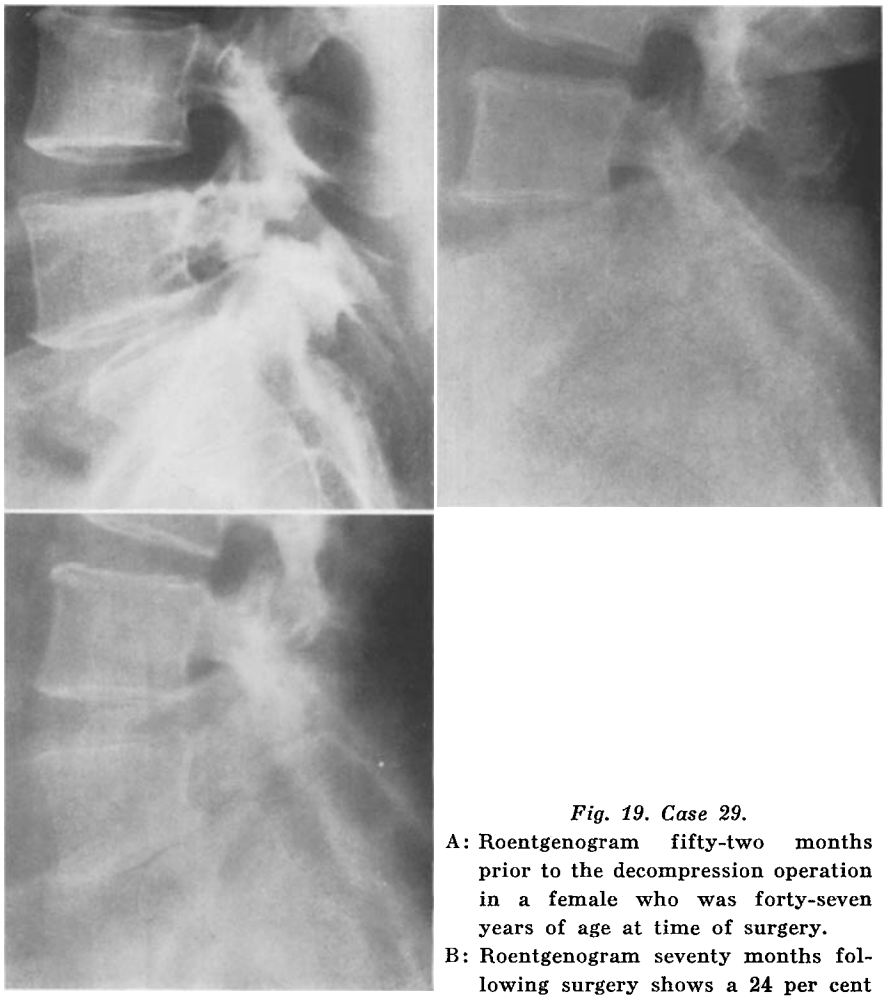


Fig. 19. Case 29.

A: Roentgenogram fifty-two months prior to the decompression operation in a female who was forty-seven years of age at time of surgery.

B: Roentgenogram seventy months following surgery shows a 24 per cent progression of the first degree spondylolisthesis. (The roentgenogram has been retouched.)

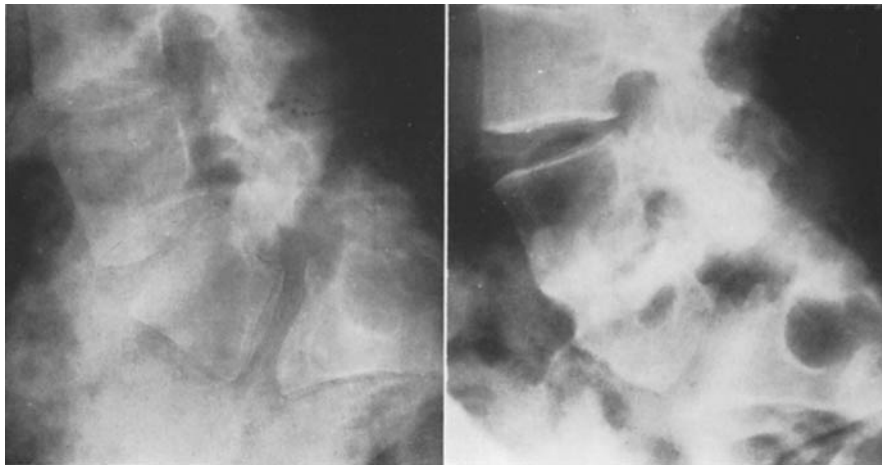
C: Roentgenogram seventy months following surgery. In this film sand bags weighing twenty-four pounds were placed on the patient's shoulders, but no essential change in the position of the body of the fifth lumbar vertebra is noted with this added weight. (The roentgenogram has been retouched.)

A B

Fig. 20. Case 30.

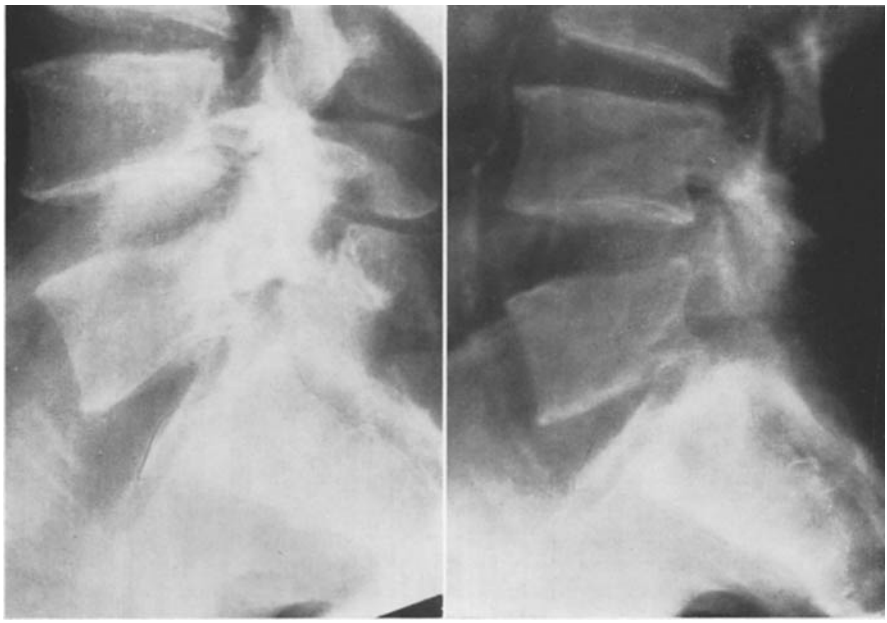
A: Roentgenogram thirteen months before the decompression operation in a female who was thirty-two years of age at the time of surgery. There is a first degree spondylolisthesis of the fourth lumbar vertebra. Two years previously a fusion from the fourth lumbar vertebra to the sacrum was attempted elsewhere and resulted in pseudarthrosis.

B: Roentgenogram eighty-six months following the decompression shows no progression of displacement.



A B

Fig. 21. Case 31.



A B

Fig. 22. Case 32.

A: Roentgenogram four months prior to the decompression operation in a fifty-one year old male. (The roentgenogram has been retouched.)

B: Roentgenogram seventy-four months following surgery shows no progression of displacement. (The roentgenogram has been retouched.)

←

Fig. 21. Case 31.

A: Roentgenogram twenty-one months prior to the decompression operation in a woman who was twenty-one years of age at the time of surgery. (The roentgenogram has been retouched.)

B: Roentgenogram eighty-three months following the decompression procedure. Interbody fusion at the fourth and fifth lumbar levels was attempted elsewhere forty-eight months following the initial surgery and resulted in pseudarthrosis. No progression of displacement has occurred. (The roentgenogram has been retouched.)

A B

Fig. 23. Case 34.

A: Roentgenogram immediately prior to the decompression operation in a thirty-seven year old male. (The roentgenogram has been retouched.)

B: Roentgenogram seven months following surgery shows a 3 per cent progression of the first degree spondylolisthesis. (The roentgenogram has been retouched.)

A B

Fig. 24. Case 35.

A B

Fig. 25. Case 36.

A: Roentgenogram immediately prior to the decompression operation in a thirty-eight year old male. (The roentgenogram has been retouched.)

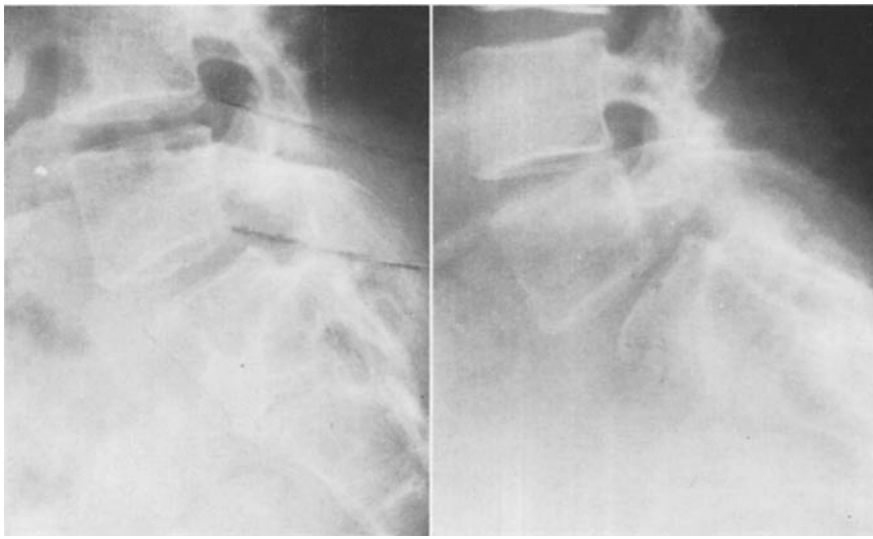
B: Roentgenogram seventy-eight months following surgery shows a 5 per cent progression of the first degree spondylolisthesis.

←

Fig. 24. Case 35.

A: Roentgenogram three months following the decompression operation in a thirty-six year old male. Preoperative roentgenograms were not available. (The roentgenogram has been retouched.)

B: Roentgenogram seventy-nine months following surgery shows a 6 per cent progression of the first degree spondylolisthesis.

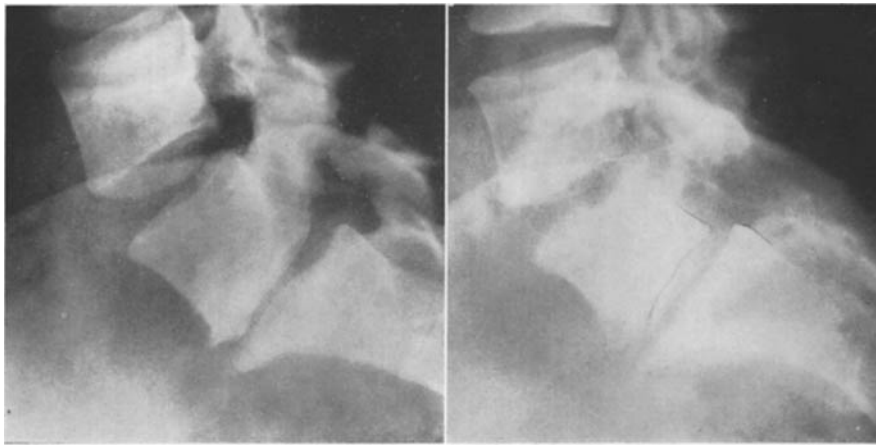


A B

Fig. 26. Case 37.

A: Roentgenogram thirty-one months after the decompression operation in a woman who was forty years of age at the time of surgery. Preoperative roentgenograms were destroyed. (The roentgenogram has been retouched.)

B: Roentgenogram eighty-one months following surgery shows a 3 per cent progression of the first degree spondylolisthesis.

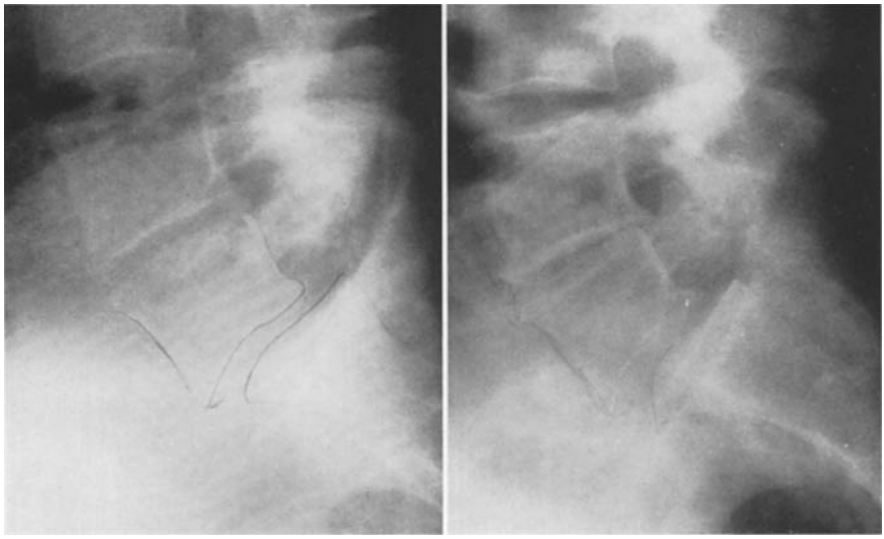


A B

Fig. 27. Case 38.

A: Roentgenogram immediately prior to the decompression operation in a thirty-eight year old female. (The roentgenogram has been retouched.)

B: Roentgenogram seventy-seven months following surgery shows no progression of displacement. (The roentgenogram has been retouched.)

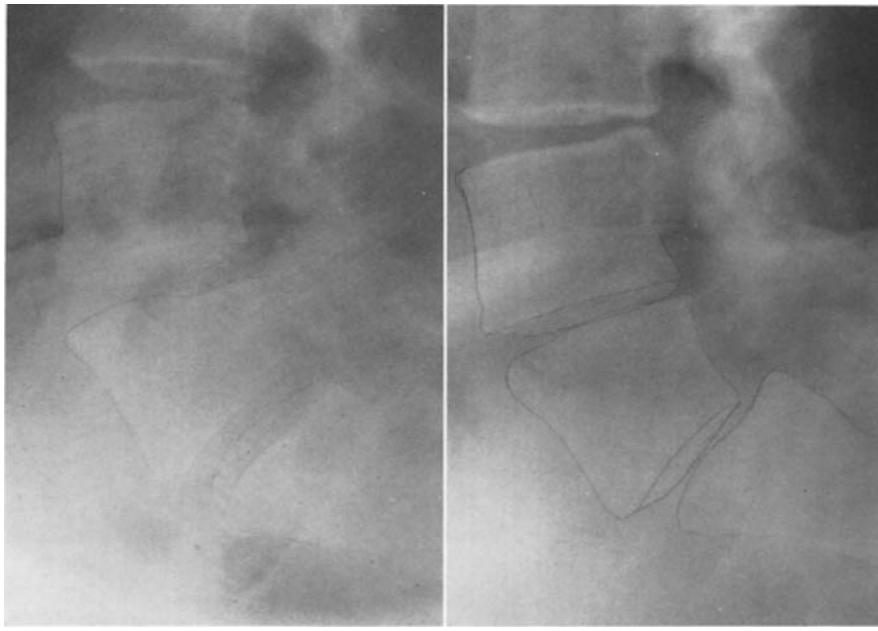


A B

Fig. 28. Case 39.

A: Roentgenogram two months following the decompression operation in a forty-five year old male. Preoperative roentgenograms were not available. (The roentgenogram has been retouched.)

B: Roentgenogram seventy-five months following surgery. There has been no progression of displacement. (The roentgenogram has been retouched.)

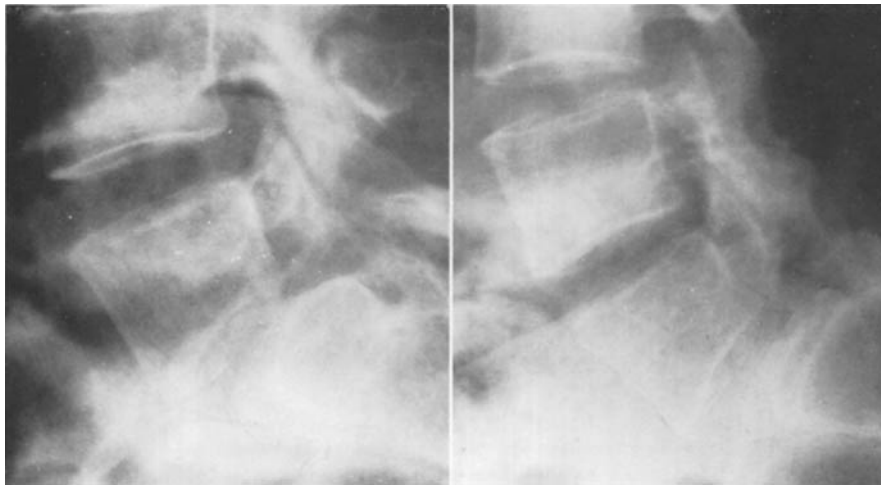


A B

Fig. 29. Case 40.

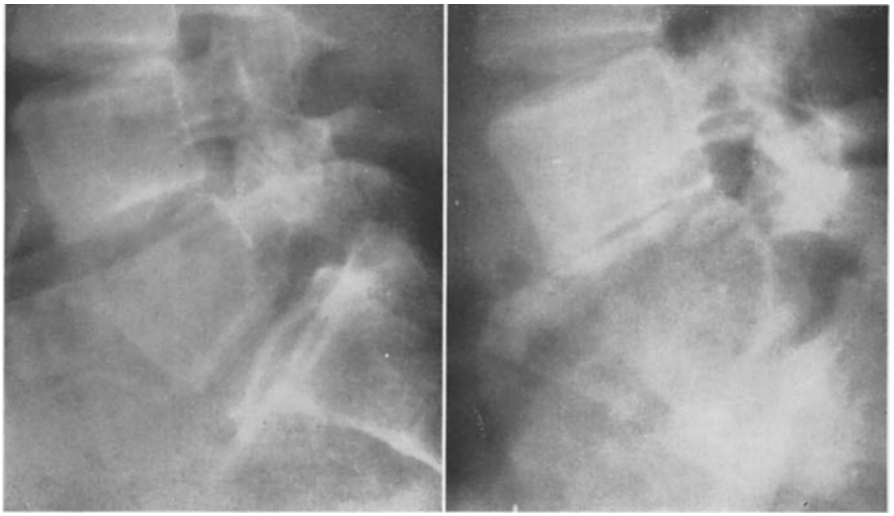
A: Roentgenogram immediately prior to the decompression operation in a thirty-six year old female. (The roentgenogram has been retouched.)

B: Roentgenogram seventy-five months following surgery shows an 8 per cent progression of the first degree spondylolisthesis. (The roentgenogram has been retouched.)



A B

Fig. 30. Case 41.



A B

Fig. 31. Case 42.

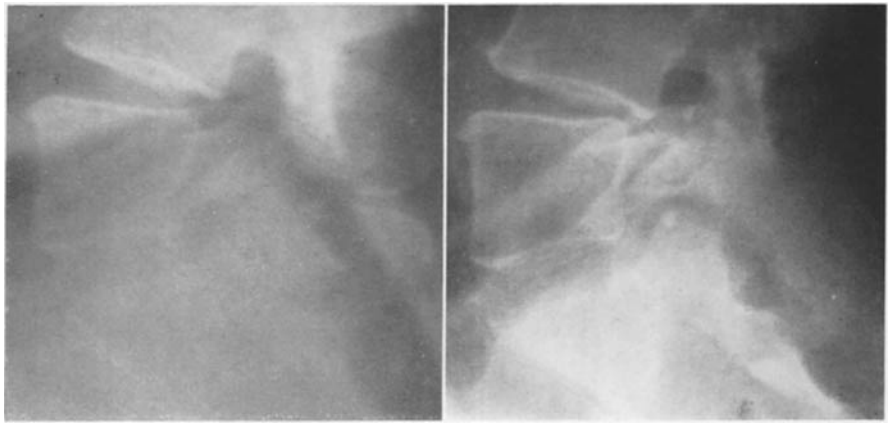
A: Roentgenogram immediately prior to the decompression operation in a forty-seven year old male.

B: Roentgenogram seventy-two months following surgery shows no progression of displacement.

← *Fig. 30. Case 41.*

A: Roentgenogram two months before the decompression operation in a thirty year old female. (The roentgenogram has been retouched.)

B: Roentgenogram sixty months after surgery shows no progression of displacement.

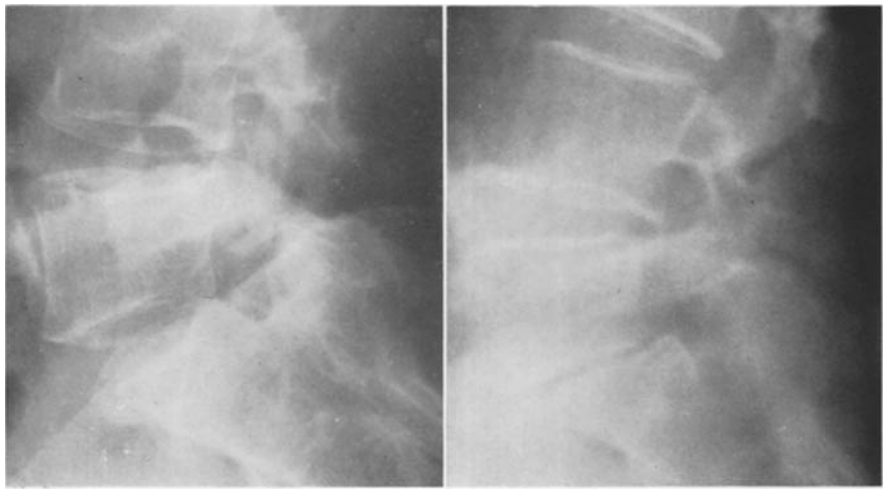


A B

Fig. 32. Case 43.

A: Roentgenogram one month prior to the decompression operation in a fifty-seven year old female. (The roentgenogram has been retouched.)

B: Roentgenogram fifty-seven months following surgery shows no progression of displacement. (The roentgenogram has been retouched.)

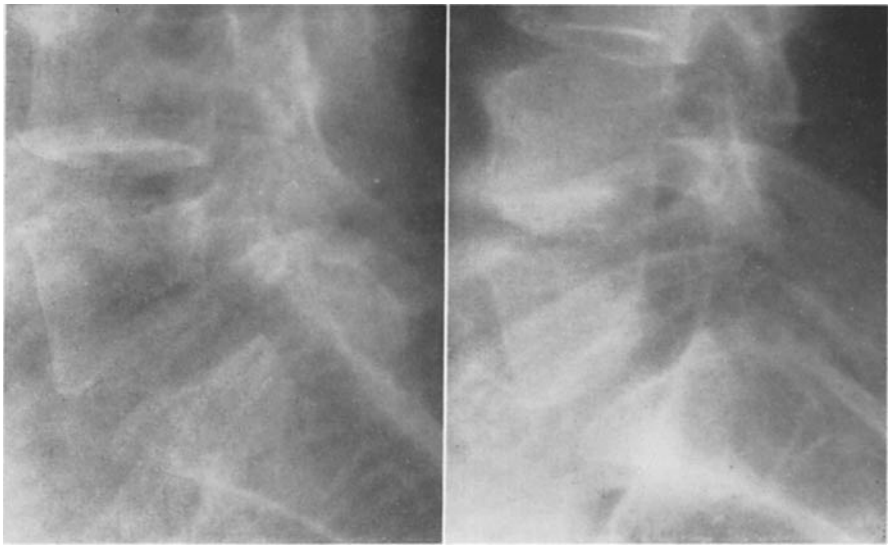


A B

Fig. 33. Case 44.

A: Roentgenogram fifty-three months prior to the decompression operation in a woman who was fifty-five years of age at the time of surgery. (The roentgenogram has been retouched.)

B: Roentgenogram sixty-eight months after surgery shows a 9 per cent progression of the first degree spondylolisthesis.

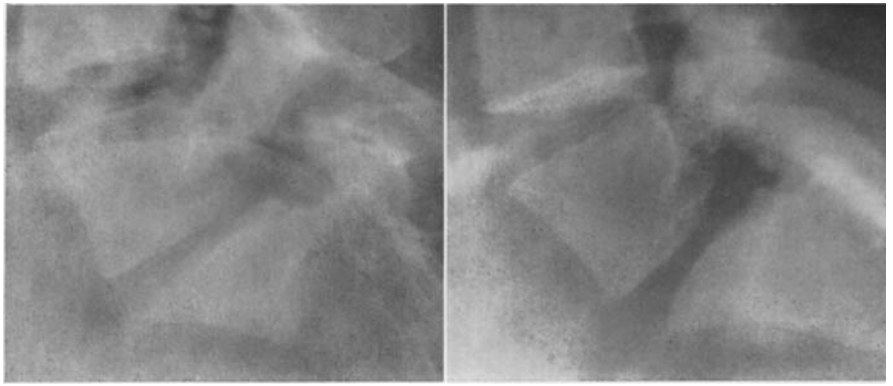


A B

Fig. 34. Case 45.

A: Roentgenogram shortly before the decompression operation in a fifty-seven year old female. (The roentgenogram has been retouched.)

B: Roentgenogram fifty-six months after surgery shows no progression of displacement.

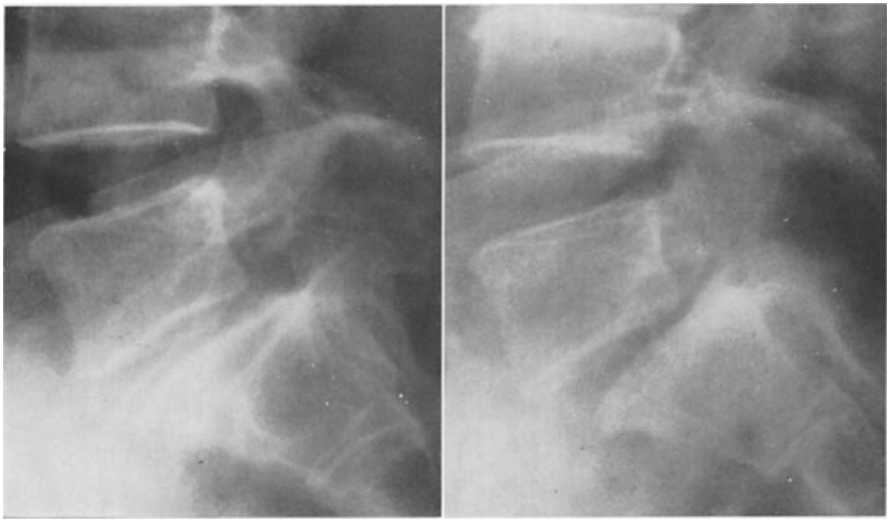


A B

Fig. 35. Case 46.

A: Roentgenogram two months before the decompression operation in a twenty-nine year old female. (The roentgenogram has been retouched.)

B: Roentgenogram forty months following surgery shows no progression of displacement.

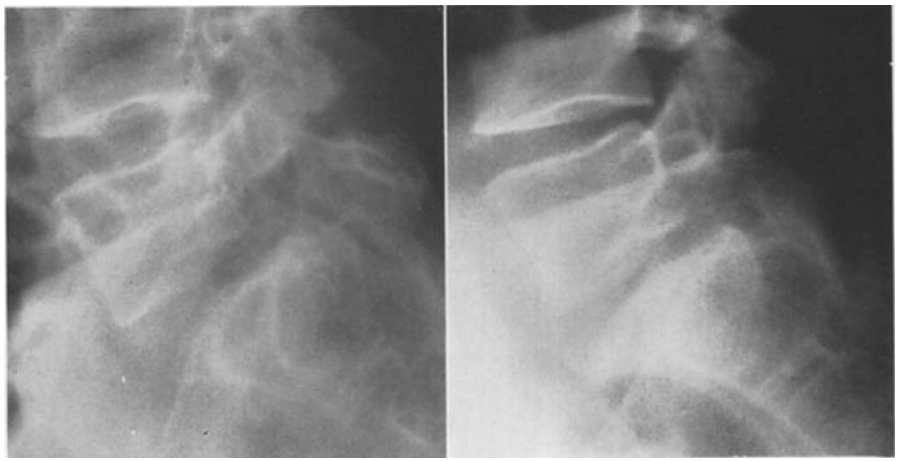


A B

Fig. 36. Case 47.

A: Roentgenogram two years prior to the decompression operation in a male who was fifty-seven years of age at the time of surgery.

B: Roentgenogram thirty-four months after surgery shows a 9 per cent progression of displacement.

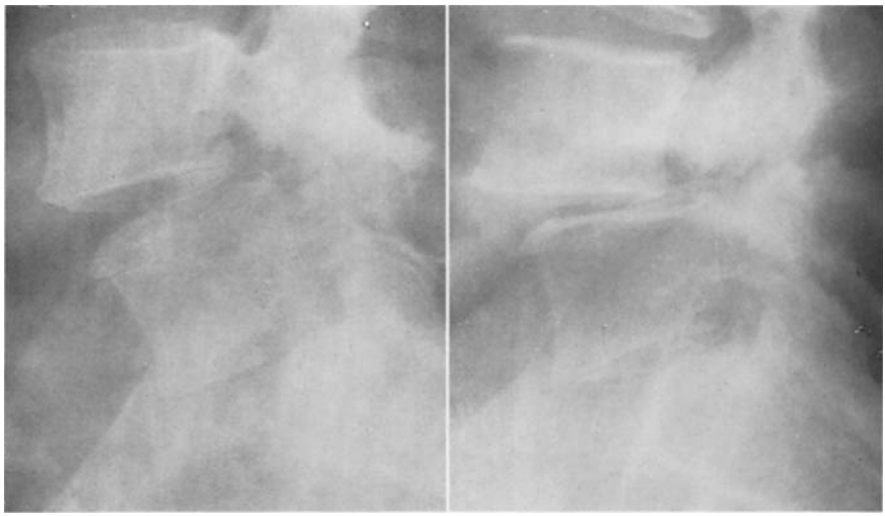


A B

Fig. 37. Case 48.

A: Roentgenogram nine months prior to the decompression operation in a forty-six year old female.

B: Roentgenogram thirty-two months after surgery shows no progression of displacement.

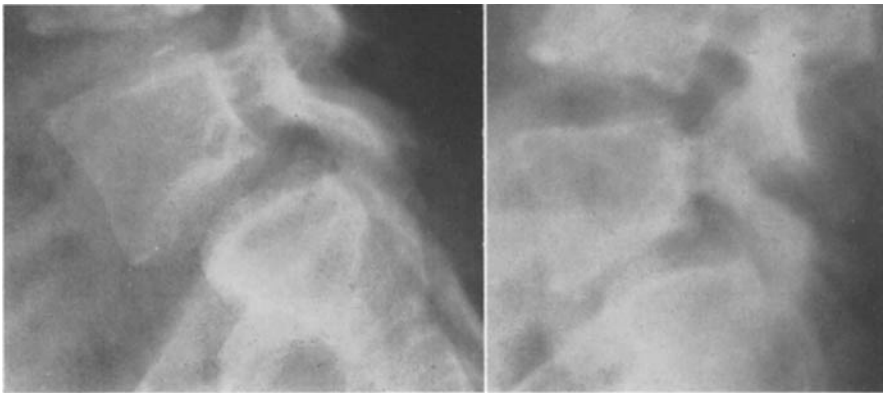


A B

Fig. 38. Case 49.

A: Roentgenogram immediately prior to the decompression operation in a forty-eight year old male. There is a first degree spondylolisthesis of the fourth lumbar vertebra. (The roentgenogram has been retouched.)

B: Roentgenogram ninety-six months following surgery shows a 7 per cent progression of displacement. (The roentgenogram has been retouched.)



A B

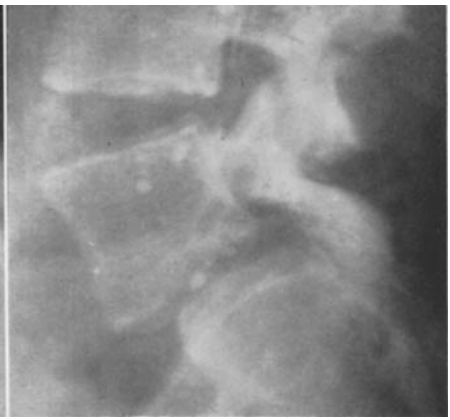
Fig. 39. Case 50.

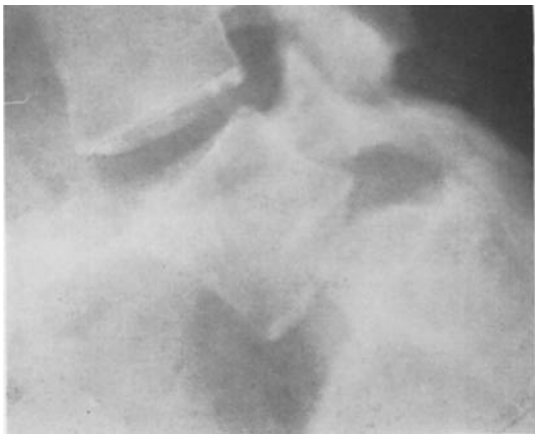
A: Roentgenogram thirteen months before the decompression operation in a girl who was fourteen years of age at the time of surgery. (The roentgenogram has been retouched.)

B: Roentgenogram two months before surgery shows no progression of displacement.

C

D





E

Fig. 39. Case 50.

C: Roentgenogram immediately following surgery shows some rocking forward of the body of the fifth lumbar vertebra but no actual progression of displacement by measurement. No defect was found in the fifth lumbar vertebra at surgery. A simple laminectomy was done, and the inferior facets were left intact.

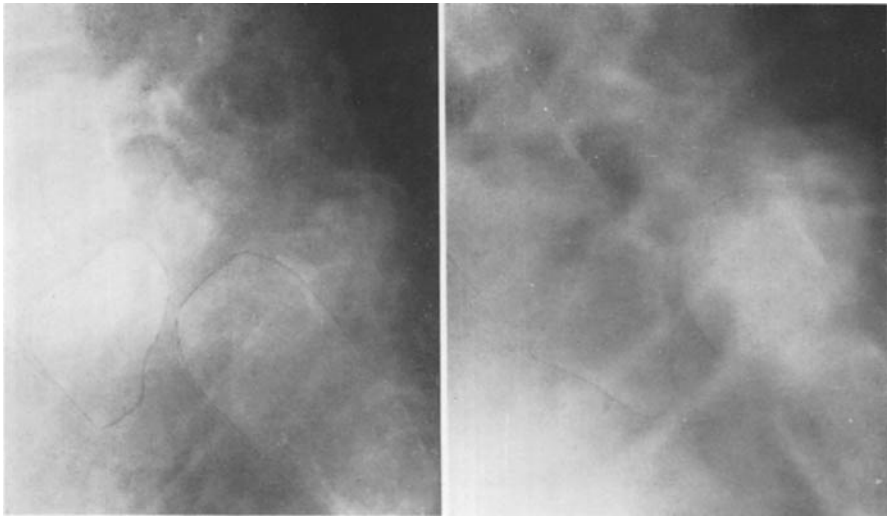
D: Roentgenogram nine months following surgery still shows no progression of displacement.

E: Roentgenogram twenty-four months after surgery shows a 22 per cent progression of displacement.

Fig. 40. Case 51. →

C: Roentgenogram two months prior to the decompression operation now shows a fourth degree spondylolisthesis of the fifth lumbar vertebra. (The roentgenogram has been retouched.)

D: Roentgenogram one month following the decompression operation. At surgery solid healing of the defect in the pars interarticularis on the left and spontaneous fusion of the inferior facets of the fifth lumbar vertebra to the superior facets of the sacrum bilaterally were found. (The roentgenogram has been retouched.)

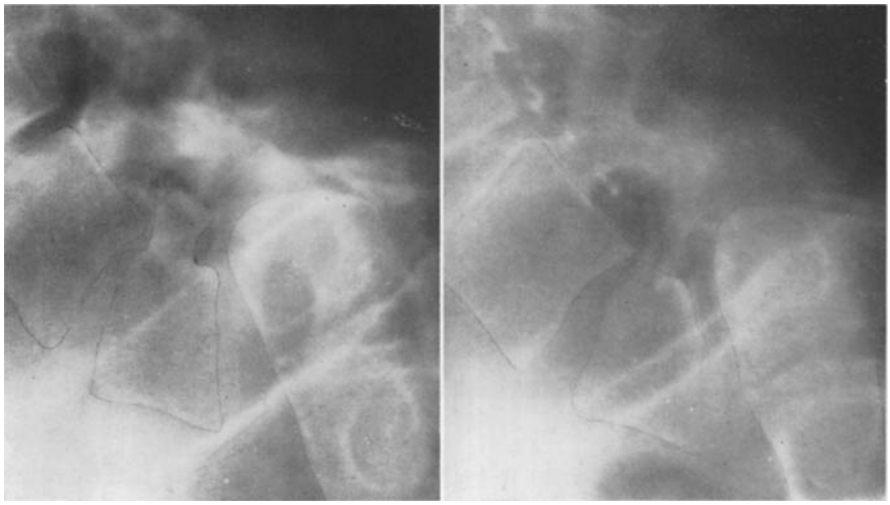


A B

Fig. 40. Case 51.

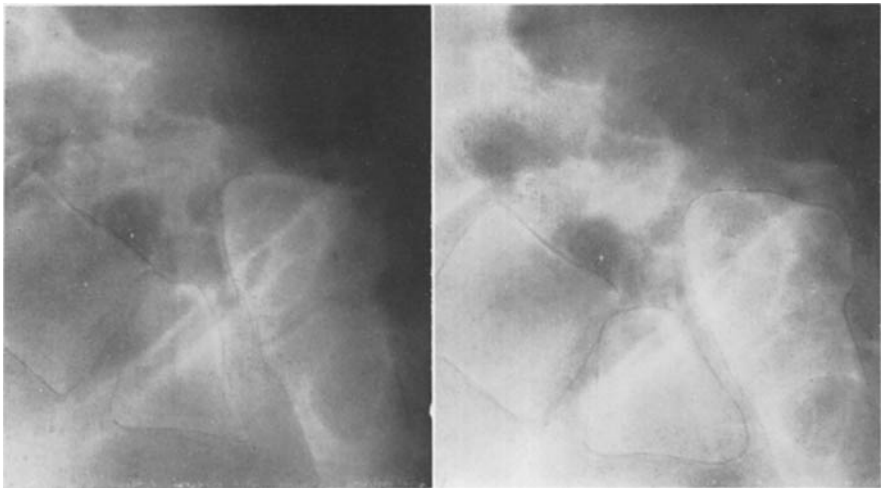
A: Roentgenogram twenty-six months before the decompression operation in a boy who was fourteen years of age at the time of surgery. (The roentgenogram has been retouched.)

B: Roentgenogram sixteen months prior to surgery shows continued progression of displacement. (The roentgenogram has been retouched.)



C D

Fig. 40. Case 51.

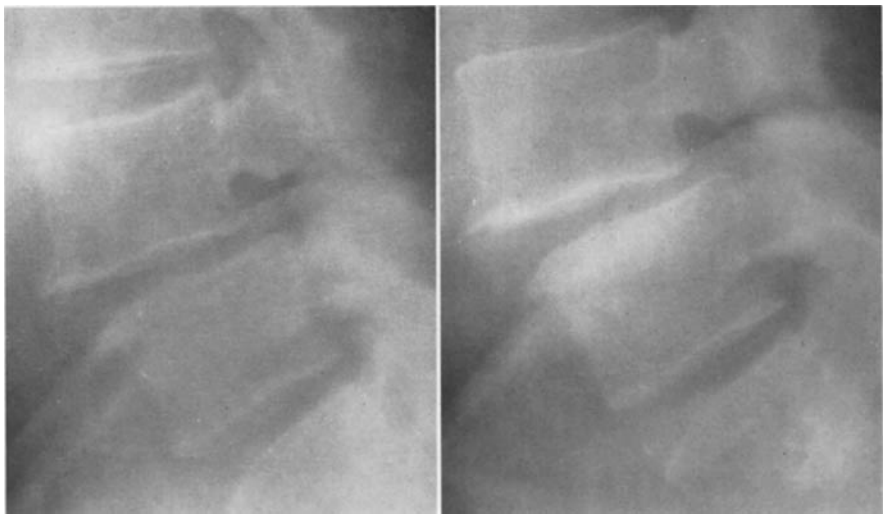


E F

Fig. 40. Case 51.

E: Roentgenogram eighteen months after surgery. (The roentgenogram has been retouched.)

F: Roentgenogram twenty-three months after surgery. (The roentgenogram has been retouched.)



A B

Fig. 41. Case 52.

A: Roentgenogram immediately prior to the decompression operation in a fifty-two year old male. There is a first degree spondylolisthesis of the fourth lumbar vertebra.

B: Roentgenogram four months following surgery shows no progression of displacement.

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