ANTERIOR INTERBODY FUSION OF THE LUMBAR SPINE
SIDNEY SACKS, JOHANNESBURG, SOUTH AFRICA

"Give me something different for there is a chance of it being better."—Codman.

Before 1948 there were only a few isolated reports of fusion of the lumbar vertebral bodies by an anterior transabdominal approach. Most of these reports dealt with patients suffering from tuberculosis or spondylolisthesis (Capener 1932, Burns 1933, Mercer 1936). None of them mentioned intervertebral disc degeneration as an indication for the operation.

Before 1938 Gjessing (1951) could find a description of only twelve cases in the literature in which this operation had been performed for spondylolisthesis. These included reports of one case by Burns (1933), one by Jenkins (1936), three by Mercer (1936) and one by Speed (1938). From 1938 to 1943 there were sporadic reports of this operation for spondylolisthesis by Friberg in 1939 with four cases, Chaklin in 1939 with sixteen, Henschen in 1942 with two, Brunner in 1942 with one and Ramser in 1942 also with one.

The first description of the operation of anterior disc excision and fusion of the vertebral bodies in the lumbar region by the transabdominal route, for conditions other than tuberculosis and spondylolisthesis, was by Lane and Moore in 1948. Their paper can be regarded as the first endeavour to popularise this procedure for symptoms caused by lumbar intervertebral disc degeneration. They reported thirty-six patients in whom they had inserted heterogenous bone between the denuded adjacent lumbar vertebral bodies and described the advantages of this operation over the usual posterior approach. In 1950 Harmon described a retroperitoneal transabdominal approach for cases of acute intervertebral disc prolapse caused by disc degeneration. He excised the disc and inserted tibial bone grafts with some cancellous chips. He reported thirty cases in 1950 and by 1960 he had operated on 244 patients for the same indication. He claimed adequate removal of posteriorly protruding fragments of disc through this anterior approach and relief of pressure on the nerve roots. Other authors who occasionally employed the anterior approach for intervertebral disc degeneration were Hult (1951), Hensell (1958), Humphries, Hawk and Berndt (1959) and Sibbrandij (1962). The numbers reported by these surgeons were small, the largest series being that of Humphries et al. who reported thirty-two cases in which they reinforced the bone graft with a special compression plate in front of the vertebral bodies.

Later reports of anterior fusion for spondylolisthesis included those by Merle d’Aubigné, Cauchoux and Faulong (1950), Merle d’Aubigné and Gérard (1959), Hult (1951), Gjessing (1951), Zaaijer (1952), Suermann (1953) and Ingebrigtsen (1953). These investigators also reported only small numbers of cases, the largest series being that of Merle d’Aubigné and Gérard (1959) with thirty-four cases.

It will be perceived that, apart from spondylolisthesis, very few authors have reported on anterior transabdominal interbody fusion for intervertebral disc degeneration. It was therefore decided to investigate the value of this procedure in patients with chronic disc lesions and to determine whether the anterior approach was justified.

In this paper are analysed the results in 150 patients operated upon by the author and his colleagues in Johannesburg over a period of five years. Up to the present this appears to be the largest series in which a transperitoneal approach for interbody fusion has been employed.
INDICATIONS

As already noted, this operation was first used in patients with spondylolisthesis or tuberculosis of the lumbo-sacral spine. Enthusiasm seemed to wax and wane, and analysis of these reports indicated that patients with severe spondylolisthesis did not always benefit from this operation.

The indications were not confined only to spondylolisthesis. In the small number of patients with this condition on whom the operation was done it was soon discovered that only those with a slight forward slip could be fused satisfactorily by the anterior approach. When the cephalad lumbar vertebra had slipped forward more than a third on the immediately adjacent caudad vertebra there was insufficient bony contact for the interbody graft to be successful.

The indications for operation in this series were symptoms caused by mechanical insufficiency of the lower lumbar spine, as follows: 1) Chronic intervertebral disc degeneration with or without nerve root compression; 2) spondylolisthesis (of the first degree only); 3) spondylolysis; 4) retrolisthesis or backward shift of a vertebral body; 5) congenital anomalies such as facet disturbances, transverso-sacral joints and transitional vertebrae; 6) instability from fractures or dislocations; 7) failure of previous posterior operations; and 8) chronic infections (pyogenic or tuberculous). The diagnosis of chronic intervertebral disc degeneration from acute disc prolapse is not always easy. Often the symptoms are different only in the degree of discomfort and pain, or in the relative severity of the pain in the back to the pain in the leg. Patients with chronic lumbar disc degeneration usually give a long history of recurrent attacks of backache between which there is partial or complete relief. The pain in the leg is not prominent at first but occurs later during an acute attack, nor is it as well localised as it is in those patients with an acute disc prolapse; often bilateral, it is usually slightly more severe in one or other leg; it is diffuse, it spreads into the buttocks, the groins, the back of the thighs but seldom radiates below the knees. The lower lumbar vertebrae are tender to heavy pressure but spinal percussion does not cause pain radiating to the legs. Often there is a history of a recurrent lumbar scoliosis or tilting of the trunk with or without severe backache or pain in the leg. Equally often the patient may mention visits to osteopaths with temporary relief of symptoms by manipulations. In assuming the erect position after bending forward—for instance over a wash basin—the patient nearly always feels discomfort in the lower back. Reflexes, sensation and motor power in the legs are mostly unaffected. Paraesthesiae are seldom present. Straight leg raising can be slightly limited but never so severely, or unilaterally, as in patients with an acute disc prolapse. Spinal movements between the acute attacks may be full in all directions, and they may be only slightly limited during an attack.

These features, together with radiographic evidence of diminished disc spaces at one or two lower lumbar levels and occasional marginal or facet osteophytosis with foraminal narrowing, help in making the correct diagnosis of chronic intervertebral disc degeneration. When this diagnosis is not clear-cut, and when doubt exists, the posterior approach is more suitable.

Early in this investigation patients with symptoms suggestive of an acute prolapsed disc were also operated upon by the anterior approach, but it was soon realised that complete removal of a posterior disc protrusion was not always possible. Posterior exploration in three patients later on revealed adhesions of the nerve roots which had not been relieved by the previous anterior exposure. It is considered, therefore, that when nerve root compression is the dominant symptom a posterior exposure is not only justified but is manifestly more reliable.

It must be emphasised that operations were only undertaken after other therapeutic measures had failed to produce symptomatic relief, and that, on the average, the symptoms before operation in these 150 patients had been present for six years. The average age of the patients was thirty-five years.
OPERATIVE PROCEDURE

It has been our experience that, in a procedure of this nature, the best results are obtained by teamwork. In most patients the abdominal incision and mobilisation of the bowel and great vessels were done by a general surgeon thoroughly experienced in vascular surgery. Apart from the many other obvious advantages, the orthopaedic surgeon is able to take and shape the bone grafts during this part of the operation. Undoubtedly the patients are benefited by the saving of time and the increased safety produced by this cooperation.

The day before the operation the patient is given a Dulcolax suppository to clear the lower bowel. Under general anaesthesia the patient is placed in a supine position on the operation table with the kidney or gall bladder rest under the fourth lumbar spine. The bladder is emptied by a catheter which is left in place until the end of the operation, the urine being allowed to drain into a cotton-wool pad in the perineum. The abdomen is opened through a left paramedian incision and the operation table is tilted into a Trendelenburg position. The small intestine and lower bowel are displaced upwards and to the side with three abdominal packs. The aortic bifurcation with the sacral promontory is then seen. An incision is made in the posterior peritoneum in the midline in front of these structures and the areolar subperitoneal tissue is carefully cleared with small gauze swabs to expose the intervertebral disc between the fifth lumbar and the sacrum. In this dissection the presacral nerves are carefully swept aside and not injured. The middle sacral vessels are ligated and cut (Fig. 1). Diathermy is not used here because of the danger of injuring the presacral nerves in the male. The anterior longitudinal ligament and anulus fibrosus in front of the lumbo-sacral joint are thus exposed. Specially designed spike retractors are inserted into the vertebral bodies to retract the aortic bifurcation and the common iliac vessels. The kidney rest of the operation table is elevated to increase the lumbar lordosis and to improve exposure of the intervertebral disc space. With a sharp scalpel on a long handle a flap of anulus hinged laterally to the left is raised to expose the interior of the intervertebral disc (Fig. 2). The disc material is removed in its entirety with straight nibblers or curved gouges and spoons, until the posterior longitudinal ligament becomes visible or palpable in the depths of the exposure.

![Figure 1](image1.png)  ![Figure 2](image2.png)

Figure 1—The posterior peritoneum has been incised at the aortic bifurcation and the presacral vessels have been ligated to expose the disc space between fifth lumbar vertebra and the sacrum. Figure 2—The spike retractors are in position, protecting the great vessels. A laterally hinged trapdoor incision in the anulus, which exposes the degenerated disc, is used to retract the left common iliac vessels.

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Figure 3
After the degenerated disc and end-plates of the vertebral bodies have been excised, three vertical pillar grafts, taken from iliac crest, are impacted into the empty disc space.

Figure 4
A diagram of the method of fusion. Figure 4 shows how the grafts are taken from the anterior iliac crest. Figure 5 shows their placement, looking down on the fusion, and Figure 6 shows the antero-posterior view.

During the operation, blood for transfusion is held in readiness in case a large vessel is torn. Usually the loss of blood is small and transfusion is not necessary. After the operation the patient is given two litres of 5 per cent glucose alternating with one litre of intravenous normal saline. This is continued until flatus is passed or bowel sounds are heard, to prevent the onset of ileus.
When awake the patient is placed in a semi-Fowler’s position. He is allowed to sit out of bed on the third day after operation and to walk on the fourth day and is discharged from hospital on the tenth to twelfth day after operation.

A back support such as a corset or brace is indicated only for patients with spondylolisthesis or with infection or when severe vertebral instability was encountered at operation. Only a small number of patients in this series were given plaster jackets, because it is not considered that the lower lumbar spine can be completely immobilised in this way. The introduction of a bone block between the vertebral bodies under compression provides sufficient stability without further support, but uncooperative patients who cannot be trusted not to strain their backs by bending, lifting or twisting in the period after operation can be protected by a spinal brace for three or four months.

If the operation has been done for pyogenic infection or tuberculosis the patient is kept in bed longer and given appropriate antibiotic treatment. Routine antibiotic administration is not encouraged.

If the third and fourth lumbar vertebrae need to be fused, the anterior approach is possible by extending the posterior peritoneal incision upwards and retracting the aorta and

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**Fig. 7** and **Fig. 8**
Antero-posterior (Fig. 7) and lateral (Fig. 8) radiographs of annular "biscuit"—or "bung"—grafts at the lumbo-sacral level.

**Fig. 9**
Figure 9 is a diagram, in the antero-posterior view, of a biscuit graft, and Figure 10 is a lateral view, showing two grafts in place. Figure 11 shows how the grafts are taken from the anterior part of the ilium.

**Fig. 10**

**Fig. 11**

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FIG. 12
A two-level interbody fusion done as a salvage procedure after a failed posterior fusion.

FIG. 13
Disc degeneration at the lumbo-sacral level after treatment by anterior interbody fusion. Figure 13—Antero-posterior radiograph. Figure 14—Lateral radiograph.
vena cava to the right side. This is made possible by finding a line of cleavage between the left psoas and the vertebral bodies, taking care to preserve the left sympathetic chain. Occasionally the left lumbar vessels coursing over the vertebral bodies may have to be ligated and cut, to facilitate the exposure.

An alternative method of bone grafting the lumbar vertebral bodies has been developed in South Africa and has since been reported by Harmon (1963). In this procedure the anterior annulus is excised and a circular excision of the disc and adjacent vertebral bodies is done with a brace and auger bit. This hole is usually seven-eighths to one inch in diameter and is finally plugged with two circular biscuit-shaped grafts, one to one and an eighth of an inch in diameter, taken from the full thickness of the ilium by means of a hole-cutting saw (Figs. 7 to 11).

LEVEL OF FUSION

Much has been written about the methods used to find the correct level of fusion for disc degeneration in the lumbar spine. Radiographs to show movement, myelographs, discographs, saline acceptance and many other investigations have all been described in detail. It is our view that, in experienced hands, a clinical examination and careful digital palpation of the disc at operation is just as effective—if not more so—as these exhaustive, and occasionally dangerous, investigations. It has been proved by anatomists and others that the two lower lumbar intervertebral discs are the levels affected by disc degeneration, with or without prolapse, in almost 95 per cent of patients. It might, therefore, be advisable to fuse those two levels in all manual labourers or in patients in whom doubt exists as to which of these two levels is at fault (Fig. 12). Only when the third lumbar disc is suspected are auxiliary diagnostic measures warranted. Myelographs of disc protrusion at this level are of doubtful value, but discographs or the saline acceptance test may also be helpful. In this series fusion was done at one level, mainly the fifth lumbar, in eighty-two patients (Figs. 13 and 14), at two levels, mainly the fourth and fifth lumbar, in fifty-eight patients, and at other levels in ten patients.

THE TYPE OF BONE GRAFT USED

Fresh autogenous iliac bone has been used mostly. Frozen homogenous bone taken from the ilium, tibia, fibula or patella has also been used. In one patient a fresh homograft was tried. Heterogenous beef bone, boiled for two hours, and preserved in ether was tried in a few patients (Table 1). In most patients cortical fragments plus cancellous chips or cortico-

<table>
<thead>
<tr>
<th>Type</th>
<th>Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Autogenous</td>
<td>86</td>
</tr>
<tr>
<td>Homogenous</td>
<td>34</td>
</tr>
<tr>
<td>Heterogenous</td>
<td>30</td>
</tr>
<tr>
<td>Total</td>
<td>150</td>
</tr>
</tbody>
</table>

cancellable blocks were used and in only a few patients did the graft consist entirely of cortical bone. Screw fixation across the graft was used sometimes, especially with spondylolisthesis (Figs. 15 to 18). Autogenous iliac bone gave the most satisfactory results.

COMPLICATIONS

In these days of advanced anaesthesia, increased competence in vascular surgery, improved surgical instruments, better facilities for care after operation, and readily available antibiotics,
the anterior exposure of the vertebral bodies by a transabdominal approach need not cause trepidation.

The complications that occurred in our series were wound haematomata in five patients (in the abdominal incision in one and in the iliac crest donor area in the other four), abdominal incisional hernia in one patient; non-fatal pulmonary emboli in two, deep vein thromboses of a leg in two, collapse of an osteoporotic vertebra in one, mild ileus in two, and difficulty of micturition for three or four days in two patients. Two men became sterile. There has been no death.
Most of the complications were in the same proportion as are found in other operations in the lower abdomen. It should be noted that no patient had a thrombosis of an iliac vein or of the vena cava.

Sterility, which occurred in two men, was probably caused by some interference with the presacral sympathetic nerve in the region of the aortic bifurcation. In patients done early in this series we used diathermy extensively to cauterise the middle sacral and other small bleeding vessels in front of the sacral promontory; since then we have avoided this, and careful soft-tissue dissection and precise ligation of vessels have been done instead. The mechanism by which interfering with the presacral sympathetic nerve causes sterility is most probably either because it is the motor nerve to the seminal vesicles or because it relaxes the internal bladder sphincter to allow a retrograde ejaculation. It must be emphasised that a dry ejaculation occurs and that the patients, although sterile, are still potent.

ASSESSMENT OF RESULTS

In assessing the results of interbody spine fusion by the anterior or posterior approach most authors have relied on radiological appearances of the grafted area. We believe that this is not an entirely satisfactory method, and that an accurate appraisal of successfully fused lumbar vertebrae can be made only by re-exploration of the fusion site. Since this is not feasible, our results have been assessed on the patient's subjective statements together with the surgeon's clinical examination. We realise the shortcomings of this system but, until a better method is devised, the risk of criticism will be accepted. It has been our experience that various experts viewing the same radiograph have often expressed different opinions as to whether solid fusion is or is not present (Fig. 19). Moreover, mobility radiographs of the lower lumbar spine are not always helpful because the condition for which the patient is being treated often causes some limitation of movement of the vertebral bodies in that region.
Our patients were, therefore, presented with a questionnaire in which the following questions were asked: 1) Did you experience: (a) 100 per cent relief of pain? (b) 75 per cent relief of pain? (c) 50 per cent relief of pain? (d) 0 per cent relief of pain? 2) Have you had recurrence of the pain? 3) Was further surgical treatment necessary? 4) Are you doing heavy work or light work or no work at all? 5) How long after the operation did your back first feel strong? 6) Do you still have back pain—Yes or No? 7) Do you still have pain in the leg—Yes or No? 8) Have you any complaints due to the operation which you did not have before?

**TABLE II**

**RESULTS OF ANTERIOR INTERBODY FUSION**

<table>
<thead>
<tr>
<th>Type of result</th>
<th>Number</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asymptomatic—complete relief of back and leg symptoms</td>
<td>39</td>
<td>26</td>
</tr>
<tr>
<td>Improved—occasional backache or ache in the leg or both</td>
<td>93</td>
<td>62</td>
</tr>
<tr>
<td>Unchanged</td>
<td>18</td>
<td>12</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>150</td>
<td>100</td>
</tr>
</tbody>
</table>

**TABLE III**

**DETAILS OF PATIENTS AND THEIR TREATMENT**

<table>
<thead>
<tr>
<th>Patients</th>
<th>Number</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Further spine operations after anterior fusion</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>Occupation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Manual</td>
<td>75</td>
<td>50</td>
</tr>
<tr>
<td>Sedentary</td>
<td>75</td>
<td>50</td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men</td>
<td>90</td>
<td>60</td>
</tr>
<tr>
<td>Women</td>
<td>60</td>
<td>40</td>
</tr>
<tr>
<td>Period of stay in bed and hospital</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average stay in bed</td>
<td>4 days</td>
<td></td>
</tr>
<tr>
<td>Average stay in hospital</td>
<td>12 days</td>
<td></td>
</tr>
<tr>
<td>Return to work</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sedentary</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average time of return to light work</td>
<td>3 weeks</td>
<td></td>
</tr>
<tr>
<td>Average time of return to full work</td>
<td>7 weeks</td>
<td></td>
</tr>
<tr>
<td>Manual</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average time of return to light work</td>
<td>6½ weeks</td>
<td></td>
</tr>
<tr>
<td>Average time of return to full work</td>
<td>12 weeks</td>
<td></td>
</tr>
</tbody>
</table>

Sixty per cent of the patients replied to this questionnaire. The remaining patients were examined clinically. It was found that several patients had complete relief of their symptoms despite the fact that the radiographs showed complete absorption of the graft (Fig. 20). It was presumed that fibrous union or a bony block was controlling the previous mechanical insufficiency. The results from this questionnaire and from the clinical examinations are shown in Table II.

**RESULTS**

Of the 150 patients in our series, thirty were prospective claimants for compensation either because they had had an injury at work or because of a motor vehicle accident. It is
of some interest that thirteen out of the eighteen patients whose symptoms remained unchanged after operation were in this compensation category. The other seventeen patients claiming compensation were classified as improved.

The other details of the patients and their treatment are given in Table III.

**DISCUSSION**

In discussing this operation it is pertinent to consider the advantages and disadvantages of this procedure.

**Advantages**—The anterior approach to the lesion allows the intervertebral disc degeneration to be attacked directly. The entire disc space is seen and the degenerated material removed. This prevents further disc protrusion at the operation site at some later date.

Only the vertebrae adjacent to the affected disc are fused; the vertebrae farther away are not fused as may often happen with the posterior approach. Because of this limitation, solid fusion is the more likely to occur.

The compression of the bone graft is aided by the erect posture of the patient who is ambulant soon after operation, thus producing a more rapid consolidation of the graft. With posterior interlaminar fusion the graft is under tension, or merely attached to the posterior vertebral appendages, and there are no beneficial effects of compression.

The operation may be used as a salvage procedure in patients who continue to suffer from symptoms after laminectomy or posterior fusion (Fig. 12). A second posterior approach may fail because of the fibrosis of muscles and ligaments from the previous operation, as well as the scarring and avascularity of the laminae and spinous processes. Under the same circumstances the anterior approach offers fresh broad bony surfaces between the vertebral bodies with an increased chance of successful bony fusion.

There is less haemorrhage; there is no interference with posterior structures such as muscles, nerves, ligaments and articular facets; convalescence is rapid and there is an early return to work.

Even if bony fusion is not achieved, the symptoms are often permanently relieved because the cortical portion of the graft between the vertebral bodies acts as a bone block under compression or in the manner of a ball bearing or rocker in place of the removed disc. This accounts for the relief of symptoms in those patients in whom the radiographs showed non-union.

A final advantage of the anterior fusion is that, if non-union of the graft persists and if the symptoms are not relieved, posterior interlaminar fusion can still be performed through vascular and uninjured muscles and ligaments, and on fresh and unspoilt laminae and spinous processes.

**Disadvantages**—Anterior interbody fusion is not to be undertaken lightly without adequate facilities or instruments, nor by a surgeon inexperienced in abdominal and vascular surgery. Adhesions from previous laparotomies, anomalies of aorta or vena cava and the presence of other intra-abdominal conditions may present difficult problems to the inexperienced operator.

In a man there is the possibility of producing sterility by interference with the presacral nerve. In women this danger does not exist and a presacral neurectomy may even be beneficial.

From the anterior approach it is not possible adequately to see posteriorly protruding fragments of disc material, adhesions around nerve roots, osteophytes surrounding facet joints, or other spinal lesions including tumours. Despite the fact that some surgeons consider the anterior approach ideal for patients with sciatica caused by an acute disc prolapse, here it is not considered possible that all loose fragments can be removed satisfactorily, especially if the disc is herniated or sequestrated. It may be argued that anterior decompression of the disc space will relieve pressure on remaining posterior fragments which are impinging on nerve
roots. It may also be claimed that the incidence of constricted or sequestrated discs is very low, but it is the view here that these successful results must be considered to be fortuitous—because the procedure is not based on the fundamentally sound surgical principle of the surgeon being able to see what he is doing.

In spondylolisthesis the anterior operation has many dangers because the condition is sometimes associated with vascular anomalies at the aortic bifurcation. Furthermore, spondylolisthesis of more than one-third slip does not offer sufficient bony contact for the bone graft; cases with less than this can be fused satisfactorily (Figs. 21 and 22). Also an acute lumbo-sacral angle is an unfavourable factor.

**FIG. 21**
Spondylolisthesis before operation (Fig. 21) and (Fig. 22) after anterior interbody fusion.

**SUMMARY AND CONCLUSIONS**

1. At the present stage of our experience, when 150 patients have been analysed over a period of five years, the conclusion has been reached that anterior interbody fusion in the lower lumbar spine is a procedure which should be added to our surgical armamentarium for use in selected cases.
2. Patients suffering from chronic intervertebral disc degeneration whose main symptoms are recurrent incapacitating backache derive the most benefit from this procedure.
3. When used as a salvage operation in patients who have had previous unsuccessful laminectomy or posterior fusion, good results can be expected.
4. In patients with spondylolisthesis anterior interbody fusion should be confined to cases in which the vertebral bodies have not slipped forward more than one-third.

I wish to express my gratitude to my colleagues, Mr G. T. du Toit and Mr D. Roux, for their assistance and for allowing me access to their patients and their files. Particular thanks are due to Mr L. Stein, the Vascular Surgeon, for his expert handling of the abdominal approach. For the photographs I wish to thank Mr A. M. Schewitz of the Medical Photography Department of the University of Witwatersrand.

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