LUMBO-SACRAL INTER-BODY SPINAL FUSION

G. F. DOMMISSE, PRETORIA, SOUTH AFRICA

During the years from 1948 to 1956 a lumbo-sacral inter-body spinal fusion was done on forty-eight patients through a posterior approach. The operations have been divided chronologically into three groups. Improvements in the surgical technique were added in the two later groups, so that ultimately a new operative procedure was evolved and used in the last group, which gave the highest rate of bony fusion.

In this new operation the lumbo-sacral intervertebral disc is approached through the lateral mass of the sacrum, which gives a good exposure through which to perform the inter-body fusion. It must be emphasised that this operation was developed not only from the personal experience of the author but also from reports and advice from other workers such as James and Nisbet (1953), Cloward (1953), du Toit (1955), du Toit, Dommiss and Muller (1956) and du Toit (1957).

PRINCIPLES OF THE OPERATION

Through a mid-line incision, extended distally as far as the third or fourth sacral spinous process, the sacro-spinalis muscle mass is exposed and retracted laterally on each side; the laminae and paravertebral joints are exposed by cleaning off all muscle and fascia.

Figure 1 is a diagram of the operation: for clarity it shows the graft on one side only. Both sides must be grafted for a successful fusion, which involves only the two adjacent vertebrae. Since the grafts are horizontal they are compressed by the vertical thrust of the body weight, and shearing strain is eliminated (Fig. 2).

The shearing angle at the lumbo-sacral level, which is increased in spondylolisthesis, can be reduced only if the bed for the graft is cut horizontally, as shown in Figure 2, to pass obliquely through the intervertebral disc.
Shearing strain is thought to have been the most important factor in causing the complete absorption of the grafts in the past, a phenomenon that has probably been observed by other workers in this field.

The graft must have the greatest possible contact with the graft bed and this is an important detail in helping to ensure fusion (Fig. 3). Each graft has a surface area of about half a square inch, whereas that of a vertebral body is two to three square inches. When the graft is deeply countersunk, as shown in Figure 4, the sides form additional contact surfaces and double the contact area between the graft and the bed.

It is necessary to insert the two grafts in an antero-medial direction, so that they converge towards the centre of the anterior surface of the vertebral body. This not only assures the greatest penetration of the bodies by the grafts, but also eliminates the risk of perforating the visceral cavity or injuring the great vessels. The grafts, being locked together in the form of an inverted V in the deep grooves in which they lie, are secure against shift and shear in both horizontal and perpendicular planes.
OPERATIVE TECHNIQUE

1. The general anaesthetic is chosen with care and, to prevent accumulation, a carbon dioxide absorber is used. The patient is placed prone on a Wilson frame in such a position to lessen pressure on the thoracic and abdominal viscera and so diminish bleeding. A blood transfusion, usually of two to three pints, is given routinely during the operation.

2. Through a posterior mid-line incision the laminae and articular facets in the lumbo-sacral region are bared and the first sacral nerve root is exposed by excision of the inferior articular facets and the distal half of the lamina of the fifth lumbar vertebra as well as the proximal quarter of an inch of the first sacral lamina on each side.

3. The fifth lumbar nerve roots are exposed in the intervertebral foramina by removing all, or as much as necessary, of the superior articular facets of the first part of the sacrum. Great importance is laid on the very wide exposure of the nerve roots (Fig. 5), and this is the key to a successful operation.

4. The superior surface of the lateral mass and body of the sacrum is channelled (Fig. 6) in an antero-medial direction obliquely between the exposed nerve roots.

5. The intervertebral disc is undermined and the deep grooves are completed in the adjacent surfaces of the first sacral and fifth lumbar vertebrae, which now form the box-shaped beds for the bone grafts (Fig. 7). Special instruments have been made for this step in the operation, and the du Toit box-shaped osteotome is used as a starter (Fig. 8). Curved U-shaped osteotomes are used to finish cutting the graft beds (Fig. 9). They are designed to accommodate the posterior iliac crest and the sacro-spinalis muscle mass so that they can be inserted in the antero-medial direction as shown in Figure 3. A complementary pair of these instruments is needed for the upper and lower surfaces of the bed for the graft. The smooth sides of a special bone graft introducer (Fig. 10) prevent the rough edges of the graft from catching and damaging the delicate tissues around the graft bed.

6. Two grafts, either homogenous or autogenous, and usually from the iliac crest, are prepared to fit accurately into their respective beds.

7. With the spine slightly flexed the grafts are hammered firmly into position, and it is necessary to ensure that impaction of the second graft does not cause retropulsion of the first.
Careful adjustment of the direction in which the bed for the second graft is cut eliminates this small difficulty.

8. Both grafts are made so that they are countersunk below the level of the posterior surfaces of the vertebral bodies; the spine is then extended. This causes firm compression of the grafts. It is of interest that slight retropulsion of the grafts may be seen if the spine is
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flexed at this stage, emphasising the importance of avoiding flexion in the post-operative period.
9. Two weeks after operation a short single plaster hip spica is applied to prevent flexion at the lumbo-sacral angle. The patient is kept in bed for three months.

RESULTS
Of the thirty-two patients who had homogenous bone grafts foreign body reaction, with fibrous tissue barrier formation, was seen in nine (28 per cent). This barrier may develop between the whole or only a part of the graft and the host; this has not been observed in any of the sixteen patients who had autogenous grafts, and the speed of incorporation of the latter was also considerably faster than that of the homogenous grafts.

TABLE I
RESULTS IN PRESENT SERIES

<table>
<thead>
<tr>
<th>Clinical assessment</th>
<th>Number of patients</th>
<th>Per cent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good and good</td>
<td>39</td>
<td>81</td>
</tr>
<tr>
<td>Improved</td>
<td>5</td>
<td>11</td>
</tr>
<tr>
<td>No change</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Worse</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Untraced</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>48</td>
<td>100</td>
</tr>
</tbody>
</table>

Radiological assessment

| Fusion present               | 24                 | 50       |
| Fusion absent                | 20                 | 42       |
| Undetermined                | 4                  | 8        |
| Total                       | 48                 | 100      |

The results in this series are shown in Table I. The results of other workers are summarised in Table II. This shows that good clinical results were obtained in over 74 per cent (and in one series in 100 per cent) but that fusion occurred in as little as 1-5 per cent in one series and as many as 98-5 per cent in another. Variations in operative technique render further comparison of little value.

TABLE II
RESULTS IN PUBLISHED SERIES

<table>
<thead>
<tr>
<th>Author</th>
<th>Jaslow 1946</th>
<th>Cloward 1953</th>
<th>Adkins 1955</th>
<th>Nisbet and James 1956</th>
<th>Wiltberger 1957</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of patients</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bony union</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>?</td>
<td>315</td>
<td>1</td>
<td>8</td>
<td>40</td>
</tr>
<tr>
<td>Per cent</td>
<td>?</td>
<td>98</td>
<td>1-5</td>
<td>42</td>
<td>87</td>
</tr>
<tr>
<td>Clinically cured or improved per cent</td>
<td>100</td>
<td>85</td>
<td>approx. 77</td>
<td>74</td>
<td>87</td>
</tr>
</tbody>
</table>

Of the forty-eight patients in the series twenty-nine were men and nineteen were women. Thirty-five patients had spondylolisthesis or spondylolysis and the remainder suffered from spinal instability either associated with disc lesions or following unsuccessful disc surgery.

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The average age was thirty-five; the youngest patient was fifteen and the oldest fifty years of age. There was no selection: all patients subjected to this type of operation during the period under review are included. The longest follow-up is nearly ten years, the shortest seventeen months and the average is exactly four years.

Figure 11—Successful inter-body fusion clearly shown on an antero-posterior film. Figure 12—An unsuccessful inter-body fusion which clearly shows the pseudarthrosis.

The pre-operative radiograph of a patient with spondylolisthesis. The defect in the pars interarticularis shows well.

It must be emphasised that the 42 per cent of unsuccessful fusions included the early failures, and the percentage of successful fusions increased to 76 per cent in the final group of twenty-four patients.
FIG. 14
The same patient as in the last illustration ten months after fusion. Some change can be seen in the defect in the pars interarticularis.

FIG. 15
The same patient as in Figure 14. The defect in the pars interarticularis appears ossified, and sound inter-body fusion is present.

DISCUSSION
Adkins, in 1955, believed that "some intrinsic factor peculiar to the vertebral bodies" militates against successful inter-body fusion. This has not been my experience, for bony union between vertebral bodies has been seen after fractures, after sepsis following removal of a disc and after inter-body grafting.

The assessment of bony fusion has been based on radiological appearances which,
although difficult and inaccurate, must suffice for lack of a better method. There was, however, one patient in whom the opportunity occurred of doing a biopsy on the site of a graft performed ten months earlier. In this patient radiological assessment showed a failure of union; yet microscopical examination revealed evidence of sound fusion and of the presence of living bone indistinguishable from the host bone. Radiological examination after a further ten months corroborated these findings.

The success of spinal fusion is best shown radiologically in antero-posterior views and in lateral views in flexion and extension. Absorption of the grafts and replacement by visible new bone, the absence of encapsulation or sequestration of the grafts, and failure to demonstrate mobility on flexion and extension of the spine are the most important radiological features, all of which must be present before a successful fusion may be claimed. The appearance of a successful fusion is shown in Figure 11.

Failure of spinal fusion is much more easily recognised, and in some of the patients under review there has been complete absorption of the grafts. In others the grafts have become encapsulated and have remained unchanged, without improvement of the spinal instability. In yet other patients a pseudarthrosis has developed which is easily recognised radiologically (Fig. 12).

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Figure 16—This professional wrestling champion (on top in this picture) had an inter-body fusion nine years previously. Figure 17—Building his own house, this man is lifting a concrete block weighing 67 pounds five years after his inter-body fusion. Figure 18—This patient can "touch his toes backwards" five years after the operation.

The progressive ossification of the defect in the pars interarticularis in three patients with spondylolisthesis has recently, and quite unexpectedly, been suggested in the radiographs taken at intervals after operation. In none of the three was the pars interarticularis disturbed at operation, which resulted in bony fusion in each patient. Figures 13 to 15 show the radiological changes in one of these patients.

Although healing of the defect in the pars interarticularis does not seem to have been described before it would be premature to comment on the significance of these findings, but a similar ossification was not seen when the inter-body fusion failed. Perhaps the defect in the pars, if it is in the nature of a stress fracture, might be capable of healing when the strain is removed.
Complications—The complications that occurred in this series were: 1) Fusion failed to occur in twenty patients (42 per cent), but the incidence of failure dropped to 26 per cent in the final group. 2) Retropulsion of the grafts occurred in three patients (6 per cent). 3) Foot drop occurred in two patients (4 per cent). The cause of this is not clear, but it was seen only when a revision operation was performed for failure of fusion or some other complication; there is some evidence that a segmental thrombosis of the spinal vessels occurred after the second operation, and this is supported by the permanent nature of the lesion. 4) Sepsis occurred in only one patient and has proved intractable. This patient is one of the two mentioned with a permanent foot-drop. 5) A pulmonary embolus occurred in one patient and a venous thrombosis in another, but both made a complete recovery. Transitory bowel and bladder complications occurred frequently. There were no deaths in the series.

CONCLUSIONS

This review shows that inter-body spinal fusion can be achieved in a satisfying percentage of cases, and the assertion that there is an intrinsic factor peculiar to the vertebral bodies which prevents such a fusion cannot be supported. The operation has a limited but definite place in the field of spinal surgery, and should be reserved for those patients with spinal instability associated with intractable and persistent backache. Spondylolisthesis is the indication par excellence. A new operative technique, which has been developed during ten years, has become standardised. The trans-sacral approach provides a better and safer exposure than those described before. In the event of failure of inter-body fusion, it is suggested that further attempts at grafting should be restricted to one of the posterior methods which have a 75 per cent chance of producing successful bony fusion.

Clinical photographs are reproduced in Figures 16 to 18 to show that patients suffering from a painful spondylolisthesis may be restored to normal activity by this operation.

I wish to thank Mr G. T. du Toit for his great help and Mr J. G. du Toit for special instruments; Drs F. W. McLachlan, A. V. B. Smith and A. C. Macdonald for their untiring co-operation in obtaining radiographs; Professor C. J. N. Loubser for his assistance; and Professor J. F. Barnetson and Mr J. G. de Swardt for their advice on pathological examinations.

REFERENCES

DU TOIT, G. T. (1957): Personal communication.