A MORTISED TRANSFACET BONE BLOCK FOR LUMBOSACRAL FUSION *

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For many years the orthopaedic surgeon has performed fusion as a dependable method of treating intractable low-back pain. Attention was sharply focused on the importance of the lumbosacral region through the discovery of the herniated intervertebral-disc syndrome by Mixter and Barr. It has now become necessary to re-evaluate the indications for lumbosacral fusion and to re-determine the end results.

The exceedingly prompt relief from acute pain obtained by operation for a herniated disc did not mask for long the fact that the pathological manifestations associated with herniation of the intervertebral disc are fundamentally structural deficiencies and only secondarily neurological entities. A more appropriate term would be "disc disease". Because the neurological phenomena are more obvious, a tendency exists to ascribe all low-back symptoms to the disc. Removal of the disc only has received too much credit, as stressed by Farrell and MacCracken. At present the literature contains many analyses of results of disc operations, with little or no consideration being given to the mechanics of associated structural disorders. It is the author's practice to expose freely and to investigate the posterior facets and foramina, bilaterally, in all disc operations. In 100 cases in which the facets and laminae on both sides were exposed at the time of disc operation, 46 per cent. showed mild structural deficiency and 35 per cent. showed marked pathological changes, such as telescoping of facets due to settling down of the intervertebral space, unexpected anomalies, senescent or osteo-arthritis changes, and obstructions along the course of the nerve roots. A large proportion of these abnormalities are missed if the roentgenogram alone is depended upon to reveal them.

The favorable end results in patients with disc lesions of long standing which have not been operated upon, and also in many cases in which operation has been done but not fusion, are probably due to stabilization from fibrous ankylosis. Slow, gradual narrowing of the intervertebral space is apt to follow removal of the disc. If this fibrous-tissue stabilization gives way, low-back pain may return. Bony fusion is the only way to counteract the predisposition of the lumbosacral structures toward progressive degenerative changes.

THE PRINCIPLE OF FUSION

Present Status of Opinion as to Value

Many variations and conflicting opinions exist concerning the advisability of fusion in the lumbosacral region. Briefly, the following assertions may be made:

1. Stabilization by fusion of the structurally affected lumbosacral joint is a sound, dependable procedure. It still may be said that a well-fused joint ceases to be painful. However, fusion is not a substitute for removal of the herniated disc or other source of nerve-root irritation.

2. Surgical intervention for the relief of pain due to posterior herniation of disc tissue has focused attention upon the frequency of a specific lesion in the lumbosacral region.

3. Whether or not to fuse in cases of herniation of the disc is debatable. Although enthusiasm for removal of the herniated disc has temporarily overshadowed the importance of structural disorders, fusion to prevent residual symptoms or relapse is justified to an extent greater than the neurological findings alone would indicate.

4. The numerous variations in technique of fusion operations in the lumbosacral region indicate dissatisfaction with results. Statistics have revealed a higher percentage of relapse with pseudarthrosis than is generally realized.

5. Little new has been added to the technique of surgical fusion. Many methods have been described, but practically all are based upon the original method of Hibbs or Albee.

6. Interbody fusion by bone blocks in the intervertebral space, by either the abdominal or laminal approach, has been tried by Lane and Moore with some favorable results.

7. One new principle which has gradually gained recognition is that of distraction by propping apart the laminae or spinous processes to lessen foraminal impingement and to give immediate interlaminal support and stabilization.

8. Long periods of plaster-cast immobilization or bed confinement are being avoided.

9. A quick method of immobilization by transfixion screws in the facets, as recommended by King and others, is being tried. The reports are not convincing.

10. Metallic fixation by plating or wiring has been used in conjunction with bone transplants.

11. Iliac bone is rapidly replacing tibial bone, when transplants are used.

Recent Concept

In the light of present knowledge, surgical procedures in the lumbosacral region must be carried out with more specific intentions. Arthrodesis is not a substitute for removal of a herniated disc; but, if all local pathological factors are investigated, more fusions will be done supplemental to removal of a disc. More consideration is now given the taut stationary nerve roots. These nerve cables are threaded through passageways that might require bone decompression. If the smooth gliding surfaces of these nerve trunks are compressed or bound by adhesions, they will not respond to vertebral reactions from body shock, stress, or strain, even after fusion has been established. The great majority of end results following simple removal of the disc may be classified as good; but, in a joint defective enough to cause extrusion of a disc, further degenerative changes can develop. In this respect the situation is not unlike that found in inguinal hernia. One certainly would not remove the sac without carrying out the reparative procedure.

Improved Technique

Time has proved that successful fusion in the lumbosacral region depends greatly upon good engineering. The conventional bone-chip method of Hibbs or the bone-transplant method of Albee is more adaptable to the thoracic spine in children, for which these methods were originally recommended. Even though extremely heavy grafts and extensive bone chipping, of mutilating proportions in some cases, have been applied with many variations, absorption, followed by pseudarthrosis of the supposedly fused lumbar areas, has too often been the result. In a recent study, Cleveland, Bosworth, and Thompson have noted an incidence of pseudarthrosis as high as 20 per cent. in 647 fusions over a period of twenty years. This included all fusions extending from the third or fourth lumbar segment to the sacrum. In the lumbosacral joint, the incidence of pseudarthrosis was 3.4 per cent. This should be a stimulus for others to compare their end results and to seek improved methods.

The improvements needed in fusion of the lumbosacral area might be summarized as follows:
1. A more certain method of fusion, especially above the fifth lumbar body;
2. Development of a method providing earlier mobilization after operation;
3. Simplification of the technique of fusion and lessening of the time and risk when this procedure is done after a disc operation.

Principle of Interlaminal Distraction

The innovation of interlaminal distraction to decrease intraforaminal compression has proved valuable. It is usually accomplished by propping apart the spinous processes.
In many cases the collapse of the intervertebral space is found to have caused telescoping of the facets, to the extent that the inferior borders of the inferior articular processes rest on the adjacent laminae.

Williams first recognized the principle of distraction in his "conservative treatment" of lumbosacral disabilities, by maintaining a posture of flexion to correct the intervertebral subluxation and the narrowing of the foramina. Breck and Basom introduced the concept of maintaining fixed surgical distraction through the use of interspinous bone blocks. Gibson devised the clothespin or fish-tail graft; Bosworth used a similar graft to lock the spinous processes in distraction. Moore has termed still another similar procedure the self-locking graft.

**THE MORTISED TRANSFACET BONE BLOCK**

It is frequently stated that fusion would be done more often after disc operations if a simpler method were available. The procedure described here is suggested with the aim of simplicity.

The most strategic point for elimination of intervertebral motion is at the facet articulations, as stressed by Meyerding. Their surfaces are comparatively large and the center of gravity is more nearly at this point. The articular processes are strong and sturdy enough to provide an excavated bed and abutments for the firm implantation of a substantial block of bone. When accurately countersunk across the facets (Figs. 1-A and 1-B), such a graft will render immediate support and stabilization, and will eventually produce an interlocking bony fusion. An operative technique devised for such a mechanical objective has been employed in 135 cases with gratifying results.

**Technique**

The patient lies prone on an especially devised convex frame (Fig. 3); two padded saddle bars support each side of the pelvis, leaving the abdomen free from pressure. The spinous processes and laminae on both sides are thoroughly denuded and the soft tissues are widely retracted, to permit free visualization of the facet articulations of the involved region.

Attention is directed to a small but definite anatomical structure, not described in the anatomy texts, consisting of a ball of fat that fills the interlaminar fossa. It borders the ligamentum flavum medially and is attached laterally to the fascia over the facet, to
receive a small terminal artery and nerve from the lateral margin of the superior articular process of the vertebra below. No doubt this is the cause of the troublesome bleeding which Hibbs originally mentioned in describing his fusion operation. It is of advantage to coagulate this vessel and to remove the entire fat pad before removal of the ligamentum flavum.

If the disc is to be explored, this part of the operation is completed prior to the fusion. Whether the disc operation is done or not, the ligamentum flavum and all fibrous tissue are thoroughly cleaned from the bone. Spreaders are then applied between the spinous processes to correct any telescoping of the facets that may have occurred from collapse of the intervertebral space.

A rectangular excavation is made lengthwise in the articular processes, crossing the facets above and extending into the laminae below. The excavation should be about one-fourth to three-eighths of an inch wide, one-eighth to three-sixteenths of an inch deep, and from one-half to three-quarters of an inch in length. The upper end should be so located as to include about equal parts of the articular processes. A right-angled osteotome, with each blade one-quarter of an inch wide, is used to make square corners, although an ordinary thin osteotome, one-quarter-inch wide, may be employed. Starting at a point about three-sixteenths to one-quarter of an inch above the inferior border of the facets, the first cut is made into the articular processes until the osteotome extends through the facet of the inferior articular process of the vertebra above. The lateral margins are then cut and accurately squared. The upper end of the excavation is undermined and all cartilage surfaces are removed. Care should be used not to break the outer ledge of the superior articular process of the lower lumbar vertebrae. Likewise, it is important to have a substantial medial wall to the excavation; otherwise the graft will shift sidewise.
The lower end of the excavation is located on the lamina below, about one-half inch lateral to the base of the spinous process. The depth may be from one-eighth to three-sixteenths of an inch, but caution should be used not to penetrate the wall of the neural canal. The floor of the excavation, which consists largely of the articular facet of the superior process of the lower vertebra, is leveled by a thin, quarter-inch osteotome, slightly curved on the tip. The upper and lower ends of the excavation are undercut to the extent that a beveled bone block, about three-sixteenths of an inch thick, can be countersunk in dovetailed fashion to lock the graft into the depth of the cavity as the interlaminal spreaders are removed. Additional bone chips may be wedged about the articulations, or other additions may be made as desired. The bone-block grafts are taken preferably from the spinous processes; each process will furnish material for two blocks. The prominence at the posterior spine of the ilium may be used if thicker, heavier bone is desired. Two qualifications are necessary for the bone blocks:

1. They must be long enough to be wedged firmly in place by the driving force of a carpenter's punch.

2. They must be strong enough to withstand the pressure when the distraction force between the vertebrae is released.

To wedge the graft into the excavation, the interlaminal spreaders are applied. The upper end of the block is first pressed into place. Then with a punch, the other end is tapped firmly and impacted into position. The transfacet bone blocks are wedged into place on each side before the distraction produced by the spreaders is removed or changed. If the graft is not impacted firmly and does not lock in place, it should be removed and made to fit more accurately. When the spreaders have been removed, the grafts are tested for firm impaction and the wound is closed, after the operator has made certain that all blood
oozing has stopped. The patient is placed in bed on his back with no external immobilization.

In spondylolisthesis, the cartilaginous material in the pars interarticularis is removed thoroughly, and the bone block is made long enough to insert well into the cavity. The laminae are left intact. Immediate immobilization is the result. Additional bone chips and grafts may be used if further assurance of fusion is necessary.

In four cases of spondylolisthesis, the blocks have been applied on the concave side for correction of the curve. With one-quarter inch of spread on eight interlaminal spaces, a positive correction of two inches is obtained.

The patient is allowed bathroom privileges on the tenth or twelfth day. On the fourteenth day, a model is made for a low-back corset type of brace, and a plaster jacket is applied. This jacket is exchanged for the brace about the fortieth day after the operation, when light work is permitted. Hard manual labor, such as riding a tractor or heavy lifting, is not permitted for four months. A number of patients have disobeyed this rule, however, with no apparent harm.

RESULTS

In the 135 cases in which fusion was achieved by this method, there have been no deaths or serious complications. Abdominal distress, mild or severe, has occurred occasionally, and catheterization has been necessary for the first day or two after operation in about 20 per cent. of the cases. Most of these complications occurred when the fourth and fifth lumbar interspaces, as well as the lumbosacral joints, were fused. Most patients

![Fig. 5-A](image1)

Biplane roentgenograms following transfacet bone-block fusion of the fourth and fifth lumbar vertebrae.

Fig. 5-A: Forced flexion.

![Fig. 5-B](image2)

Fig. 5-B: Forced extension.
TABLE I

EVIDENCE OF PSEUDARTHROSIS IN FORTY-ONE CASES, AS DETERMINED BY ROENTGENOGRAMS IN FORCED LATERAL AND FORWARD BENDING, TAKEN AFTER SIX MONTHS TO TWO YEARS

<table>
<thead>
<tr>
<th>Diagnosis</th>
<th>No. of Cases</th>
<th>Area Fused</th>
<th>Cases Showing Possible Pseudarthrosis by X-ray</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fifth Lumbar and First Sacral Only</td>
<td>Fourth and Fifth Lumbar and First Sacral</td>
</tr>
<tr>
<td>Herniated disc</td>
<td>31</td>
<td>15</td>
<td>16</td>
</tr>
<tr>
<td>Spondylolisthesis</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Collapsed narrow joint</td>
<td>2</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>Other anomaly</td>
<td>2</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>Osteo-arthritis</td>
<td>3</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Totals</td>
<td>41</td>
<td>17</td>
<td>24</td>
</tr>
</tbody>
</table>

experience a sense of stability by the third or fourth day. Undue pain following operation is rare; but, when it does occur, it is usually due to a hematoma. In no case could it be determined that the nerve was affected by the excavation into the articular processes or by the trauma of inserting the bone block.

In one case, recurrence of symptoms was sufficiently severe to justify reoperation. The lower margins of the bone block were fused; the upper margins were not. Various methods have been tried to demonstrate more clearly whether or not fusion takes place. Tantalum wire was passed tightly around the edges of the bone block in a few cases, and the ends were fastened by twisting. The wire localized the bone block in the postoperative roentgenograms (Fig. 4). Otherwise the graft is not discernible, even in an oblique view.

Seventy-four cases were followed by roentgenograms taken with the patient in forced anteroposterior bending, a method described by Gianturco. Since Cleveland, Bosworth, and Thompson described their "biplane roentgenographic test", follow-up roentgenograms have been taken in both the lateral and the anteroposterior views of forced bending (Figs. 5-A to 5-D). In the first series, only 11.1 per cent. showed the presence of pseudarthrosis in the fourth and fifth lumbar segments, and 2 per cent. in the fifth lumbar and first sacral region. An analysis of forty-one cases tested by biplane roentgenograms is found in Table I. These roentgenograms were taken at the end of six months and after one year or more.

Pseudarthrosis, as demonstrated by biplane roentgenograms, was found in four cases with fusion of the fourth and fifth lumbar vertebrae, while the same roentgenographic technique seemed to have indicated that solid stabilization occurred in all instances in the lumbosacral joint. Fusion has depended almost solely upon the wedged bone blocks; occasionally a few bone chips were added about the facets. There are no contra-indications to any additional measures for reassurance of fusion; however, they require time and induce greater risk. It is thought that the simple bone-block procedure is entirely adequate in the lumbosacral joint. Fusion of the fourth and fifth lumbar vertebrae seems less certain. Here, additional bone chips packed about the denuded facet articulations offer greater security.

SUMMARY

Lumbosacral fusion must be considered in light of the newer concepts developed through surgical treatment of herniated intervertebral discs. Structural faults must be re-evaluated. Stabilization by fusion is still the treatment of choice in lumbosacral instability, irrespective of the spectacular results obtained after removal of the disc without.

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fusion. Pseudarthrosis, especially of the fourth and fifth lumbar segments, has been found frequently after the regular types of fusion, and a special technique is necessary.

The technique described for accurately impacting a mortised transfacet bone block under interlaminal distraction has the following advantages:

1. The period of confinement in bed is increased very little over that required for simple removal of a herniated disc.

2. The fusion technique adds thirty minutes or less to the time involved in removing a herniated disc.

3. There is a minimum amount of mutilation of the spinal structures.

4. The articular facets are fused, which is of mechanical advantage.

5. The bone block rigidly stabilizes interlaminal motion, immediately after being countersunk into position.

6. Extension of the spine after operation locks the bone grafts firmly in position.

REFERENCES


DISCUSSION

Dr. DAVID M. BOSWORTH, NEW YORK, N. Y.: In June 1947, Dr. Cleveland, Dr. Thompson, and I reported the incidence of pseudarthrosis in our series of lumbosacral spine fusions. Comparable reports by other authors are possible only through the presentation of a similar number of cases and similar roentgenographic criteria of fusion (superimposable roentgenograms taken at the extremes of bending in two planes). It does not avail to emphasize the high incidence of pseudarthrosis in the past as a standard of comparison for a new technique of fusion, unless comparable evidence of fusion and pseudarthrosis is presented in support of the new technique.

The development of pseudarthrosis after lumbosacral fusion has not been discouraging. Some pseudarthroses are always likely to occur, but the percentage has gradually decreased over the years as new surgical means have been employed, based on better understanding of the basic factors of bone growth and repair. Of some 650 cases of lumbosacral fusion reported by us, about 3 per cent. of pseudarthrosis developed when

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DISCUSSION

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the fifth lumbar interval alone was bridged. The percentage rose roughly to 17 when the fourth and fifth lumbar intervals were crossed. Later cases in the series showed a lowering of this percentage to about 12 when the last two lumbar intervals were spanned. The development of surgical technique has made a considerable difference in the percentage of successes, but mainly through the use of more finely divided graft material, material of more cancellous nature, and through the use of procedures which better stabilize the region.

Among the 680 patients operated upon, approximately 1,300 spinal intervals were crossed with an incidence of pseudarthrosis of 12 per cent. Since 1940, all results have been checked by superimposable roentgenograms and, although our technique has improved and more solid ankyloses have been obtained, the reportable pseudarthrosis rate has risen. This is directly attributable to the better knowledge gained by the use of such roentgenograms; in the future, no results should be reported which are not based upon them. Curettage of the facet area, followed by graft implantation, was not carried out in our series. Reports on a similar series by Dr. Alan DeForest Smith, in which the facet area was curetted and grafted, showed essentially the same percentage of pseudarthrosis. Hence we prefer to leave the facets intact, to provide a normal stabilizing mechanism in case pseudarthrosis develops.

It would have been somewhat difficult to use Dr. McBride's technique in many of the spines we have seen. Distraction he undoubtedly can obtain, but permanent stability of the grafts (beyond two or three weeks) might not be present routinely. I believe that lately he has been using considerable supporting graft material, after placing his blocks in the facet region to produce distraction. His ideas are logical and the results may be good.

Such future advance as may occur in the art of spine fusion at the lumbosacral angle will probably not be the result of surgical techniques. Further development of knowledge of the factors favoring bone growth and repair, both local and general, will undoubtedly help to reduce the percentage of pseudarthrosis.