LUMBO-SACRAL ARTHRODESIS AFTER LAMINECTOMY *

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The necessity for arthrodesis of the lumbo-sacral spine after laminectomy has been performed arises mainly in the treatment of spondylolisthesis and some lesions of the intervertebral discs. In most cases of spondylolisthesis the lamina is loose and unattached to its body, so it can play no useful part in the fusion operation. Apart from this, it should in all cases be removed to allow a thorough decompression of the cord and nerve roots. In the operation for exploration of a disc it is impossible to get adequate exposure of the lower two disc spaces unless the spinous process and at least one half of the lamina of the fifth lumbar vertebra are removed. Sometimes, especially in the L.4-5 segment, it is necessary also to remove the medial facet of the posterior intervertebral joint, and this is not infrequently removed inadvertently. I do not believe that arthrodesis is necessary in the routine treatment of all cases of disc prolapse, but in the cases in which it is considered necessary there will usually be too little of the neural arch left for the performance of a satisfactory posterior arthrodesis. The commonest indication for fusion is the so-called scarred disc, in which severe backache is associated with some sciatic radiation. Although a prolapsed nucleus will not usually be found in these cases it is most important that a thorough exploration of both the affected and adjacent discs should be made to exclude its presence. For the same reason, although disc lesions probably play an insignificant part in the common low back pain syndrome, until the etiology of this condition is better understood it is unwise to perform a posterior arthrodesis without first exploring the disc spaces. In both cases the exploration inevitably removes the basis of a sound posterior fusion.

In the past this problem has usually been tackled by using a long graft to bridge the laminectomised vertebra. An attempt is thus made to fuse two intervals, most commonly the fourth lumbar to sacrum. The choice lies between an onlay cortical graft as used by Albee (1911) or one of its many modifications, perhaps a graft fixed to spinous processes by bolts and plates as described by Wilson and Straub (1947), or the H-graft impacted between spinous processes as used by Bosworth (1942). All are open to the same criticisms: the gap to be bridged is too large; the lever-like action of a long graft greatly exaggerates the slight movements which are so hard to eliminate in this region; and the sacral spinous process is so often absent or ill-developed that adequate fixation of the sacral end is impossible. All published results show a greatly increased rate of failed fusion when more than one interval is spanned. Cleveland, Bosworth and Thompson (1948), in a review of 594 cases of grafts of various kinds, quoted an increase from 3.5 per cent for the lumbo-sacral interval only to 17.3 per cent for the fourth lumbar to sacral interval, and a figure as high as 35 per cent for spondylolisthesis cases. For reasons to be mentioned later, I believe that even these results may represent a too optimistic view of this problem. My own experience of these types of graft is small, but none the less unfortunate. Excluding fusions done for fracture or tuberculosis, I have been able to study the late result in eight cases, of which at least four are certain failures.

Many writers have mentioned the need for improved methods of arthrodesing this region of the spine, especially in cases of spondylolisthesis, and during the past six years I have devoted much time and thought to attempts, mostly unsuccessful, at solving this problem. A bone graft inserted between the vertebral bodies through the same posterior approach and at the same time as the exploratory operation seemed to offer much promise.

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A few reports of such a procedure have appeared in the literature (Cloward 1953, Jaslow 1946, and James and Nisbet 1953) but so far as I am aware none of these writers has studied the late results or attempted to assess the incidence of pseudarthrosis. This method seemed to me to be the perfect bone-grafting procedure, but a study of the late results in an extensive series, described in detail later, has convinced me that these grafts seldom become incorporated.

Having accepted, albeit reluctantly, the complete failure of the intercorporal method, I turned my attention to the lateral elements of the vertebra which remain after laminectomy—namely the pedicles and transverse processes. An interpedicular (or alar-pedicular) fusion, although it produced a few good results, was considered unsatisfactory for technical reasons and was soon abandoned in favour of the more certain intertransverse (or alar-transverse) arthrodesis.

Before relating my experiences with these various methods of grafting, I wish to make some comments on two problems that are common to all methods: firstly, the difficulty of determining whether fusion has occurred or not; and secondly, the difficulty of adequately immobilising the lumbo-sacral region of the spine.

ESTIMATION OF FUSION

Many surgeons have assessed the value of an arthrodesis by the subjective test of relief from symptoms. Such an assessment is so obviously unreliable that it needs no further comment. An assessment can be based on the direct radiological evidence of incorporation of the grafts. This method is seldom helpful because most spinal grafts are obscured by other parts of the vertebra and cannot be displayed clearly enough to show definite incorporation. The usual test therefore is by mobility films. The technique consists of taking lateral projections of the spine in flexion and extension, and antero-posterior films in right and left lateral flexion. Absence of movement in the grafted segment is accepted as evidence of bony fusion.

In attempting an end-result study by this method, however, I soon found myself in grave difficulties. However carefully the position of the patient is controlled it is virtually impossible to maintain a constant relationship of the x-ray tube to the patient, or of the patient to the film. The result is that exactly comparable films cannot be produced and, even if solid fusion is present, the bony outlines can rarely be accurately superimposed. In many cases, even after repeated investigations, I found it impossible to decide whether these slight differences were due to this factor or to lack of complete immobility which, of course, would indicate a failed arthrodesis. Bosworth (1948) mentioned that the antero-posterior radiographs may not superimpose accurately because of what he called the "stereoscopic effect" of slight shifts, but he stated that all outlines should remain parallel. This is an over-simplification of the problem, and ignores the fact that any shift of the patient, and especially slight rotation, may bring quite different contours into the outlines on the radiograph. These need not necessarily be parallel to the earlier ones. Armstrong (1952) also noted the unreliability of this method.

A statistical investigation was made still more difficult by the occurrence of a few cases in which, from obesity or a marked degree of spondylolisthesis, it was impossible to obtain radiographs good enough for comparative study.

The interpretation of mobility films is rendered difficult by a still more important factor. After any extensive operation on the lumbo-sacral spine involving partial laminectomy there is often dense fibrosis in the region of the excised lamina and ligamentum flavum, and also within the intervertebral space itself if the disc has been resected. Anyone who has been unfortunate enough to have to re-explore such cases is only too well aware of this fact. This fibrosis greatly reduces the mobility in this segment, and often leads to a firm fibrous ankylosis, even when no bone graft has been inserted. In an investigation of sixty patients subjected to simple resection of a disc without arthrodesis, I found that mobility of the affected segment

was absent or almost absent in 40 per cent. With the more extensive interference necessary for a grafting procedure, one might expect this figure to be increased considerably.

In assessing the results of lumbo-sacral arthrodesis by this method, therefore, an attempt is being made to estimate mobility of joints in which movement is likely to be slight or absent, even if the arthrodesis is unsuccessful. The investigator has to distinguish such cases from those of true bony fusion which show apparent slight mobility from changes of position during radiography. From my own experiences while investigating over a hundred cases by this method, I believe it to be subject to grave personal error which could seriously upset one's judgement of the value of any particular method of arthrodesis. Such an investigation of my earlier cases of intercorporal bone grafting deceived me so completely that I believed fusion was occurring in nearly every case. Thus encouraged, I operated upon a large number of patients, and it was only after a much later follow-up that I realised that the results were very different from what I expected.

Many surgeons reporting cases of lumbo-sacral arthrodesis have assessed their results by this method. Most have claimed a high proportion of successful fusions. I think it significant that, apart from the authors mentioned above, I have seen no reference to this difficulty of interpreting mobility films, although I cannot believe that any of these investigators have failed to experience it. Until more is known of the criteria accepted for bony fusion I believe that many of the previously published figures should be accepted with the greatest reserve.

IMMOBILISATION OF THE LUMBO-SACRAL REGION

Immobilisation of the lumbo-sacral region has always presented a difficult problem, and it is doubtful whether any of the usual methods is entirely satisfactory. A well fitting plaster jacket will limit movement of the lumbo-sacral joint, but it will certainly not prevent movement altogether while hip movements and the associated rotation of the pelvis are left uncontrolled. Both spine and hip movements can be controlled either by a plaster bed or by a combination of a plaster jacket and double short hip spica. A patient immobilised by the latter method presents a formidable nursing problem, and runs the risk of serious chest or urinary tract complications. I have used it only on rare occasions.

Theoretically the plaster bed, which controls spine, pelvis and hip movements, offers the most satisfactory method of immobilisation. I have used it routinely in cases such as those of spondylolisthesis in which arthrodesis was considered an essential part of the operation. In practice, however, I doubt whether the immobilisation is altogether successful, for these patients almost invariably flex their hips, prop themselves up with pillows, or even turn on to their sides to speak to their neighbours!

After most of my operations for disc lesions in which arthrodesis was considered desirable but not absolutely essential, I have compromised with a combination of plaster jacket and single short hip spica. This is applied a few days after the operation and the patient is allowed up in the plaster. Most patients soon learn to walk, sit down and use the toilet, and can be discharged home or to a convalescent home. The plaster is retained for fourteen to sixteen weeks, and then replaced by a plaster corset or Jordan's brace. Movements of the uncontrolled hip probably cause slight rotation movements of the pelvis within the plaster, with the possibility of slight movement at the lumbo-sacral joint. I have come to the conclusion, however, that in practice this method ensures better immobilisation than a plaster bed.

In some cases I have tried internal fixation with a Wilson plate bolted to the spinous processes. It is often not practicable on account of deficiency of the sacral spine. In many cases firm fixation has been demonstrated on the operating table by flexing the spine before closing the wound. But in every case the bolt through the sacral spine has loosened, often within a few days after the operation. In my opinion plates and bolts alone cannot be relied upon to give even temporary fixation.

Some surgeons, especially in America, have discarded plaster fixation altogether, and

allowed the patient up in a lumbo-sacral brace. This does not immobilise the spine, and at best can only partly restrict movements at the lumbo-sacral joint. Adequate immobilisation is still considered necessary to effect arthrodesis in almost any other joint in the body, and until more satisfactory end-results can be demonstrated it seems foolish to discard this important aid to fusion in this region.

It is possible that the difficulty of securing fusion of the lumbo-sacral joint is largely explained by the impossibility of providing adequate immobilisation, particularly when long grafts are used. These often appear to fuse at one end but develop a pseudarthrosis at the other end, where any slight movements are magnified by the lever-like action of the long graft. To minimise this effect, when more than one segment has to be fused, and no matter what type of graft has been chosen, a series of short intersegmental grafts should always be used in preference to a single long graft. Firm impaction of the grafts between the two vertebrae to be fused can itself produce considerable fixation; and while the available methods of immobilisation, either external or internal, remain unsatisfactory this is probably the best safeguard against failure.

THE INTERCORPORAL BONE GRAFT

Cancellous chip grafts—In my initial attempts at producing intercorporal fusion the excavated disc space was packed with bone chips. The method posed many problems. It is

FIG. 1

Case 1—Spondylolisthesis. Radiograph four years after packing cancellous chips between the vertebral bodies. The only case in which such grafts consolidated.

FIG. 2

Case 2—Radiograph four and a half years after intercorporal cancellous chip grafting. No consolidation of grafts, but fusion by anterior bridge.

obviously important to bare as wide an area as possible of the contiguous surfaces of the vertebral bodies by removal of the cartilaginous plates. As the cartilage is usually firmly adherent to the bone it is difficult to do this with a spoon, and the dome-shaped surfaces of the vertebrae make access with a gouge equally difficult. After a thorough curettage of the disc space a large quantity of bone chips is required to fill it—far more than are provided

by the excised spinous process and lamina. Extra bone has therefore to be obtained from the ilium, with the disadvantage of a new incision and considerable waste of time. To overcome the danger of retropulsion of the chips, the gap in the posterior annulus must be closed with a piece of bone impacted under its edges, and the patient must be nursed on his face for two to three weeks.

On account of these difficulties and the lack of radiographic evidence of consolidation of the grafts, the method was soon abandoned in favour of the solid graft described later. A much later follow-up of these cases showed that the results were not satisfactory, but some interesting observations are thought to be worth reporting and may be of interest to others who have tried this method.

Of five patients (four with disc lesions and one with spondylolisthesis) only the one with spondylolisthesis showed evidence of consolidation across the disc space (Fig. 1). Mobility

FIG. 3

FIG. 4

Case 3—Scarred lumbo-sacral disc. Intercorporeal spinous process graft. Figure 3—Early post-operative radiograph. Figure 4—Two years after operation: pseudarthrosis at upper end of graft.

films confirmed that this segment was stable. In none of the remaining four cases, nor of several others in whom chips were used in conjunction with a solid graft, was there evidence of consolidation of the chip grafts. In one case radiographs taken four and a half years after operation still show no evidence of consolidation, although the chips are still visible in the disc space. Mobility films suggest stability, but I believe this is due to fibrous ankylosis and not to bony fusion; this impression is supported by one of the other cases in which the radiograph of the disc space is exactly similar, but in which there is definite movement in the mobility films. What peculiar circumstances resulted in the one successful fusion remains a mystery.

In one other case fusion occurred through a firm bony bridge in front of the vertebrae (Fig. 2). This closely resembles the anterior fusion seen after some cases of fracture of the vertebral bodies. A similar anterior or antero-lateral bony bridge (sometimes visible only in

oblique films) has been seen in one case with an intercorporal solid graft, one with an interpedicular graft, and in one case after simple disc resection. The factors in the operative procedure responsible for this desirable end-result remain obscure. It is possible that it is caused by haemorrhage under the anterior longitudinal ligament after deep curettage of the disc, but the rarity of its occurrence makes this unlikely. Just as it is the ideal end-result of a fractured vertebra, it would probably be the ideal end-result of disc resection also, if only it could be produced to order.

Solid cortical grafts—Since the chip grafts failed to consolidate, a technique using a solid graft was developed. After curettage of the disc space, slots about half an inch long were cut in the opposing surfaces of the vertebral bodies on each side of the disc space. The osteotome was driven into the body of the vertebra to a depth of about three-quarters of an inch. A graft cut to the appropriate size was then inserted into these slots and across the

FIG. 5

Case 4—Intercorporal spinous process graft two and a half years after operation. There is a pseudarthrosis at each end of the graft.

FIG. 6

Case 5—Lumbo-sacral intercorporal graft eight months after operation. There is a pseudarthrosis in the middle of the graft.

disc space (Figs. 3 to 8). At first a spinous process cleaned and freshened was used for the graft, but in some of the later cases a tibial graft was used instead (Fig. 7). The operation was performed with the spine flexed, and on extending the spine the graft was firmly impacted within its bed.

After I had become familiar with this technique it became an easy and attractive procedure, adding no more than a few minutes to the operating time for disc resection. It seemed an ideal grafting procedure, because the graft was in close contact with a wide area of the host bone, and was not only firmly fixed but actually under compression when the spine was extended. Estimation of fusion by the mobility method produced films which could be completely or almost completely superimposed and were interpreted as showing bony fusion of the grafted segments. Although I do not believe that arthrodesis is essential for all cases of disc prolapse it would be desirable if it could be effected as simply and quickly

as by this method. The method was therefore adopted routinely for all cases of disc resection and spondylolisthesis operated upon in 1949-50. It was used in seventy cases, fifty-eight of disc resection and twelve of spondylolisthesis. The joint grafted was the lumbo-sacral in thirty-eight, lumbar 4-5 in nineteen, and both joints in thirteen cases. In the earlier cases chips from the excised lamina were packed around the solid graft, but as no visible consolidation occurred in these, this addition was discontinued. In twenty-six, twin grafts were used, one inserted from each side. In nine of the later cases tibial grafts were used instead of the spinous processes.

Results—The difficulty of estimating fusion in the lumbo-sacral region by mobility films has already been stressed. In most cases investigated the films showed either no movement or a very slight shift which was thought to be due to changes in position during radiography. A detailed radiological investigation of the grafted area was therefore undertaken in the hope

FIG. 7

Case 6—Intercorporeal tibial grafts for spondylolisthesis a year after operation. Pseudarthrosis at upper end of right graft and lower end of left graft.

FIG. 8

Case 7—Intercorporeal tibial graft for spondylolisthesis. Radiograph one and a half years after operation shows the graft partly absorbed.

of finding direct evidence of incorporation of the grafts into the host bone. Such an investigation is difficult, for the embedded parts of the grafts are often obscured by superimposed shadows of other parts of the vertebra. Instead of providing evidence of bony fusion, the follow-up radiographs gave direct evidence of failure of incorporation of the grafts. With the possible exception of one single graft, the study has failed to produce evidence of incorporation of any of these grafts in two to four years. Whether use was made of single or twin grafts, tibia or spinous process, with or without chips, the results were the same.

In many cases a definite pseudarthrosis was shown at one end of the graft, where there was well defined sclerosis around the margins of the bed and often a gap between this sclerosed margin and the inert graft lying within it (Figs. 4, 5, 7, 8). This was much the commonest finding. In a few cases there was a pseudarthrosis within the graft itself where it bridged the disc space (Fig. 6). In others there was partial absorption of the graft (Fig. 8). In none was

there evidence of a build-up in strength of the graft, or of buttressing with new bone, such as is seen so commonly in the comparable ischio-femoral graft of the hip joint or in the intertransverse spinal graft to be described later. If these grafts had really become incorporated such changes would almost certainly have occurred.

These rather startling conclusions led me to review and in most cases repeat the radiological investigation of mobility in these grafted segments. Sixty-six patients were reinvestigated and the results were as follows: no movement, seventeen (26 per cent); doubtful or slight movement, thirty-four (51 per cent); definite movement, fifteen (23 per cent). There was no difference in the appearance of the grafts in these three groups, and in many immobile joints the characteristic appearances which I am now convinced indicate failure of bony fusion were evident. In relation to other published figures, it may be of some significance that had the findings in the first two groups been accepted as evidence of bony fusion (I was originally inclined to do this) a figure of 77.2 per cent of successful arthrodeses might have been claimed. This figure compares closely with many published results.

I now feel certain that intercorporal bone grafting, although it appears to aid the formation of a firm fibrous ankylosis, is ineffective as a method of producing bony arthrodesis. It is nevertheless worth recording that in none of these cases was there any complication attributable to the graft. There were no cases of sepsis; and, as evidenced by the relief of symptoms in many cases of spondylolisthesis, it seems that fibrous ankylosis is almost as effective as bony arthrodesis.

Discussion—What is the reason for this total failure of a method which theoretically approaches the ideal? The avascularity of the gap to be bridged across the disc space suggests a possible cause. In this case, however, one would expect the pseudarthrosis to develop in the middle of the graft. But on the contrary, the pseudarthrosis is between one end of the graft and the host bone. It might be due to the inefficient immobilisation which is inevitable in this region. This factor, however, is not peculiar to the intercorporal graft and cannot explain the discrepancy in the pseudarthrosis rates between this method and the more conventional types of grafting. I believe the answer lies in some intrinsic factor peculiar to the bone of the vertebral bodies. This would explain not only the failure of incorporation of these grafts but also the absence of consolidation of vertebral bodies after compression fractures.

LATERAL FUSION

Failure of the intercorporal method led me to consider the possibilities of using the lateral elements of the vertebrae which remain after laminectomy. In spondylolisthesis, the inferior facets are attached to the loose lamina and so are of no use. After excision of a disc the facets will usually be left intact on at least one side, but there is no really satisfactory method of using them in a grafting operation. The difficulty of removing the articular cartilage from between the facets has been referred to by many surgeons, and even if this is done satisfactorily, there is a considerable gap left which has to be filled in with free grafts. Grafts laid across the facets or along their lateral surfaces cannot be adequately secured and act purely as onlay grafts. I feel certain that it is impossible to perform a satisfactory arthrodesis operation using these elements alone.

There are left therefore only the pedicles and transverse processes. A technique of fixing grafts between the pedicles or between pedicle and ala of sacrum was developed. Adequate fixation is difficult to secure and this method was soon discarded in favour of the more certain intertransverse or ala-transverse method to be described. A few satisfactory fusions were obtained by this method, however, and it is possible that it could be modified into a more satisfactory procedure. In view of this I think the technique and results of the few cases so dealt with are worth reporting.

Bosworth (1948) used the transverse processes in a grafting procedure for cases of pseudarthrosis after attempted arthrodesis by other methods. The technique described below

has produced some very satisfactory results and offers great promise as a solution to the problem of arthrodesis after laminectomy.

INTERPEDICULAR GRAFTS

Technique—The pedicles are nibbled down to form flat surfaces just clear of the emerging nerve roots as they curve round their inferior surfaces. A tibial graft drilled at each end is laid across the pedicles and the drill is passed through the pedicles and into the vertebral bodies (Fig. 9). Into these drill holes bone pegs cut to the shape of a tent peg are driven. Unfortunately there is no means of compressing the graft against the pedicular surface and it is often difficult to keep it in close contact with its bed. For the lumbo-sacral segment, the lower end is either driven into a hole cut in the ala with a curved gouge or punched into

FIG. 9

Case 8—Interpedicular grafts bridging the L.4-5 joint. Note bone pegs holding the grafts, one extending into the body of L.4.

a slot cut in the upper border of the ala. The latter method is the more satisfactory as it is difficult to cut a hole in exactly the right direction.

Results—During 1951 eight patients (five with disc lesions and three with spondylolisthesis) were operated upon by this method. In five the joint concerned is stable and there is definite evidence of incorporation of the grafts (Fig. 10). The three others, all in the lumbo-sacral interval, have failed.

INTERTRANSVERSE GRAFTS

By continuing the dissection of the erector spinae laterally from the pedicles it is possible to expose the transverse processes and alae of the sacrum. This is easier when the facets have been removed but if these are intact it can be performed quite satisfactorily without disturbing them. A groove is cut in the upper or lower border of the transverse process with a sharp gouge or Citelli's forceps. Great care must be taken over this part of the operation, for the transverse process is easily fractured, and in the event of fracture firm impaction of the graft is impossible. In the ala of the sacrum parallel cuts are first made

in its postero-superior border with an osteotome, and a gouge is then driven across the ends of these cuts and the intervening bone levered out of the slot so made. For the lumbar 4-5 joint a tibial graft is cut with V-shaped ends; it is inserted obliquely between the transverse processes and then rotated into position so as to cause slight distraction of the processes and become firmly impacted between them. For the lumbo-sacral joint the graft is cut V-shaped at its upper end and straight but slightly obliquely at its lower end. One arm of the V is inserted in front of the transverse process and the lower end is punched into the slot in the sacrum. The slight wedging of the lower end ensures firm impaction as the graft is punched home. Bilateral grafts are best because they afford a considerable degree of internal fixation. If one side only is grafted the patient must be so arranged that there is a slight convex curve of the spine on this side so that firm impaction will occur when the spine is straightened.

FIG. 10

Case 8—Later oblique radiograph showing full consolidation of the graft on the right.

The grafts must be placed as far laterally as possible to avoid their contact with the emerging nerve roots, and also to gain the maximum mechanical stability.

If two spaces have to be arthrodesed, two separate intersegmental grafts should be used to avoid the lever-like action of a long-graft previously mentioned.

In some cases bone chips were packed around the grafts but I believe this to be unnecessary if the grafts are firmly impacted. On two occasions I have dispensed with a solid graft and turned the transverse process itself into a groove cut in the ala. Although theoretically attractive, in practice it is difficult to get satisfactory contact and the process will almost certainly fracture and possibly become displaced. Although fusion seems to be occurring in both these cases it is not a procedure that I would recommend.

Results—I first performed this operation in April 1951, and it has not so far been possible to undertake a late follow-up study on an extensive series. It may be said, however, that the method has given some very beautiful results, in which certain and solid incorporation of the grafts can be seen in the radiographs, and in which there is no need to rely on the doubtful evidence of mobility films (Figs. 11 to 17). In the light of experience many modifications have been made in the technical details of the operation, and I believe that most of the failures can be attributed to obvious technical errors.

FIG. 11

Case 9—Lumbo-sacral spondylolisthesis treated by bilateral tibial ala-transverse grafts. Six months after operation the grafts are incorporated and buttressed by new bone.

FIG. 12

Case 10—Lumbar 4-5 spondylolisthesis and lumbo-sacral spondylolysis. Separate intertransverse grafts L.4-5 and L.5-ala. Six months after operation grafts are well incorporated.

FIG. 13

Case 11—Lumbar 4-5 spondylolisthesis, eight months after bilateral intertransverse fusion with tibial grafts. Note massive buttressing at inner side of graft on left side.

FIG. 14

Case 12—Ala-transverse graft two years after operation. Oblique radiograph showing left graft fully incorporated at both ends.

FIG. 15

Case 13 Unilateral ala-transverse graft six months after operation. Oblique radiograph showing massive consolidation.

FIG. 16

Case 14—Boiled tibial intertransverse graft bridging L3-4 joint. Figure 16—Soon after operation. Note fractured lower transverse process. Figure 17—A year later. Full incorporation with buttressing at both ends of graft.

FIG. 17

FIG. 18

Case 15—Ala-transverse graft of boiled tibial bone. The graft has become disimpacted from the transverse process, probably because it was inserted on the concave side of a spinal curve as the patient lay on the table. The graft was later absorbed.

FIG. 19

FIG. 20

Case 16—Ala-transverse graft of tibial bone. Figure 19—Soon after operation. The transverse process has been fractured; the graft has moved upwards and is disimpacted from its bed in the sacrum. Figure 20—A year and a half later. The graft is incorporated at its upper end but a pseudarthrosis persists at the lower end.

The commonest of these errors is failure to obtain firm impaction of the grafts. This may be caused by using too short a graft, by applying it to the concave side of a spinal curve so that it disimpacts on straightening the spine (Fig. 18), by failure to cut adequate grooves in the transverse process or ala, or by fracture of the transverse process (Figs. 19 and 20). Fracture does not necessarily prevent incorporation (Figs. 16 and 17) but I believe makes it less likely to occur. Placing of the grafts too medially, especially the lower ends (Figs. 21 and 22) reduces the mechanical stability of the segment and is another likely cause of failure. In a few cases boiled tibial grafts were used, and although many of these have incorporated satisfactorily (Figs. 16 and 17) they appear to be much less certain than autogenous bone (Fig. 23).

Up to the end of 1952 thirty patients (twenty with disc lesions and ten with spondylolisthesis) were treated by this method. One patient died from pulmonary embolism

FIG. 21

FIG. 22

Case 17—Lumbo-sacral spondylolisthesis. Bilateral ala-transverse grafts from tibia. Figure 21—Soon after operation. The grafts are implanted too medially in the sacrum and mechanical stability is impaired. Figure 22—A year later. The grafts have failed to become incorporated and are largely absorbed.

sixteen days after operation. In the remaining twenty-nine the results were as follows: certain fusion, seventeen (59 per cent); probable fusion, seven (24 per cent); failure, five (17 per cent). The cases listed as certain fusions show incontrovertible radiographic evidence of fusion (Figs. 11 to 17). In all of these the grafts are firmly incorporated at both ends and there is definite buttressing, often of massive dimensions, by new bone around the grafts. The cases listed as probable fusions all appear stable in mobility films, the embedded ends of the grafts appear incorporated, with no such evidence of pseudarthrosis as was seen in the intercorporate grafts, and the grafts appear healthy without any apparent absorption. They are listed as probable instead of certain fusions only because the conclusive evidence of buttressing by new bone cannot as yet be demonstrated.

In all five failures (four cases of disc lesion and one of spondylolisthesis) one or more of

the technical errors mentioned can be detected. In one case a boiled graft was used and the transverse process fractured; this graft absorbed completely. In another a boiled graft became disimpacted from the transverse process (Fig. 18) probably because it was inserted along the concave side of a spinal curve; this graft also absorbed completely. In a third case in which a boiled graft was used the graft has made no effort to fuse but persists as an inert sequestrum (Fig. 23). In the fourth case an autogenous graft was used but fracture of the transverse process has enabled it to ride upwards and become disimpacted from the sacrum (Figs. 19 and 20); this graft has become incorporated into the transverse process above and has made a gallant effort to fuse below, but a pseudarthrosis at this end is present and mobility persists. In the final case, in a patient with spondylolisthesis, the only demonstrable error is the implantation of the grafts very medially into the sacrum (Figs. 21 and 22), with probable loss of mechanical stability; although the grafts have partly absorbed, this segment

FIG. 23

Case 18—Ala-transverse graft of boiled tibial bone. Radiograph a year and a quarter after operation. No incorporation. The graft persists as an inert sequestrum.

is quite stable in mobility films and would certainly have been accepted as a success if direct films did not display the grafts so clearly.

Although it is clearly too early to make extravagant claims for this method, if these technical errors can really explain all five failures, and if a later follow-up confirms incorporation of the grafts in the seven cases of probable fusion, then these results must be considered extremely satisfactory.

In the first six months of this year (1953) a further fourteen patients have been treated by this method. The difficulties of the operation make it impossible to adopt a perfectly standardised technique, but in most of these cases it has been possible to exclude the obvious errors described. Five of these later cases already satisfy the criteria of certain fusion, and all but one of the remainder fall into the probable group. In the one failure, a rather half-hearted attempt at fusion was made by simply wedging a boiled graft between the transverse process and ala; it remains as an inert sequestrum.

CONCLUSIONS

I believe that the conventional methods of posterior fusion after laminectomy are not satisfactory and it is therefore important to search for a better method. I strongly suspect that some of the reported results, especially when the graft has to bridge the gap between L.4 and the sacrum, are not as good as their authors believe, and I believe many surgeons are of the same mind (Armstrong 1952). It was a bitter disappointment to discover that the easy inter-body operation, upon which I had built up great hopes, was of no use, and I hope that the reporting of this rather extensive series of failures will be of some value to future workers in this field.

I have great hopes for the intertransverse method described here, which undoubtedly produces sound arthrodesis in a fair proportion of cases. I believe it is the most promising method yet reported and that, perhaps after further modification or in combination with other techniques, it is likely to give a very satisfactory fusion rate.

SUMMARY

1. The usual methods of posterior arthrodesis of the lumbo-sacral joint are not satisfactory in cases in which laminectomy has been performed.
2. Estimation of fusion by mobility radiographs is unreliable and cannot distinguish between fibrous ankylosis and bony fusion.
3. Bone grafts inserted from behind between the vertebral bodies almost invariably fail to become incorporated.
4. Intertransverse arthrodesis has given promising results and is probably the best method available at present.

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