

A METHOD OF SPINAL FUSION

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The incidence of failure in spinal fusion is still too high (Barr 1951). It has been stated that if the operation could be undertaken with little or no danger from shock, subsequent thrombosis and embolism, and if it would offer a high prospect of firm union with a short period of bed rest, then a larger proportion of patients would be grafted (Young 1953). Spinal fusion was the subject of an editorial (Scott 1953) in which the need was stressed for a technique in which it would not be necessary to remove bone from other sites or to keep the patients in bed for a long time after operation.

King (1948) described internal fixation by the use of screws. Short screws were placed almost transversely across the lateral articulations. A high incidence of failure from this method was reported by Thompson and Ralston (1949). Bosworth (1957) stated that screw fixation did not prove to be of value compared to the difficulties encountered, and he mentioned the adverse psychological effect associated with their use.

The principle of internal fixation by screws is sound. Such fixation, however, is only temporary because the screws will loosen (Watson-Jones 1952). Careful preparation of the fusion area and the use of cancellous bone shortens the time needed to obtain fusion. Long, well placed screws give the required stability during this period and make the development of a pseudarthrosis unlikely. This paper describes such a procedure which has been used by the writer for the past twelve years (Boucher 1954).

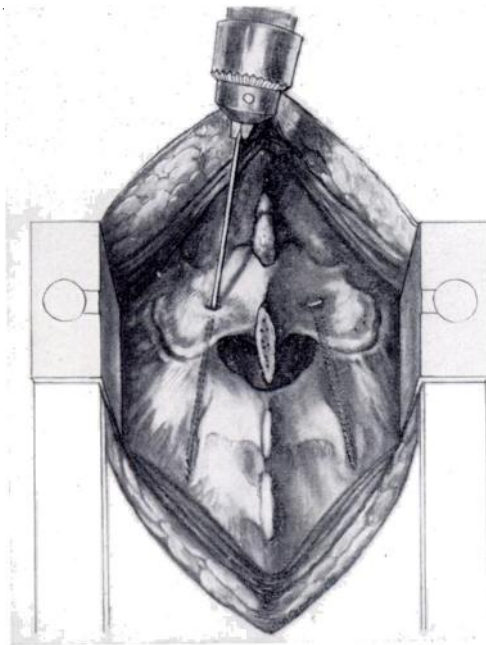


FIG. 1

All soft tissue has been removed out to, and including, the lateral articulations. The guide pin, in practice, is withdrawn after penetrating the cor ex of the ala. The obliquely placed screws avoid the nerve roots.

TECHNIQUE OF LUMBO-SACRAL FUSION

A midline incision is made. The soft tissue is completely removed from the spinous processes and laminae of the fifth lumbar vertebra and from the upper part of the body of the sacrum, out to, and including, the capsule of the lumbo-sacral joint. A gauze sponge interposed between the elevator and soft tissue will simplify the stripping of the laminae. Excision of the fatty tissue just lateral to the ligamentum flavum exposes a bowl-like cavity surrounded by bone except on its medial aspect. It is formed superiorly by the lamina of the fifth lumbar vertebra, laterally by the pedicle of the first part of the sacrum, inferiorly by the first sacral lamina which also forms the floor, and medially by the ligamentum flavum. A screw, one and a half to two inches in length, is driven through the lamina of the fifth lumbar

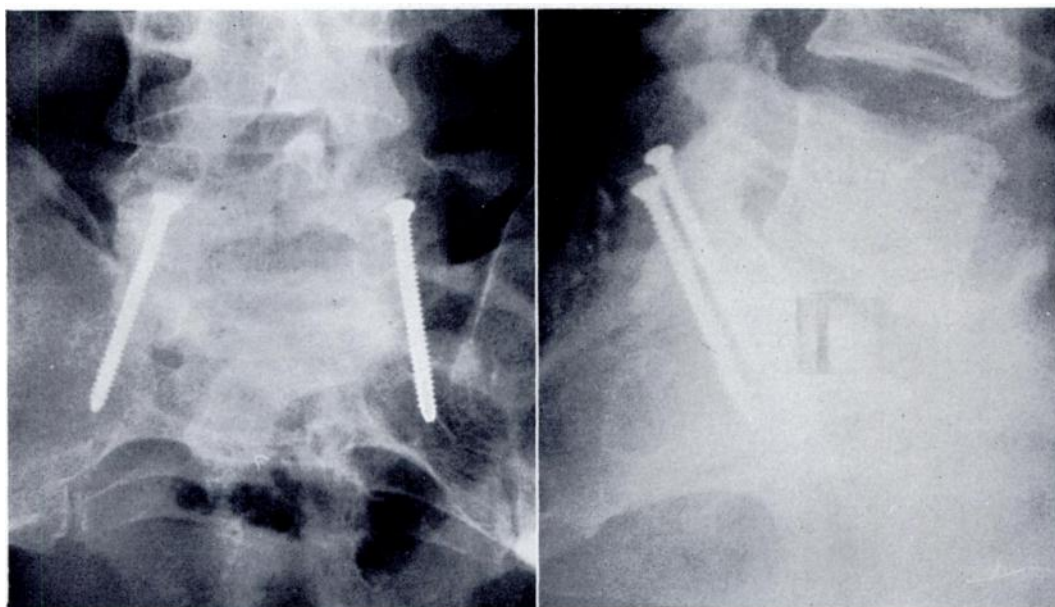


FIG. 2

The long screws traverse almost the full antero-posterior diameter of the alae of the sacrum.

vertebra on each side just medial to the lateral articulation in an antero-inferior and lateral direction (Fig. 1). It enters the ala of the sacrum obliquely, just lateral to the sacral canal, at the base of the superior process, and traverses almost the full antero-posterior diameter of the ala (Fig. 2). The drill hole is made with a long stainless steel pin, three-thirty-secondths of an inch in diameter, introduced by a hand drill, the flexibility of the pin making it possible

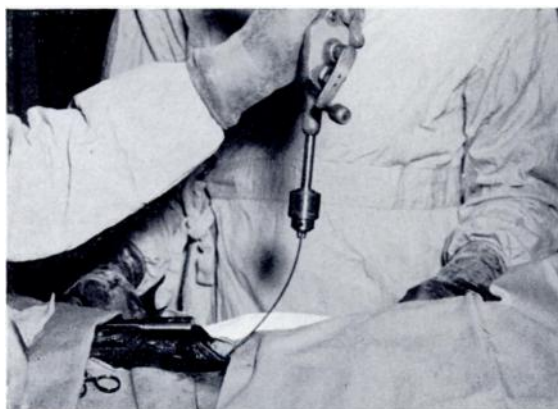


FIG. 3

A flexible stainless steel pin may be bent to obtain the desired direction of the screw. The surgeon faces the head of the patient while drilling.

by firm pressure to bend and guide it in the desired direction. The introduction of this pin is made easy if the surgeon will turn and face the head of the table while drilling (Fig. 3). A self-holding screwdriver may be used to start the screw but should be changed for a plain screwdriver to allow the screw to follow the desired direction. If the spinous process of the fifth lumbar vertebra is in the way of the screwdriver it may be removed. Cancellous bone is

obtained from the posterior superior spine of the ilium which faces the surgeon. It is easily reached by subcutaneous reflection of the original skin incision. The overlying deep fascia is then incised, the roof of the iliac spine is elevated by a broad osteotome and the spongy bone is removed with a large curette. The roof is replaced and snugly sutured to prevent the formation of a superficial haematoma. The cancellous bone obtained is cut up into crumbs with strong scissors. The cortical bone of the bowl-like cavity is elevated by thin, narrow osteotomes, and a little ingenuity will surround this cavity with hinged bleeding flaps (Fig. 4). The presenting posterior margins of the lateral articulations are turned laterally with an osteotome to present further bleeding surfaces, but otherwise the articulations are left intact to preserve stability. The spongy bone is packed firmly into this prepared bed, using the convex side of a broad curved periosteal elevator pressed against a folded gauze sponge. The spinous processes of the first sacral and fifth lumbar vertebrae are turned up and down in an interlocking manner; further bone may be turned up from the first and

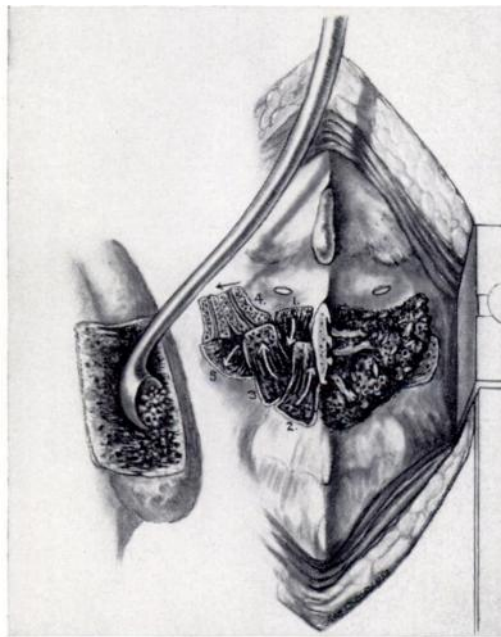


FIG. 4

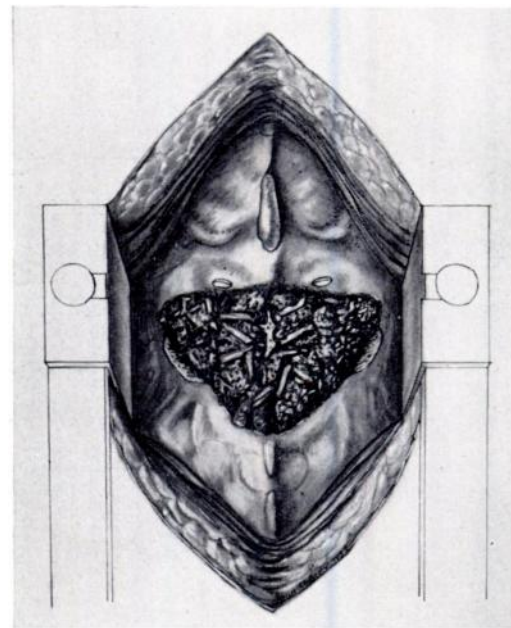


FIG. 5

Figure 4—Preparation of the area for fusion with the use of cancellous bone from the posterior superior iliac spine. Figure 5—The area of bone grafting has been completed.

second sacral laminae and any spare crumbs of bone are added as mortar. When the operation is completed, fixation is firm and the bone mass is usually more than adequate (Fig. 5).

Thorough stripping of the posterior elements of the spine may be associated with brisk bleeding and, as a relatively dry field is most helpful, various measures can be used to obtain this. Epidural anaesthesia without a vasopressor agent and general anaesthesia plus induced hypotension are in common use, or a weak solution of adrenaline may be injected locally. The writer uses whichever method seems best in consultation with the anaesthetist. Blood should be available for immediate use if needed, but frequently the blood loss is so slight that replacement is not necessary.

POST-OPERATIVE MANAGEMENT

The patient is encouraged to move about actively in bed and to get up in a few days, the average stay in hospital being a week or ten days. As fixation is usually sound, no external support of any kind is worn for lumbo-sacral fusions, and it is seldom found necessary to

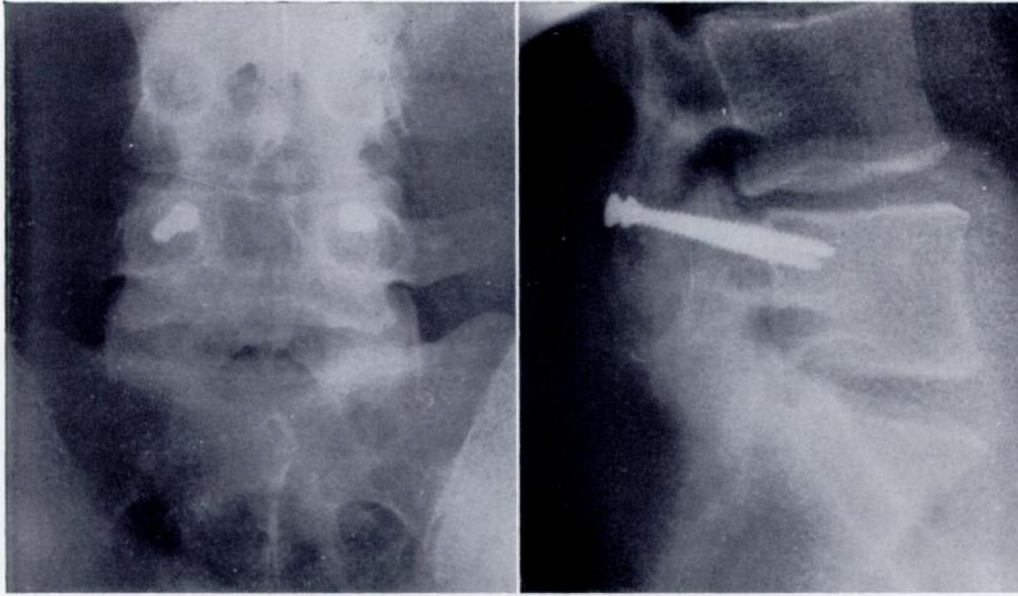


FIG. 6

Fusion between the fourth and fifth lumbar vertebrae. This placement of screws above the lumbo-sacral level seems to offer satisfactory stability and avoid root irritation. No external support is worn.

support double-level fusions. Spondylolisthesis is the exception. Activity is restricted to walking for twelve to sixteen weeks, with no bending or lifting, the patient being taught to flex knees and hips (as perhaps he should have been doing since childhood and so possibly have escaped the disc lesion). Antero-posterior and lateral bending radiographs are taken about four months after the operation and, if these are satisfactory, rehabilitation of the low back is begun and unrestricted activity is allowed with regard to the general condition of the

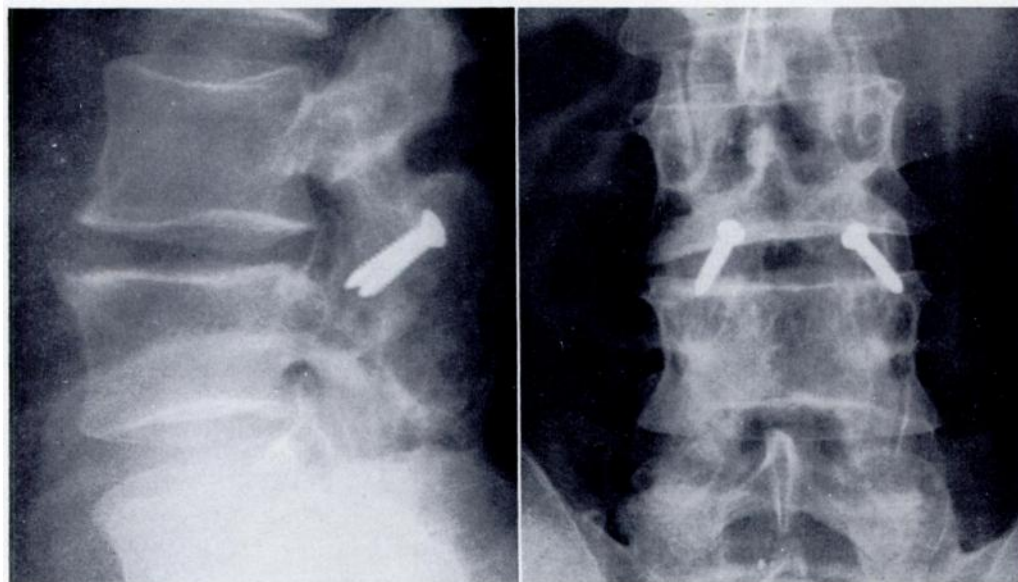


FIG. 7

Fusion between the third and fourth lumbar vertebrae. The screws, though short, engage the root of the pedicle of the fourth lumbar vertebra and fusion was early and sound. No external support was used. Considerably longer screws may safely be used if the technique is as shown in Figure 6.

patient. Occasionally the cancellous bone has not become sufficiently well organised and a few degrees of movement are seen; the patient is then asked to continue being careful with activity, and repeat radiographs a few weeks later will usually show no evidence of movement.

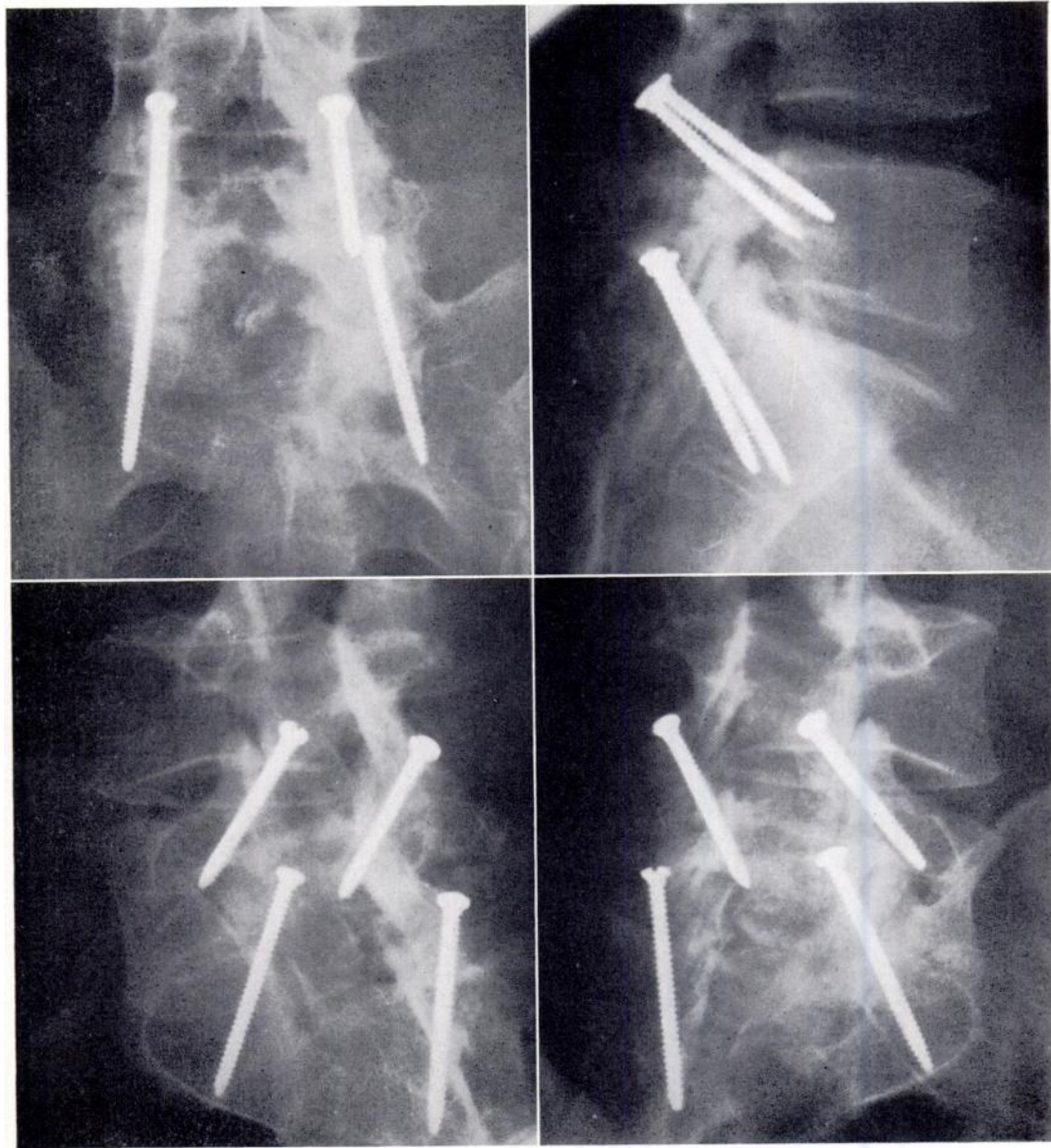


FIG. 8

Fusion at two levels, shown just after operation. This would seem to be a satisfactory placement of the screws, giving the desired stability and avoiding root irritation. No external support will be used.

FUSION AT HIGHER OR MULTIPLE LEVELS

The same technique has been used at the fourth (Fig. 6) and third lumbar levels (Fig. 7) and for multiple fusion operations in the lower lumbar spine (Fig. 8). Above the lumbo-sacral level, the screw is placed so as to pass from the lamina of the vertebra above into the body of the vertebra below, just medial to the root of the pedicle. The drill point, placed well laterally,

will bypass the vertebral canal and enter the upper part of the body of the vertebra below, if directed straight forward and antero-inferiorly at about an angle of 30 degrees or more. The error is usually to allow not enough inferior angulation and thus to engage the very upper part of the body and perhaps the disc (Fig. 9). The obvious reason for trying to keep the screw embedded entirely in the vertebral body is the avoidance of contact with the nerve root below; this complication occurred recently on one occasion when the screw was being directed into the root of the pedicle. This direction had previously been used routinely, without incident and with successful fusion, using somewhat shorter screws; it would probably be best to engage the pedicle because the cortical bone in that region would probably give better screw fixation than the spongy bone of the vertebral body.



FIG. 9

The screws between the fourth and fifth lumbar vertebrae are not directed low enough and barely engage the body of the fifth lumbar vertebra. One screw has broken during fixation.

SPONDYLOLISTHESIS

In spondylolisthesis, the body of the fourth lumbar vertebra is fixed to the body of the fifth by screws, and if the loose posterior element of the latter is not removed it is fixed to the sacrum by short screws. Of the forty-eight patients operated upon for spondylolisthesis, only a few complained of pain radiating to the lower extremities. In all but two this pain was not severe, subsided with rest in bed, and did not return after operation.

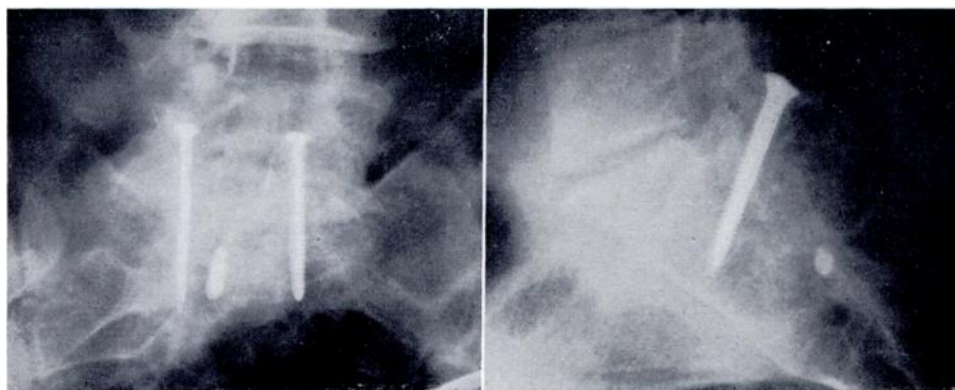


FIG. 10

These screws were placed at a right angle to the vertebral canal rather than obliquely and severe bilateral root irritation was present immediately after the lumbo-sacral fusion. The screws were thought to be responsible. Although signs and symptoms have persisted for several years, the patient refuses further surgery.

In the two mentioned, the loose element was removed and the root exposed. Otherwise, the operative technique is essentially the same and a long single plaster spica extending from just above the ankle to well up on the chest is applied, usually after removal of the sutures.

The patient is kept quiet in bed, except for routine breathing and tension exercises, until the plaster has been applied.

LAMINECTOMY AND SPINAL FUSION

Laminectomy was associated with spinal fusion either as a part of the same operation or as a previous procedure in half of the patients, and did not seem to influence the results unfavourably. Frequently several laminectomies had preceded spinal fusion.

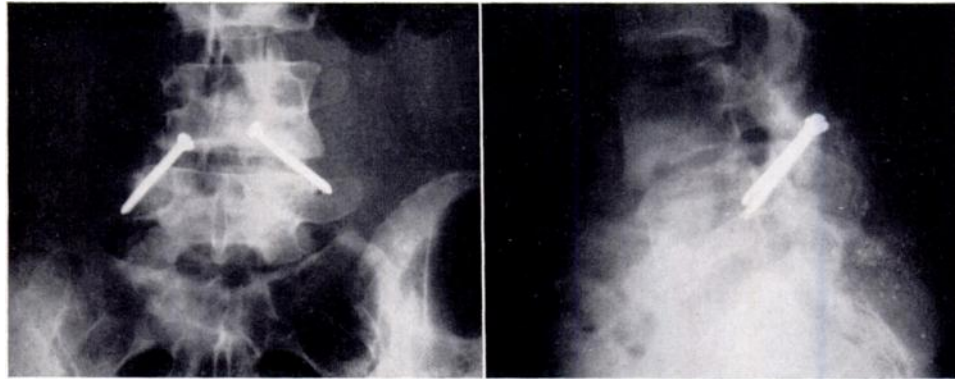


FIG. 11

Fusion at the lumbar 4-5 level produced severe nerve root irritation with sciatic pain and spasm, because the screw (shown on the left) was too oblique.

RESULTS

The usual immediate result of firm screw fixation is a disappearance of the backache. The patient is readily able to distinguish between this and the soreness after surgery, and frequently volunteers, in the early days after operation, that the original backache has

TABLE I
SINGLE LEVEL FUSIONS

Level	Number of operations	Number of known failures
L.S.	130	0
L.4 to L.5	27	0
L.3 to L.4	3	0

TABLE II
MULTIPLE LEVEL FUSIONS

Level	Number of operations	Number of known failures
L.4 to S.1	14	1
L.3 to S.1	1	1

gone and that, for the first time in years, he can lie comfortably in bed. Confidence in the final result develops quickly and the patient frequently has to be warned to restrict his early activity. It was possible to examine clinically all but a very few of the patients several months or years after operation and to obtain bending films in two planes.

This operation has been performed by the author with known results of fusion upon 175 patients with degenerative lesions of the disc in the low lumbar spine and upon forty-eight patients with spondylolisthesis. In the group of degenerative lesions, 130 were at the lumbo-sacral level, twenty-seven at the fourth and three at the third lumbar vertebra. There were fourteen multiple level fusions, thirteen including the fourth lumbar to the first sacral vertebra and one including the third lumbar to the first sacral vertebra. So far as is known, with all available means of testing for non-union, there was no failure in any of the lumbo-sacral fusions or in the single level fusions above the lumbo-sacral region (Table I). Two failures occurred in multiple level fusions (Table II). In one, an attempted fusion from the fourth lumbar to the first sacral vertebra, failure occurred at the fourth lumbar level. Both screws were loose at that level and, on exposure of the lower level, although fusion there was sound, both of those screws were found loose also. Re-fusion of the upper level was successful. In the other patient, a fusion from the third lumbar to the first sacral vertebra had been attempted before, for unknown indications, with failure at all levels. Three subsequent operations were done, two of them by the author, with repeated failure at all levels. On the last occasion, a large autogenous tibial graft was used, held in place by screws and supported by a long single spica from above the ankle to high up on the chest for twenty weeks. Progress radiographs showed that the tibial graft was undergoing absorption, and when the plaster was removed the patient, with an impish grin, bent down with movement at all levels of the spine and touched her toes without difficulty. A persistently positive Kahn test on the blood, unaffected by several heavy courses of penicillin, may have been a factor in the repeated failure of spinal fusion. When seen recently, some nine years since her last operation, she had few complaints of low backache, was still able to bend down and touch the floor and her central nervous system was apparently healthy. This patient had a sense of humour and one felt that her morale rose with each successive failure.

Spondylolisthesis—Of the forty-nine operations done for spondylolisthesis, pseudarthrosis developed in four (Table III). One of these which had failed at the fourth lumbar level was successfully repeated. One rejected the proposal of a second operation, stating that he was sufficiently improved, and the other two agreed to re-fusion but, after a lapse of several years,

TABLE III
SPONDYLOLISTHESIS

Number of operations	Number of known failures
49	4

nothing has been heard from either of them. In one instance a first-degree spondylolisthesis was present between the fourth and fifth lumbar vertebrae due to a unilateral pedicle defect in the former. Fusion of the fourth and fifth lumbar vertebrae only was done, no post-operative support was used and now, some seven months after operation, bending radiographs in two planes show no movement. The patient, with a Workmen's Compensation Board case, is pleased with the result to date and has completed his rehabilitation.

COMPLICATIONS

Deaths—None occurred in the series.

Infection—There were three instances of wound infection. Two were superficial, involving soft tissue only, and one involved bone. This man had been operated on unsuccessfully twice in another country at the lumbo-sacral level. Osteomyelitis on one side of the fusion area

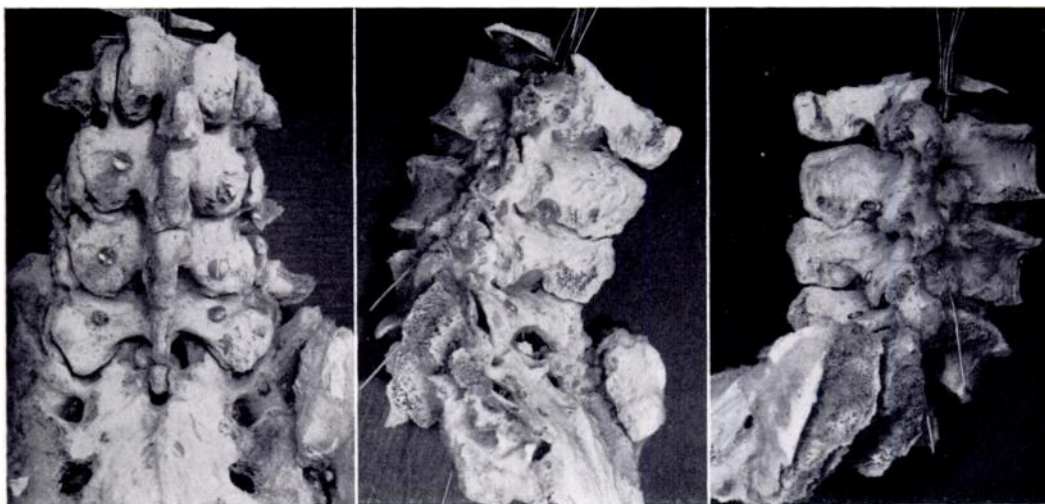


FIG. 12

Photographs of a cadaveric specimen with screw fixation. One screw can be seen emerging from the body of L.4 at the base of the pedicle, in the right-hand picture.

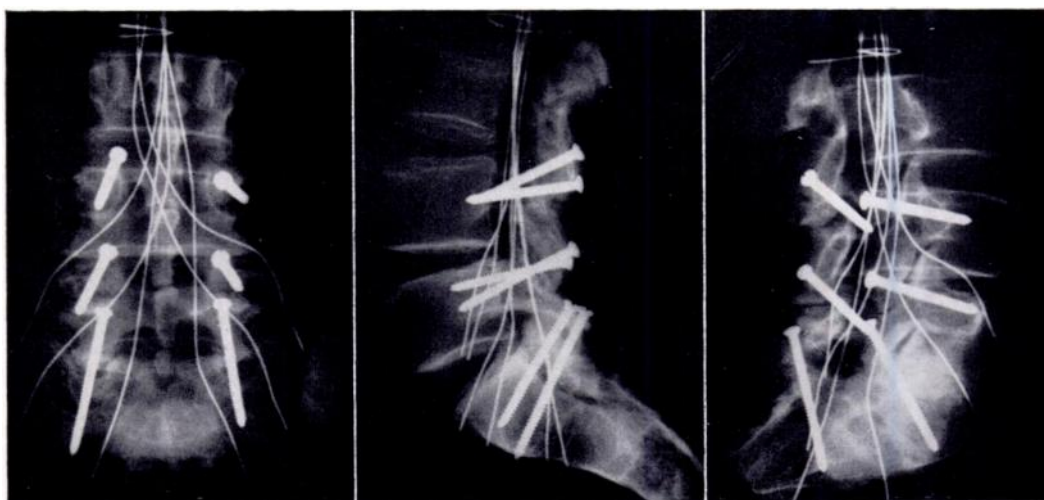


FIG. 13

Radiograph of cadaver specimen with screw fixation showing the relationship of the screws to the nerve roots. (Stainless steel wires have been passed along the nerve roots to show their position.)

developed after the operation by the author and the loose screw had to be removed. At that time the fusion area was seen to be solid, but when he returned to his own country some months later the wound was still draining.

Breaking of screws—Post-operative radiographs showed that one screw had broken in each of two lumbo-sacral fusions which in themselves were sound. As both patients were radiographed immediately after operation and about twelve weeks later, it was supposed that the screws had broken as a result of strain soon after the operation. One screw was seen to be broken in the radiographs taken immediately after operation (Fig. 9), but was not removed, and a sound fusion followed without delay. Bending of screws is not uncommon.

Nerve root irritation—This occurred on two occasions. One patient undergoing lumbo-sacral fusion for degenerative changes without signs in the leg developed severe sciatic pain and

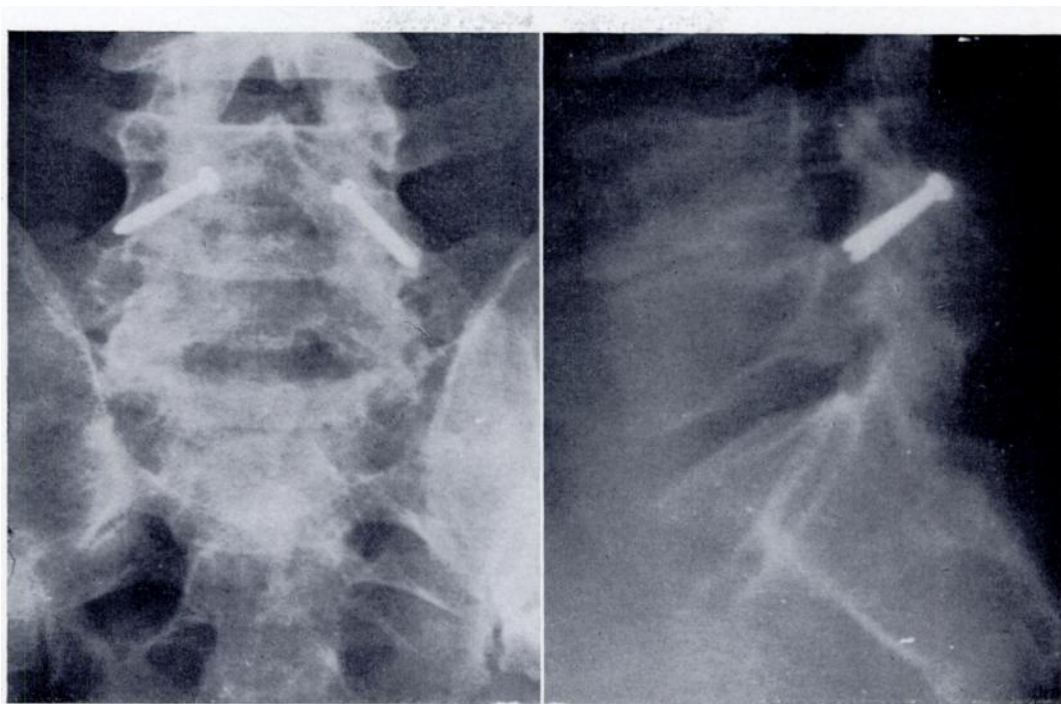


FIG. 14
A fusion at the lumbar 4-5 level in 1951.

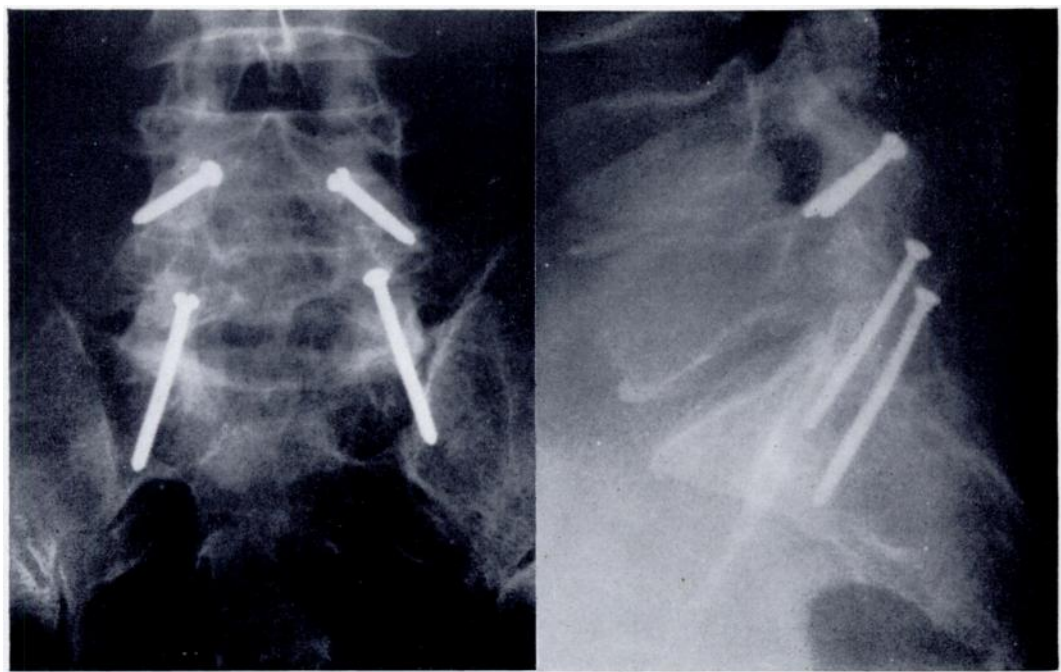


FIG. 15
Degenerative changes of the lumbo-sacral disc caused recurrence of backache in the patient shown above. Lumbo-sacral fusion in 1956, accompanied by laminectomy, gave complete relief.

spasm in both legs immediately after operation. The screws had been directed in an antero-posterior direction rather than obliquely (Fig. 10) and were identically placed. It was surmised that there was contact with the second sacral nerve root on each side. The signs and symptoms persisted for months, the pain gradually became less, but spasm remained with considerable hypoaesthesia. When the patient was last seen some three years after operation, forward bending and straight leg raising were still markedly restricted without pain, but considerable numbness was present. There has been no backache since the operation. Although the patient had been advised that removal of the screws would probably relieve the signs and symptoms of root irritation, further operation has been refused. Severe unilateral sciatica was present in one patient immediately after a spinal fusion between the fourth and fifth lumbar vertebrae. Radiographs (Fig. 11) showed that a poorly placed screw on one side had projected beyond the vertebral body to touch the nerve root as it emerged from the intervertebral foramen. The screw was partially withdrawn and the sciatica disappeared. This complication was due to an error in technique in both operations, and since it occurred only twice in this series it seems that there is sufficient margin for error to allow elimination of this complication by using greater care (Figs. 12 and 13).

Development of degenerative changes in the disc adjacent to the fusion area after operation—

This is known to have happened in two patients. A lumbo-sacral fusion for disc degeneration was done in a healthy young matron and was followed several years later by degenerative changes in the disc above. Review of the original radiographs showed early degenerative changes which had been overlooked. A heavily built man aged forty years developed degenerative changes in the lumbo-sacral region five years after fusion between the fourth and fifth lumbar vertebrae (Fig. 14). Successful fusion of these areas was followed by the disappearance of complaints in both of these patients (Fig. 15). It is to be expected that, in a longer follow-up of this series, other patients may develop degenerative changes at neighbouring levels, but the early incidence seems low. This development has been estimated by Friberg (1954) to be 8 per cent in his series.

Thrombophlebitis and embolism—There was no known instance of this complication in any of these patients.

CONCLUSIONS

In spinal surgery neither clinical nor radiographic examination can at times decide with certainty the question of success or failure in obtaining a sound fusion. Certain operations may not produce consistently good results when done by different surgeons, and no one operation may always be successful. An unusual physiological condition may exist in an apparently healthy patient which renders him unfit for bone surgery. Not uncommonly, non-union of simple single and multiple fractures occurs when reduction has been considered satisfactory and has been well maintained. Nevertheless, it seems that adequate splinting, such as is obtained by the use of long, well placed screws, the careful preparation of the fusion area and the addition of well packed cancellous bone will allow early activity and reduce the incidence of failure of spinal fusion.

SUMMARY

1. A relatively simple method of spinal fusion with internal splinting by screw fixation has been described. Complications have been few.
2. Emphasis is placed upon thorough removal of soft tissue, correct placement of screws of good length, the exposure of bleeding bone wherever possible in the fusion area, and the use of well packed cancellous bone.
3. There is enough spongy bone in one posterior superior iliac spine for an ordinary spinal fusion, and, if more is needed, the other is readily available through the same skin incision. Not only is cancellous bone more desirable than a massive cortical graft, but the leg is spared, allowing early walking and freedom from complications in the limb.

4. The lateral articulations are left intact.
5. Screw fixation has eliminated the use of external support except in spondylolisthesis, or when so much bone has been removed during laminectomy that good fixation cannot be obtained.
6. Early, sometimes immediate, relief of symptoms is usual after operation, and early walking with moderate activity is desirable.
7. When the operation was done for degenerative changes with no apparent defect in the laminae there was no radiological evidence of failure of fusion after operations at one level, but two failures were found after attempted fusions at multiple levels.
8. Root irritation from screw contact in two patients was due to faulty technique. A method of screw placement to avoid this complication is described and illustrated by radiographs and photographs of a cadaver specimen.
9. There has been no known instance of an adverse psychological effect from the use of screws. Rather, there has commonly been a lively and healthy interest shown in the factor which has allowed early activity.

I wish to express appreciation for the drawings by Nan Cheney, medical artist, University of British Columbia, and for the preparation of the anatomical specimen by Mr F. J. Nichols, Laboratory Technologist, Department of Pathology, Shaughnessy Hospital, Vancouver, B.C.

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