INTERNAL FIXATIVE DEVICE FOR ANTERIOR FUSION OF LUMBAR SPINE

Preliminary Experimental Report

ALFRED W. HUMPHRIES, M.D.,
Department of Vascular Surgery

WILLIAM A. HAWK, M.D.,
Department of Pathology

and

ALBERT L. BERNDT, M.D.*
Department of Orthopedic Surgery

SINCE Hibbs first proposed spinal fusion in 1911, the problems inherent in the operation have heretofore remained essentially unsolved. With the posterior approach, interlaminar or interspinous fusions with or without joint-facet fixation generally require a prolonged period of postoperative immobilization and an even longer period of convalescence. All of the various technics of fusion occasionally or frequently cause pseudarthrosis. Posterior fusion has an inherent mechanical disadvantage in that the support to the involved vertebrae is developed posterior to the axis of spinal flexion and extension; therefore, the everyday motion of flexion of the lumbosacral spine may cause distraction at the site of fusion. Since distraction predisposes to slow union or nonunion of bone, flexion of the spine following posterior spinal fusion must be prevented until the healing is complete.

To circumvent these problems and to permit early postoperative mobilization, anterior fusion of the spine, using a transperitoneal approach, has been proposed.[1] This procedure frequently has failed, presumably because motion has occurred at the site of intended fusion. There are conceptual advantages to the interbody site for spinal fusion. It offers a large surface area for fusion, and a sufficient amount of bone to permit intervertebral metallic fixation if this seems desirable. In patients of all ages, the blood supply in the cancellous bone of the vertebral bodies is excellent. Since the vertebral bodies are anterior to the axis of spinal flexion and extension, the normal motion of vertebral flexion is not only permissible in the early postoperative period but even desirable: this motion causes compression at the fusion site and enhances the union of the one vertebral body to the other.

**Formerly Fellow in the Department of Orthopedic Surgery; present address, 1304 Gallia Street, Portsmouth, Ohio.*

It is the purpose of this paper to record a new technic for anterior transperitoneal fusion of vertebral bodies, which utilizes an intervertebral clamp and a bone graft, and to report our preliminary experimental results with that technic.

Indications for Fusion

Many anatomic structures have been implicated in the etiology of low-back pain. Bone, cartilage, joint capsule, muscle, and ligament each has had its proponents. During the last 15 years, posterior displacement of an intervertebral disc in the low-lumbar area often has been a popular cause of low-back pain. In some patients having recurrent attacks of pain in the low back with irritation of the nerve root in one or both legs, roentgenograms show a narrowed intervertebral space. These degenerated intervertebral discs occur frequently in persons 40 years or more of age. When degenerated discs occur in persons younger than 40, they usually are the result of acute severe trauma or the late result of a laminectomy for removal of a disc.

Although narrowed intervertebral spaces frequently are observed in patients who are asymptomatic, they characteristically occur in those who have lumbosacral back pain, the severity of which is directly related to the amount of stress placed upon their backs. To avoid back pain, such a patient must restrict his activities. The pain generally will be relieved when the patient lies down or when his back is protected with a brace or corset. A patient having a degenerated intervertebral disc primarily has low-back pain and occasionally leg pain in the sciatic distribution. Contrariwise, a patient having a ruptured intervertebral disc primarily has leg pain in the sciatic distribution and occasionally back pain.

The candidate for spinal fusion is the patient with a degenerated lumbar disc who has frequent disabling low-back pain. This pain may be associated with some small amount of irritation of nerve root in the buttock and upper thigh, and tends to be precipitated by movements of the back and relieved by supporting the back or by lying down.

Technic of Fusion

There are four factors essential to the rapid union of bone regardless of location: (1) adequate blood supply, (2) adequate bone contact, (3) absolute immobilization until the bone is healed, and (4) absence of distraction even to the point of providing compression. A technic of arthrodesis of the intervertebral body has been developed to fulfill these requirements.

In brief, this technic consists of an anterior transperitoneal approach to the appropriate intervertebral disc space. The anterior common ligament is dissected away for visualization of the area, and the entire intervertebral disc and its remnants are excised. The opposing cortical plates of the adjacent vertebral bodies are removed, and the cancellous bone of the vertebral bodies is entered to provide adequate blood supply. Bone contact is afforded by packing the created space with fragmented homogenous cancellous bone. Immobilization and compression are both attained through the use of the intervertebral clamp illustrated in Figure 1.

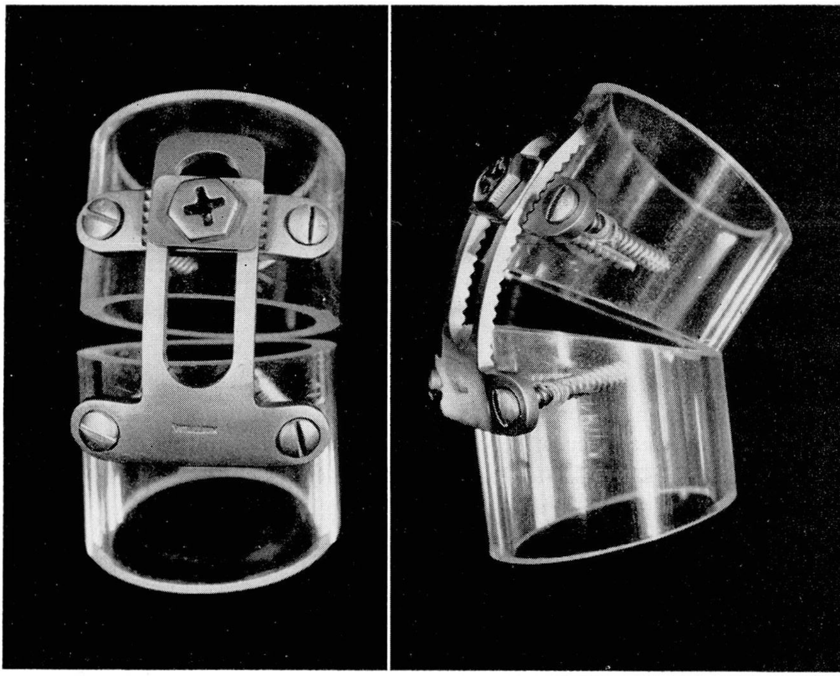

Fig. 1. Two views of the intervertebral clamp mounted on plastic tubing.

Experimental Data

Thirteen dogs, unselected adult mongrels of both sexes, were utilized in this study. Ten of the 13 dogs were operated upon according to the above-described technic utilizing an intervertebral clamp for immobilization, and the remaining 3 dogs underwent identical procedures with the exception that the internal fixative device was not employed. Immediately after fusion of two lumbar vertebrae, all 13 dogs were permitted volitional activity. All animals were sacrificed from 1 to 24 weeks after operation.

Each of the 10 dogs with internal metallic fixation had an uneventful course after surgery, and apparently moved about in a normal canine fashion. The postoperative course in each of the three control dogs was one of decreased and restricted motion with an apparent lack of desire to move and with some evidence of pain during the first few postoperative weeks.

In each dog at necropsy, the fused segment of spine including two vertebrae above and at least one below the arthrodesed joint was removed in toto and cleaned of surrounding soft tissue. Roentgenograms in both the anteroposterior and lateral projections were made, and the specimens were then fixed in Zenker's solution. The intervertebral clamps were removed from the fused segments, and these segments, together with those from the control animals, were bisected in the sagittal plane. In each of the 13 dogs, one of the halves thus obtained was kept as a gross specimen and the other was utilized for microscopic slides. Since all animals were sacrificed at relatively early stages of healing, stress studies were not performed.

The microscopic sections of the specimens from the 10 dogs in which internal fixation had been employed showed the typical progression through the various stages of endochondral bone formation. The sections of the specimens from the control dogs showed the typical progressive stages of the development of a pseudarthrosis.

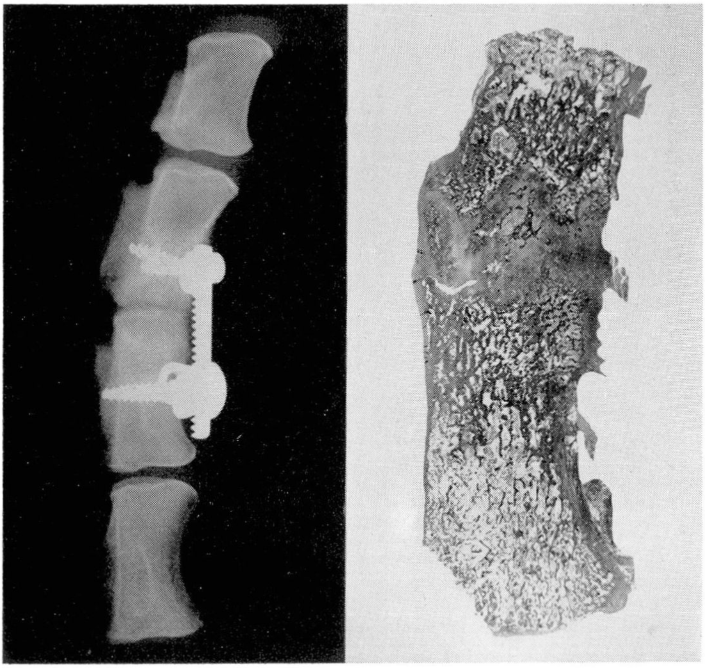

Fig. 2. (4-week specimen) *Roentgenogram:* Intervertebral space absent; vertebral cancellous plates absent. No evidence of osteogenesis. *Photomicrograph:* Defect between vertebral bodies bridged by granulation tissue containing cartilaginous islands (callus) and fragments of necrotic bone (bone-graft chips). Osteoblastic hyperplasia with early new-bone formation was present at margins of defect but is not visible in this photomicrograph. Hematoxylin-eosin—methylene blue; X 3½.

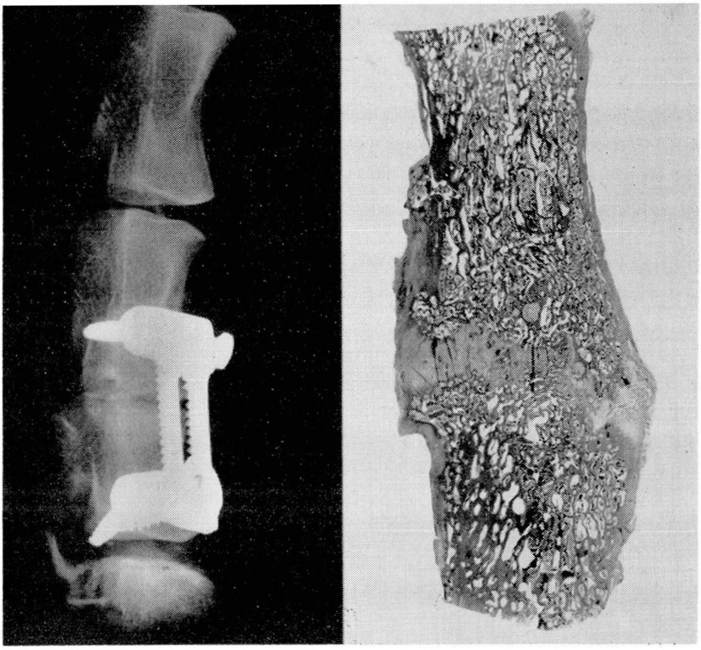

Fig. 3. (6-week specimen) *Roentgenogram:* Joint space obliterated; vertebral cancellous plates absent; no evidence of osteogenesis. There was no motion with clamp in place; free movement when it was removed. *Photomicrograph:* Vertebral bodies united by dense callus; in vicinity of defect the bone trabeculae are thickened and adjacent osteoid bars indistinct. Bone-graft chips are not evident. Hematoxylin-eosin—methylene blue; X 3½.

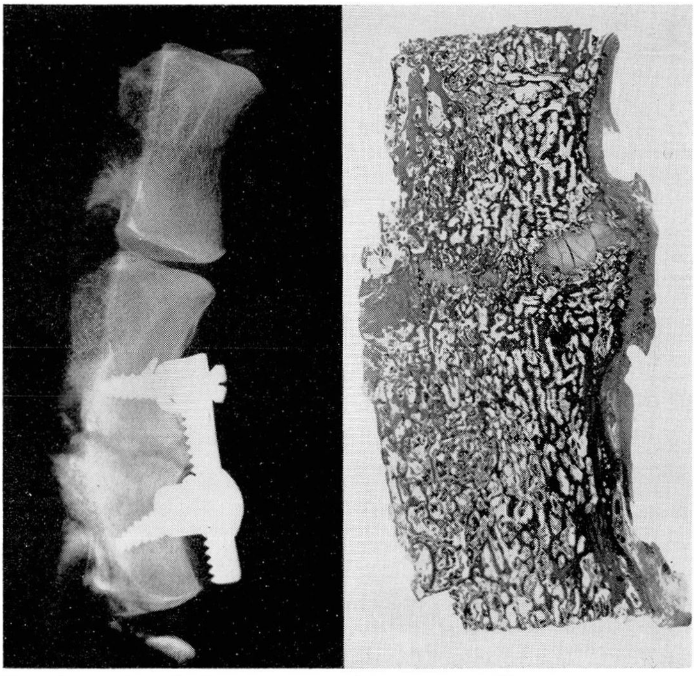

Fig. 4. (15-week specimen) *Roentgenogram:* Joint space obliterated; intervertebral cancellous bone plates absent; early bone formation seen in lateral view. An anteroposterior projection of the specimen showed lateral proliferation of bone at the site of fusion. Vertebral bodies were not movable one upon the other with or without fixative device. *Photomicrograph:* New bone trabeculae patchily unite the vertebral bodies; intervening cartilaginous islands present with foci of normal endochondral bone formation. Hematoxylin-eosin—methylene blue; X 3½.

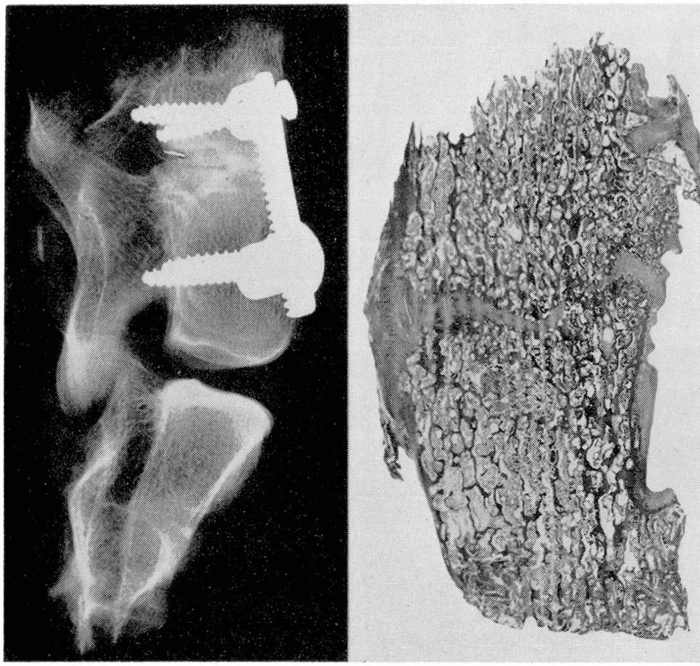

Fig. 5. (24-week specimen) *Roentgenogram:* On lateral projection there is completely normal bony architecture in the anterior one third of the fusion site; the posterior two thirds still shows lack of complete bony union, although some trabeculae appear to bridge the space. *Photomicrograph:* Further advancement of bony union, but still incomplete. Fibrocartilaginous islands present in posterior two thirds. After removal of clamp, union was solid. Hematoxylin-eosin—methylene blue; X 3½.

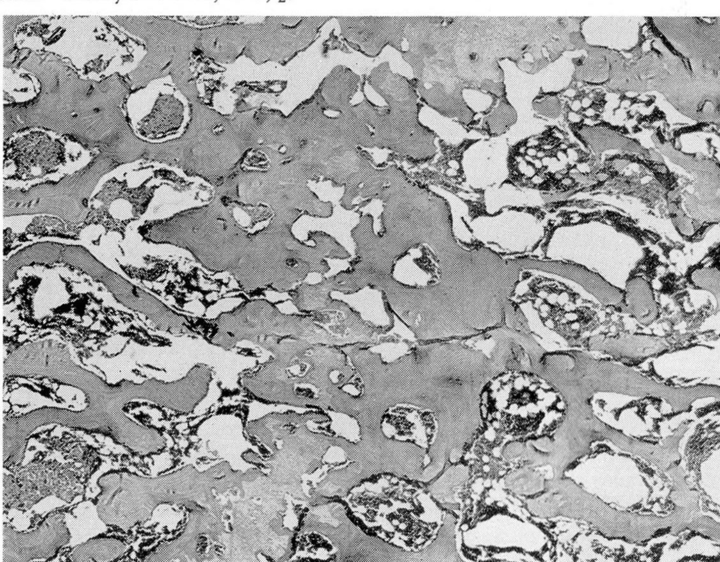

Fig. 6. Photomicrograph of a section taken from the anterior one third of the fusion site of the 24-week specimen showing the character of the bony union of the vertebral bodies. Small islands of fibrocartilage still are present superiorly and inferiorly in the photomicrograph. Hematoxylin-eosin—methylene blue; X 35.

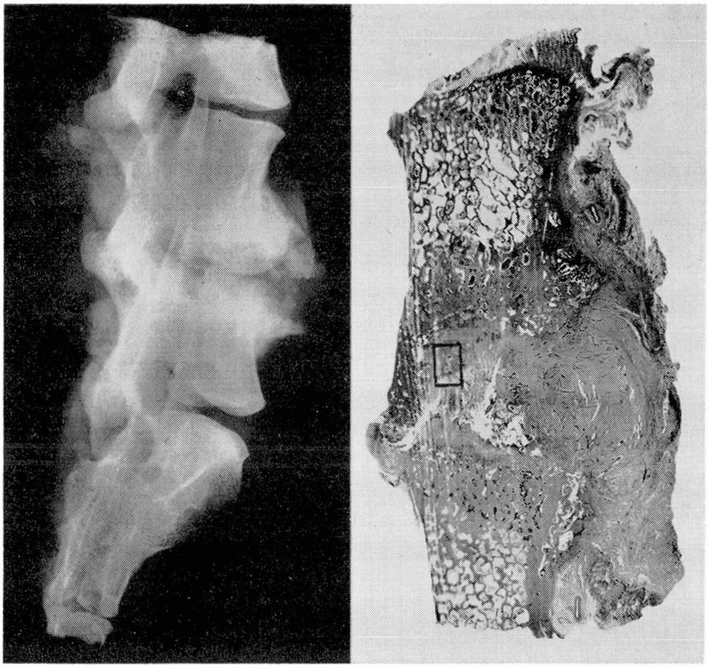

Fig. 7. (24-week control) *Roentgenogram:* Intervertebral space diminished; marked irregularity of joint space with scattered proliferation of new bone in general area in both anteroposterior and lateral projections. Obvious pseudarthrosis with some posterior luxation of the proximal vertebra on the distal. *Photomicrograph:* Peripherally, vertebral bodies joined by dense fibrous tissue; centrally, an excavation between the vertebral bodies containing necrotic bone spicules and old granulation tissue. Marked thickening of the ends of the vertebral bodies (eburnation) in part covered by an irregular layer of cartilage. Grossly, there was no stable union, the parts being readily movable on each other. Hematoxylin-eosin—methylene blue; X 3½.

Fig. 8. A higher power view of the area marked by the rectangle in Figure 7. Dense fibrous tissue, fibrocartilage, and granulation tissue are the principal components. In the center of the field are a few isolated bone trabeculae, partially surrounding the islands of granulation tissue. Hematoxylin-eosin—methylene blue; X 35.

For the purposes of this brief report, findings in only selected dogs are presented, namely those dogs in which necropsy was performed 4, 6, 15, or 24 weeks after the procedure with internal fixation, and 24 weeks after the procedure without internal fixation. The roentgenogram of the pathologic specimen and the low-power photomicrograph of the histologic section for each of these five dogs are shown in Figures 2 through 8. All the remaining animals showed a degree of bone formation that was consistent with the length of time between operation and sacrifice of the animal. Figures 9 and 10 show in chronologic order the roentgenograms and photomicrographs of the specimens from each of the five selected animals.

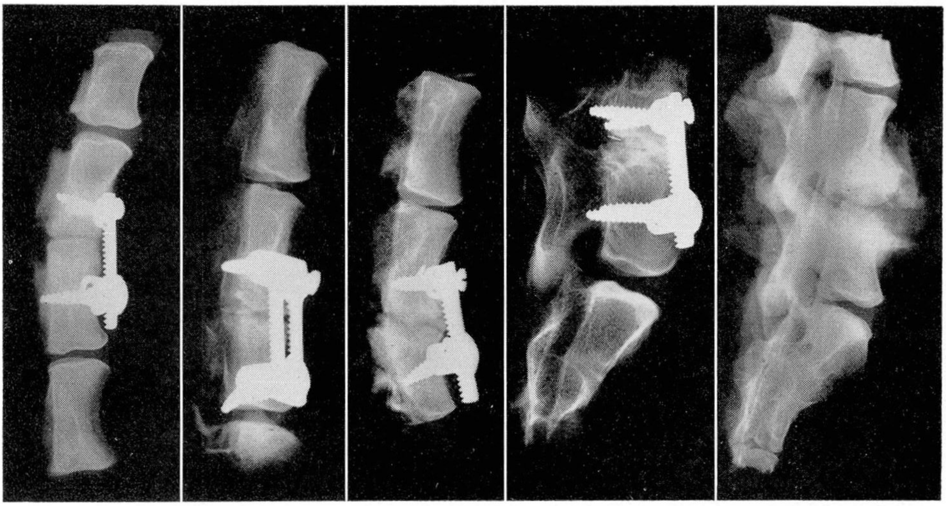

Fig. 9. A panorama of the lateral-view roentgenograms of the necropsy specimens arranged in chronologic order and showing the progression of bony union. From left to right, 4-week, 6-week, 15-week, and 24-week specimens, and 24-week control specimen.

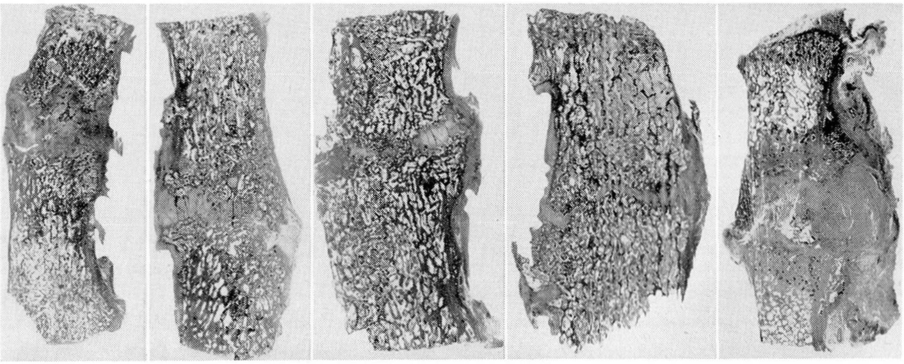

Fig. 10. A panorama of the photomicrographs of the necropsy specimens arranged in chronologic order. From left to right, 4-week, 6-week, 15-week, and 24-week specimens, and 24-week control specimen. Hematoxylin-eosin—methylene blue; X 3½.

Conclusions

A series of 10 dogs was operated upon utilizing a new technic of spinal arthrodesis based upon the concept that grafting of vertebral bodies combined with metallic fixation should provide a high incidence of successful fusion and a minimum of postoperative morbidity. Three additional dogs were operated upon in the same fashion but without the use of an internal fixative device. Each of the 10 dogs in which internal fixation was utilized showed the degree of healing that would be optimally expected for the duration of life permitted after operation. Each of the three control dogs developed or was developing pseudarthrosis, clearly indicating that adequate immobilization is essential for the consistent production of bone fusion between vertebral bodies. Further experimental fusions have been performed with the intent of studying results after one year.

Reference

1. Lane, J. D., Jr., and Moore, E. S., Jr.: Transperitoneal approach to intervertebral disc in lumbar area. Ann. Surg. **127**: 537-551, March 1948.