Arthrodesis by the Distraction-Compression Method Using a Stainless Steel Implant

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ABSTRACT: A new process for arthrodesis in humans is presented. The process has been used successfully in the cervical spine of horses and has potential for human use. The concept is encompassed in the process of an anterior cervical fusion and is an adaptation of that established practice but using an implant of stainless steel containing autogenous bone graft to encourage through-the-implant growth of bone. In the future, it may have use in the human spine and other joints.

Introduction
Arthrodesis of joints and across disk spaces has always been a significant part of orthopedics. Improved techniques of arthrodesis have depended significantly on the improvements of implants to internally fix the bony fragments. Although indications for fusions have changed through the years, three consistencies encourage early union and lowered incidence of pseudarthrosis: meticulous surgical technique, the utilization of fresh autogenous bone of adequate mass, and improved fixation devices. The new process described in this article encompasses the process of anterior cervical fusion reported by Cloward.1

Internal fixation of fractures with bone plates was first reported by Hansmann2 in 1886 and more successful results were reported by Lane3 in 1914. Advancements in internal fixation followed as metals became stronger and more acceptable to the body in addition to the incorporation of compression.4,5

Internal fixation of the spine to encourage arthrodesis is more difficult than fracture fixation. Spine fixation was first reported by Hadra6 in 1891 using wires about the spinous process. King reported the use of facet screws in 19447 while Wilson and Straub8 in 1952 reported the use of a bone plate anchored to the spinous processes.

Early attempts were made to create fixation with the bone graft material itself, such as the Gibson technique, or the "clothes pin" or H graft.9 Generally, bone graft material has been selected to stimulate osteogenesis or provide a lattice work for new bone formation with fixation being a separate endeavor.

In the Cloward technique involving the anterior cervical spine, the graft for the arthrodesis has been singularly successful in creating an excellent fixation and is biomechanically centrally placed. A shortfall of this technique, however, is the need to choose from obtaining an autogenous graft from the iliac crest or utilizing bank bone with its various disadvantages. Furthermore, the lack of a suitable size single dowel of bone and the difficulty of the anterior approach makes this technique less applicable to the lumbar spine. The dorsal approach to the lumbar spine is more accessible, but is limited by the restricted window exposure for such an interbody fusion.

Bases for this study includes work with veterinarians. One of their unsolved problems was the Wobbler syndrome in horses. This is an instability of the cervical spine in young thoroughbreds most commonly at the C3-C4 level, apparently due to maldevelopment of the facet joints. Most of these horses become ataxic and are euthanized. Various fusion techniques had been unsuccessful before attempting the Cloward technique. The technique was perfected in horses.10 Removing the bone from the iliac crest was a significant disadvantage, therefore, a bone bank was established to provide cadaveric grafts from

Presented at the annual meeting of the North American Spine Society June 1987, Banff, Alberta, Canada.
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other horses. This, however, created added expense and time, therefore a better solution was sought.

The works of Karagianes and Galante using bone-to-implant fixation were considered, but were not practical. This led to the development of this stainless steel implant. Rather than a solid cylinder of bone, a hollow cylinder of steel filled with bone chips harvested from drilling across the disc space in preparation for receiving this implant was used. Removing the disk or bony impingement on the neural structures was done consistent with the techniques of Cloward and Smith and Robinson.

Materials and Methods

The utilization of this stainless steel implant in horses has been reported by DeBowes. In his investigation, 16 healthy horses were operated for anterior cervical fusion using the Cloward technique. In eight horses, xenograft dowels (bovine) were used, the other eight horses received the stainless steel implant (stainless steel basket or SSB). Bone chips harvested in drilling across the disk space were placed into the implant. No external fixation was used. At 6 months postoperatively, the animals were killed and evaluated for evidence of bony arthrodesis. They were examined by x-ray and by gross examination of the fusion site, thin section x-rays, and histologic sections. Examination showed evidence of bone union in two of the eight xenografts. Seven of the eight fused with bone using the SSB (Fig. 1). The comparison of these two groups was not practical in that the SSB was created of ideal dimensions and the xenografts could not be reproduced at the exact same time.

The results of a preliminary study by Wagner, in which dowels of bank bone from other horses were used, showed the same incidence of successful fusion when compared to the use of SSB in DeBowes' study. Again, this is not a comparable study, the animals in the earlier study had Wobbler syndrome while the latter study used healthy horses.

This implant is not available for use in the human at this time. Potentially, the SSB could be used with local autogenous bone in the anterior cervical spine in the human (Fig. 2). The advantage is that it avoids the need for a second incision to obtain an autogenous graft or the need to use bank bone. It would, however, carry the disadvantage of potentially migrating either anteriorly or posteriorly. In studies involving the horse cervical spine, it did not migrate into the spinal canal but did migrate anteriorly on rare occasions. This may have been associated with imperfect technique of implantation, but nonetheless continues to be a significant consideration. The veterinary experience showed no difference in the bone dowel and the metallic implant in their tendency to migrate. One concern in this connection is the nature of the pathology around the implant in the event of nonunion. If pseudarthrosis occurs with a bone plug, the graft tends to absorb or become rounded and, therefore, less likely to migrate than an implant of steel. Postoperative infection would be a special complication which would vary with associated nonunion or bony union. The implant would potentially need to be removed and this may be difficult; a
cylinder saw larger than the implant would be needed.

Although the ongoing surgical techniques are excellent when carefully carried out, the complication of neural trauma would not be improved by use of an SSB. The SSB does not have a place in the routine care of cervical fusions in the human at this time.

A second consideration would be the interbody fusion of the lumbar spine (Fig. 3). In this case, available single autogenous dowels are not large enough. Although a dowel may be cut large enough in circumference, it would not be large enough in depth or vice versa. Multiple pieces would disturb the fixation potential when compared to a single implant. An anterior approach using the SSB may be feasible in the future. A posterior approach is discouraged because of the limited window of exposure to the disk space.

The ankle joint and the subtalar (Fig. 4, 5) joint are reasonable considerations for the SSB and two implants may be more suitable than one (Barnett RM, personal communication). The arthrodesis should not be limited to the implant itself but bony union should be encouraged around it by denuding the cartilage and “fish scaling.” External fixation should be strongly considered in peripheral joints such as the ankle; although it would appear that the experience with the horse cervical spine and the fetlock joint would indicate that this type of internal fixation is excellent (Crawley GR, 1987, unpublished data).

Figure 6 illustrates the distraction-compression fixation. It would appear that with the intact annulus that triangulation is accomplished and renders excellent fixation. However, it is to be emphasized that the annulus may not be intact and that at least a portion of the annulus is destroyed in the process of implantation.

Discussion

A reliable and quick arthrodesis process would be a significant advancement in orthopedic surgery. The SSB utilizes autogenous bone and reflects a method of improved fixation. This is supported by veterinary experience. Clearly, the stresses are different in the
horse and these differences would expectedly be impossible to accurately measure. However, the experience shows the presented fixation method to be excellent and worthy of consideration in the human subject.

**Conclusion**

The SSB has potential use in the human. The utilization of distraction-compression fixation creating triangulation is partly conjecture. Practically, it appears to be an excellent form of fixation as illustrated in its use with horses. It also provides a means of utilizing autogenous bone with its inherent advantages. It would appear that the horse is an excellent animal model for testing such an implant. Compression continues to be a questionable factor as it contributes to osteogenesis, whether it is by direct compression or by distraction-compression. This implant offers a reproducible consistent environment for investigating the osteogenic potential of various substances such as autogenous bone, heterogenous bone, hydroxyapatite, or mixes of bone with blood, etc.

**References**