THE HARTSHILL HORSESHOE A NEW DEVICE FOR ANTERIOR SPINAL FIXATION

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Anterior spinal fixation aims to achieve mechanically and biologically sound fusion between adjacent vertebral bodies. Current techniques are biomechnaically poor, and do not lake account of cyclical flexion and torsion loads which can result in graft extrusion and pseudarlhrosis. We have designed a new device to improve on currently available techniques. The implant is placed in the excised disc space, maintaining the disc height and avoiding the major vessels. 'There is greatly improved torsional satibilty. The bone graft is contained in the centre of the device, and cannot extrude.

The device has been implanted in 12 patients, the longest for 18 months. Initial results are good, with radiological evidence of sound fusion, but the carbon fibre epoxy material has proved to have some undesirable features. We conclude that the basic concept and shape are satisfactory, but that the material is less than ideal. We are currently assessing different materials and fabrication techniques to achieve an implant which is biomechanically stable and has osseo-integrative properties.

Key Words : *Discectomy, anterior spinal fusion, carbon fibre.*

The purpose of anterior spinal fixation is to achieve mechanically and biologically sound fusion between adjacent vertebral bodies. There arc a number of techniques currently in use, but the common techniques are biomechanically poor, and do not take account of the loads exerted on the disc space and fusion mass. Consequently, there arc a number of problems associated with this type of surgery.

Spinal surgeons arc aware that the results of anterior vertebral interbody fusion arc much less reliable than the results of posterior surgery (1,3). In certain cases, however, there is no alternative to an anterior approach. The syndromes associated with a posterior annular tear of the disc, or with internal disc disruption or isolated disc rcsorption arc becoming increasingly recognised, (4,5) due largely to the advent of MRI scanning. These patients respond in many cases to excision of the disc and fusion. The disc excision must, however, be thorough, and this calls for anterior surgery as described.

At present, anterior intcrbody fusion is commonly performed by excising the disc material, currcling the vertebral end plates and packing the cavity with bone garft (6). A variety of bone graft materials may be used, with or without internal fixation. This is less than ideal. The loads on each motion segment of the spine are complex and numerous, and have been described in detail by White and Panjabi (7). The major loads on the inlcrvcrtcbral disc, or in this case on the bone graft, arc compression and torsion.

These forces combine to result in the extrusion of the bone graft, with loss of disc space height and consequent root compression, and possible painful pseudarthrosis.

Other problems with the established techniques include donor site pain from the iliac crest wound, (8) and protrusion of the fixation device into the body cavity, endangering the great vessels.

We felt that improvements in the methods of fixation and the implants were possible, and therefore examined the feasibility of an improved device.

MATERIALS AND METHODS

We designed a new device for intcrbody fusion, which would take account of the loads and stresses expected in this area, and therefore increase the reliability of the surgery. There were a number of requirements for the new device. It should not threaten the major vessels, and must accomodate bone graft or bone graft substitute. In addition, it should be biocompatiblc, easy to use, have adequate strength and permit removal if required.

The early development of the Hartshill Horseshoe has been previously presented (9). The current device

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is made from laminated carbon-fibre reinforced epoxy resin. Previous studies and papers have shown this material to be biocompatible, and mechanically suitable a fixation device, particularly as **a** bone plate. It has been used for some time as a plate for internal fixation of long-bone fractures (10).

We carried out a thorough biomechanical evaluation of the horseshoe. Initial stiffness and cyclical loading in flexion, compression and torsion under various conditions was measured.

The central core of the horseshoe is filled with autogenous bone graft, or a bone graft substitute -at present we use Surgibonc (Unilab Inc.)- or a combination of the two. The device is then placed in the excised disc space, and fixed firmly into position using standard AO cancсllous bone screws. The device is completely within the confines of the vertebral column, as arc the screws, and thus avoids the major vessels. The bone graft is contained within the centre of the implant, and cannot extrude. The horseshoe is complctly radiolucent, and allows X-ray assessment of graft incorporation and union.

We have now been implanting the Hartshill Horseshoe for over one year, and have implanted it into 12 patients. The prcopcralive diagnoses were internal disc disruption in three, disc degeneration or resorption in five and posterior annular tears in four. Their ages ranged from 26 to 52, with a mean of 41. There were seven female and five male patients. Average hospital stay was 12 days.

RESULTS

Biomechanical testing

Initial stiffness in flexion, compression and lateral bending is adequate and similar for all the techniques which were compared. Torsional stiffness, which is probably the most important factor in preventing the extrusion of the graft, is much improved with the horseshoe.

Table
Initial stiffness coefficients of anterior spinal fixation devices

Device	Compression kN/m	Flexion N/m	Rotation Nm/radian
Intact	200	100	4.9
Bone Graft	260	170	5.4
Graft * AO plate	440	180	8.2
Horseshoe	370	170	10.4

Patient Results

Our results arc encouraging. We have had no mechanical failures of fixation, and there is radiographic evidence of union in all cases. This has appeared as early as three months post-opcrativcly. The implant is radiolucent, which allows accurate visualisation of graft consolidation. All patients have improved clinically compared with their prc-opcrative status. We have had one man who returned to heavy employment four months after surgery. Prior to surgery, he had been unable to work for over two years.

We have had two complications. In one case there was troublesome bleeding from an abcrrent ilio-lumbar vein, but which was controlled, and the operation proceeded with. One man had transient disturbance of sexual function, which has now completely resolved.

DISCUSSION

Anterior spinal surgery is specialised, complex surgery, with a frequently unpredictable result (1-3,11). The large number of materials, methods and implants available or proposed simply indicates that the ideal method has not yet been found. We feel that the mechanical shape of the horseshoe is suitable for it's purpose, and satisfies most of the ideal characteristics of an anterior spinal device. We have had no particular difficulties in implantation, and the two complications we have experienced arc attributable to the operative approach for anterior spinal surgery, and do not reflect on the device. We have found no evidence of any problems with the device itself. There are no signs of either the horseshoe or the screws shifting in position. We therefore feel that the basic design has proven itself so far, but the current carbon-fibrc-cpoxy composite material has proved to have some undesirable features, mainly **a** tendency to dclaminate after prolonged mechanical testing.

Our patients have generally been satisfactory, and complications have been few and minor. None of our patients have required prolonged immobilisation or external support post-opcrativcly. The main benefits of the implant arc secure fixation and reliable graft incorporation, reducing the morbidity and expense traditionally associated with anterior spinal surgery. We conclude that the basic concept and shape of the device are satisfactory, but that the material is less than ideal. We are now assessing different materials and fabrication techniques to achieve an implant which is biomcchanically stable and has oscointcgralive

techniques. Materials under investigation include polymers, ceramics and composites, with particular emphasis on hydroxyapatite based materials.

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