EXPERIMENTAL INTERVERTEBRAL FUSION USING BASIC CALCIUM PHOSPHATE*

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In recent years, a desire to improve the results in the operative treatment of ruptured intervertebral discs has caused many orthopedic and a few neurological surgeons to combine disc removal with fusion of the spine by bone grafting on the lamina or dorsal spines.2,8 Such a procedure has been considered unwarranted by most neurological surgeons.1,9,11 They feel that adequate simple disc removal gives very satisfactory results. A more recent approach has been suggested by Cloward,3 who uses a wedge-shaped bone graft driven into the evacuated intervertebral disc space to achieve “intervertebral fusion” and maintain a normal intervertebral distance. More recently Lindblom and Hultqvist7 have proved that a protruded or ruptured nucleus pulposus may be completely absorbed, and thus advise only an anterolateral decompression of the disc space.6

The proponents of these several methods of treating herniated discs all claim good results. Barring gross discrepancies in the various reports, it seems possible that a common critical factor may exist in all these various operative methods to explain the comparable results claimed. The only operative step common to all these procedures is the evacuation of the intervertebral disc space at the level of the rupture. It has been generally recognized that this does result in at least a fibrous if not ultimately a bony union between the vertebrae,5 though this has not been widely studied. There may be indirect evidence that such immobilization is an important factor since occasional patients who fail to respond adequately to the minimal disc removal show improvement following spinal fusion at a later date. Presumably if an early and complete intervertebral fusion could be achieved by a surgically benign procedure, the incidence of poor clinical results could be further minimized.

No extensive experimental or clinical evidence is available concerning the fibrous intervertebral fusion which supposedly follows complete removal of the intervertebral disc. The present investigation was proposed to determine two things: first, the effectiveness of the intervertebral fusion produced in monkeys following simple disc removal and curetting of the cartilaginous plates; and second, the effect on this fusion of synthetic

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hydroxyapatite introduced into the disc space at the initial operation. Synthetic hydroxyapatite is a crystalline basic calcium phosphate (BCP) the crystals of which show the same X-ray diffraction pattern and practically the same chemical and physical properties as bone. It is already known that when these crystals come in contact with the fresh bone surfaces the synthetic hydroxyapatite apparently acts as an “ossifiable medium” and thus promotes more rapid bone healing.¹⁰

MATERIALS AND METHODS

Eighteen monkeys, Macaca mulatta, 9 males and 9 females, were used in this project. Their weight ranged from 3.2 to 4.1 kg. Disc evacuation was done in 5 animals without introduction of BCP. In 2 of these, the nucleus pulposus alone was removed; in the remaining 3 monkeys, the disc space was completely evacuated and the cartilaginous plates were curetted down to bone. In 13 animals, the nucleus pulposus was removed and replaced by BCP paste; in 6 of these the cartilaginous plates were curetted. The paste was made by mixing 2 parts of powder with 1 part of saline. A single intervertebral space was evacuated in each animal though the level varied from L2 to L5. Motion of the normal lumbar spine was studied by X-ray in 3 animals.

After taking pre-operative lateral X-rays of the lumbar spine, the usual operative procedure was as follows:

The animals were anesthetized with nembutal, and the prevertebral space was reached either transperitoneally through a transverse abdominal incision or extraperitoneally by a paravertebral incision. The desired interspace was located and the annulus fibrosus was incised in the form of a U-shaped flap on its anterior or anterolateral surface. The jelly-like nucleus pulposus spontaneously protruded and was completely removed with a small spatula. The chondral surfaces of the adjacent vertebral bodies were curetted in certain cases, while in the others the cartilaginous plates were left intact. By means of a dental amalgam carrier, BCP paste was inserted into the evacuated interspace. The flap of the annulus fibrosus was then replaced and secured by a black silk suture. Muscles, peritoneum and skin were closed in a routine manner.

Postoperative lateral X-rays of the spine were taken immediately and repeated approximately every 2 weeks.

The physical activities of the animals were not restricted postoperatively. Animals in each group were sacrificed at about the 4th, 5th, and 6th month.

During the observation period, a needle was inserted under sterile conditions into the dorsal spine above and below the interspace evacuated at operation. These were used as X-ray markers to measure lumbar spine motion in hyperextension and flexion. A series of three such X-rays was taken in each animal prior to sacrifice. After sacrifice the animals were perfused with formalin, and the two vertebral bodies at the operative level were removed in one piece, fixed in formalin and decalcified. These speci-