FUSION OF VERTEBRAE FOLLOWING RESECTION
OF INTERVERTEBRAL DISC*

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THE ideal surgical treatment of disease of the intervertebral disc is still under discussion. Combination of discectomy with bone-graft fusion of the spine has been recommended in order to diminish the frequency of unsatisfactory sequelae following operative treatment of the degenerated intervertebral disc.4,13 Dandy,9,10 however, stated that “spinal fusion in disc cases is absolutely unnecessary; all one has to do is curette out the nucleus pulposus and the joint will fuse itself.” This statement, so far as we know, was not yet confirmed by post-mortem examination in man. It is, therefore, the purpose of this communication to present 2 cases in which radical discectomy by itself was followed by vertebral fusion.

CASE REPORTS

Case 1. S.L., a 48-year-old male mineral surveyor, was admitted to the Montreal Neurological Institute in 1948 complaining of severe low-back pain with right sciatic radiation and weakness of dorsiflexion of the right foot. His back had been stiff as long as he could remember and, for the previous 17 years, progressively more severe attacks of low-back pain were experienced. Three months before admission, while lifting a heavy object, an excruciatingly severe low-back pain developed suddenly and within 2 weeks radiated intermittently to the right ankle, across the foot to the big toe. Sensory or sphincter disturbances were not present. The pain had subsided somewhat 10 days before admission.

Examination. The right pelvic brim was tilted upward. Marked spasm of lumbar paravertebral muscles and pain prevented flexion of the spine. Straight-leg raising was limited to 40° on the right and to 70° on the left. The right anterior tibial group of muscles was weak. Reflexes and sensory findings were reported as normal.

Roentgenograms of the spine showed a narrow L4-L5 interspace. Myelography suggested right-sided, posterolateral protrusion of the discs at the L3-L4 and L4-L5 levels.

Operation (Dr. W. V. Cone), Sept. 12, 1948. With the patient prone and the back sharply flexed at the iliac crests, spinal and local anesthesia were administered. The paraspinal muscles were reflected subperiosteally through a midline incision. The spines and laminae were thus exposed bilaterally from the 3rd to the 5th lumbar segment. The right laminae of L3, L4 and L5 were partially resected. The ligamentum flavum was removed completely between these levels to the right of the midline. A “bulging” disc was found impinging on the 4th lumbar root. The right 5th root, in turn, was found to be compressed by a sequestrum of nucleus pulposus protruding through the annulus fibrosus. The space between the roots and the annulus contained a moderately heavy amount of scar tissue. The contents of the L3-L4 and L4-L5 interspaces were evacuated to the greatest extent allowed by the unilateral approach. The hyaline cartilage was removed following curettage. The roots were further decompressed by removal of adjacent capsular ligament, annulus fibrosus and granulation tissue. The apophyseal joints were not further disturbed. The wound was closed with interrupted wire sutures.

Microscopic Report. Sections of the excised tissue revealed typical degenerated nucleus pulposus, hyaline and fibrocartilage.

Postoperative Course. The patient was allowed to stand on the day after operation and by the 2nd day was performing intensive lumbar tension-and-extension exercises. His recovery was uneventful except for the appearance of a small operative hematoma which was aspirated. At time of discharge mild weakness of dorsiflexion of the right foot persisted and the right ankle jerk was diminished. Both the patient and his wife judged

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eroded cartilage indicative of early arthrodesis. The intervertebral foramina were quite adequate in size to allow free space for the nerve roots.

At the lumbosacral junction, the picture was different. Here a herniated disc protruded through a tear in the annulus fibrosus. The interspace was only mildly narrowed and contained loose, vascular connective tissue and cartilaginous debris. Mechanical stability was poor. The facets, however, appeared normal.

Case 2. G.F., a 57-year-old housewife, was admitted to the Montreal Neurological Institute in 1944 with complaints of severe low-back pain with right sciatic distribution of 2 weeks’ duration. She had had intermittent attacks of lumbago since the age of 18. Three weeks before admission she slipped and fell. Severe low-back pain ensued which was soon aggravated by radiation of the pain to the right heel on any movement. In the pain-free intervals, paresthesias of numbness and tingling were noticed in the posterior part of the right thigh and calf.

Examination. There was severe spasm of the paravertebral muscles in the lumbosacral region. Straight-leg raising was diminished to 60° on the right. An L5 and S1 dermatome hypalgesia and a diminished ankle jerk were found on the right side. The right calf and anterior tibial groups of muscles were weak.

Myelography demonstrated a definite right, posterolateral herniation of the intervertebral disc at the L4-L5 level. The possibility of a herniation between L5 and the sacrum was also considered.

Operation (Dr. W. V. Cone), Dec. 6, 1944. The patient was placed prone with her back sharply flexed at the iliac crests. Under spinal and local anesthesia, a low midline, lumbar incision was made. The laminae to the right of the midline were exposed from L3 to the sacrum. Partial laminectomies were performed at the L4-L5 and L5-S1 levels. The interlaminar space was narrow and the laminar alignment was abnormal between L4 and L5, resulting in compression of the ligamentum flavum. The ligamentum flavum was removed completely at both levels. An unusually large sequestrum of disc tissue herniated into the spinal canal below the edge of the 5th lumbar vertebra. The lumbosacral junction appeared entirely normal. The articular capsule adjacent to the L5 root was resected, resulting in wide decompression of the nerve root. The joints were not further disturbed. The L4-L5 intervertebral space was entered by sharp dissection through the posterior intervertebral ligament and annulus fibrosus. The contents of the interspace were evacuated to the greatest possible extent from the unilateral approach. The opposing surfaces of the

Fig. 1. Case 1. Sagittal section of lower lumbar and sacral spine. Beginning bony union was found at L3-L4 and L4-L5 levels which had been curetted. A degenerated disc was present at L5-S1 interspace which had not been operated upon.
vertebral bodies were curetted until cancellous, bleeding bone was encountered and all hyaline cartilage was removed.

Microscopic Report. The tissue excised consisted of fibrocartilage and fibrous connective tissue.

Postoperative Course. Recovery was impeded by the simultaneous onset of menopausal symptoms. As usual, ambulation was instituted on the 1st day after operation together with an active regimen of physiotherapy consisting mainly of exercises in extension. There was no evidence of infection of the wound or other inflammatory process in the interspace. By the time of discharge, the mobility of the spine was greatly improved and weakness had disappeared.

She was seen frequently in the ensuing years by members of the staff of the Montreal Neurological Institute during admissions to the Royal Victoria Hospital primarily for symptoms of generalized arteriosclerosis. Her only complaint relative to the operation was a consciousness of the lower part of the back after prolonged sitting. The findings of the most recent neurological examination (6 months before death) were normal except for the absence of both ankle jerks. In November, 1953, 11 years after her discoidectomy, the patient succumbed.

Pathological Examination. Autopsy disclosed the presence of arteriosclerotic cardiovascular disease, an old myocardial infarction with a mural thrombus and thrombotic occlusion of the superior mesenteric artery.

The lumbosacral spine was removed intact. After fixation in 10 per cent formalin, the specimen was sectioned in the midsagittal and one parasagittal plane to each side of the midline with a carpenter's handsaw.

The fusion is shown clearly in both the radiographs and the photographs of the sections (Figs. 2, 3 and 4). It was noted that the ankylosis was much more complete on the side of the discoidectomy. The sections of the apophyseal joints showed traversing trabeculae of bone indicating total arthrodasis. The right L4-L5 intervertebral foramen measured 3 mm. less in diameter than the adjacent or opposite foramina (Figs. 5 and 6). There was no significant scarring or deposition of fibrous tissue about the roots in the foraminal regions.

DISCUSSION

Healing by fusion following radical discoidectomy in these cases is similar to the results observed in studies of intervertebral-disc lesions in animals.

The intervertebral space of the rabbit was damaged by means of gross instrumentation by both Lob and Schrader. The animals were sacrificed 3 months following operation at which time bony and fibrous invasion was found at the affected interspaces. More recently, Smith and Walmsley reported dense collagenous overgrowth at the site of the removed nucleus pulposus of the rabbit. Some ossification was present about the scars of the incision through the annulus fibrosus. In dogs, fibrosis and formation of bone appear in the interspace about 5 months after mechanical damage to and partial removal of a lumbar intervertebral disc. Tamman correlated the degree of ingrowth of granulation tissue and ossification to the extent of the discoidectomies. The canine discoidectomies of Key and Ford are of interest because the animals were sacrificed just 1 month after operation. The development of fusion could not be expected during such short postoperative survival, but the finding

Fig. 2. Case 2. Parasagittal section to right of midline showing bony fusion at level of operation, L4-L5.
Case 2. (Left) Radiograph of median sagittal section. Note superiority of fusion on side of operation (right side).
(Right) Thin-section radiograph to show trabeculae of bone traversing the interspace.

of ingrowth of vascular connective tissue probably represented the initial stage of healing. Haas\textsuperscript{14,15} attempting an experimental confirmation of Dandy’s hypothesis relative to vertebral-body fusion, resected both the nucleus pulposus and the cartilaginous plates after curettage of the lumbar interspaces in dogs. His technique is directly comparable to that used in the discoidectomies of the presently described human cases. Within 4 or 5 months, bony fusion developed between the vertebral bodies. He noted that the rate of fusion was inversely proportional to the age of the animal. Islands of disc tissue remaining from inadequate extirpation accompanied failures of total fusion.

The monkey serves as an appropriate subject for investigations of intervertebral-disc surgery because of the similarity of the static
and dynamic forces acting upon its spine to those in man. Both Rabinovitch and Jenkner et al. reported firm, fibrous ankylosis following removal of only the nucleus pulposus. The vertebral bodies fused by bone after about 6 months if the cartilaginous plates were also curetted and removed. The extent of the fusion was found to depend upon the amount of cartilage removed.

These results indicate, therefore, that if only the nucleus pulposus is removed, the vertebral bodies will be joined only by fibrous connective tissue. This type of fusion is shown in the specimen removed at autopsy by Ott. The prerequisite of bony fusion appears to be the removal of the cartilaginous plates from the vertebral bodies. A direct correlation seems to exist between the amount of disc tissue removed and the rate and completeness of the fusion.

In the cases presented herein, both the nucleus pulposus and the cartilaginous plates were removed. As may be predicted from the preceding brief review of the results of experimental surgery, the vertebral bodies were found to be fused at the affected interspaces at autopsy. The ankylosis was fully mature in the case of longer survival (Case 2), yet islands of disc tissue which could not be reached from the unilateral approach remained entrapped. In the patient in Case 1, who lived only 20 months after operation, a primarily fibrous fusion was found with good mechanical stability. Beginning signs of ossification were present as well. The clinical experience of Dandy and Cone has also indicated that fusion will result from total discoidectomy. Dandy reported 30 instances in which fusion at the site of a discoidectomy was confirmed at the time of subsequent reoperation for protrusion of discs at adjacent levels. The most important phase of the operation is the establishment of the optimum conditions for healing by fusion. This is achieved by removal of a quantity of disc tissue sufficient to allow the spongiosa of the adjacent vertebral bodies to fall into close apposition. In the cases presented here, discoidectomy even from a unilateral approach sufficed for fusion; but to facilitate curetting and total removal of the disc, Cone later used a bilateral approach. Physical means, such as early ambulation and exercises commencing on the 1st postoperative day, are also employed in order to accelerate collapse of the interspace. On the other hand Foltz et al., using this technique of discoidectomy, were unable to demonstrate fusion in 16 patients operated upon.

Several objections have been raised against this procedure. First of all, doubt has been expressed that sufficient curetting is technically feasible to achieve fusion without damage to the roots or the dural sac. The technique of radical curettement, however, has been used successfully not only by Cone and Dandy but also by Cloward in a large number of cases. Cloward employs this technique in order to prepare the vertebral bodies for an intervertebral grafting procedure. The argument has also been raised that a decompression of the nerve root by the simple removal of the protruding sequestrum is in it-
self sufficient treatment because the natural healing process also terminates in fusion. It has, indeed, been demonstrated that the end result of degeneration of the human intervertebral disc, whether caused by trauma, infection or excess strain imposed by congenital or acquired structural anomalies of the vertebral column, is also partial absorption of the intervertebral disc and bony fusion of the adjacent vertebral bodies. The scarcity of such fused spines in autopsy series is a reflection of the extreme slowness of the natural healing process. This seems to be hindered by the presence of residual cartilage and nucleus pulposus which are interposed between the vertebral bodies. By the time effective fusion occurs under such conditions severe arthritic changes at the apophyseal joints may be caused by abnormal rocking and tilting movements between vertebrae that are deprived of the buffering action of an elastic, turgid disc. The resultant capsular hypertrophy may then embarrass the root between the disc and the capsule. A posterior spondylolisthesis may stretch the root over the superior articular facet of the underlying vertebra. It is the aim of radical discoidectomy to effect firm stabilization before arthritic changes can develop. The fusion of the apophyseal joints in these autopsies is interpreted as the result of immobilization rather than of repeated trauma.

Another frequently mentioned criticism of radical discoidectomy is that collapse of the interspace causes a narrowing of the intervertebral foramina. To counteract this possible source of compression of the root, some techniques call for the insertion of bone pegs or cylinders into the curetted interspace in order to maintain the normal separation of the vertebral bodies when fused. It was Dr. Cone's opinion that collapse of the interspace will not cause compression of the root if the surrounding soft tissue was resected adequately at the time of discoidectomy because the bony foramen, even with maximal collapse, remains sufficiently wide to transmit the root. In the 2 cases presented, and in many other similar instances, there was no evident of compression of the root following collapse of the interspace. Nor is fusion necessarily hastened by intervertebral grafting procedures. Such techniques also carry the danger of protrusion of the graft into the spinal canal, an increased likelihood of infection of the wound and a prolongation of postoperative disability.

SUMMARY AND CONCLUSIONS

Two autopsies are presented to illustrate vertebral-body fusion following radical discectomy. One case of a 20-month postoperative survival shows firm, fibrous ankylosis with beginning ossification. The other, of a 12-year survival, demonstrates mature bony union. In neither case was there any clinical or postmortem evidence of postoperative constriction of the root. Animal experiments indicating bony fusion following removal of intervertebral discs are discussed. The feasibility of nearly total discoidectomy to aid in preventing recurrent protrusion of the disc and to avert arthritic changes at the facets is emphasized.

REFERENCES

6. Cone, W. V. Personal communication.


