Lumbosacral Fusions with Harrington Rods and Intersegmental Wiring

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Harrington rods are a valuable adjunct for fusion of the lumbosacral spine. Major limits of distractions are achieved with these rods. Greater amounts of decompression are possible. Decompression, alignment, and stability are maintained. Intersegmental wiring increases security and eliminates the problem of hook and rod displacement and loss of lumbar lordosis. A variety of methods are available for sacral fixation to avoid neurologic complications from the distal hooks. Three- and four-level Harrington rod distraction lumbosacral fusions have proven to be successful in returning severely-disabled spinal stenotic, obese, and osteoporotic patients to normal activities.

Harrington rod fusions have been used for scoliosis for many years. The techniques for placement of the hooks and rods in the thoracic and lumbar spine have been well described in the scoliosis literature. The fusion rate and correction of spinal deformity was enhanced by the administration of distraction and internal fixation; however, there was difficulty in maintaining fixation to the sacrum. Placing hooks under the sacral lamina was rarely done because of lack of available space for the lower hooks and because of the weakness of the bone in this area. Alar hooks frequently displaced. Because of these potential complications, the patients were kept in bed or in body jackets for months after the surgery. Therefore, it did not seem reasonable at first glance to attempt to use Harrington rods as an adjunct to complex lumbar spine-pain surgery.

After more than ten years of experience with Knodt rods in the lumbar spine as an adjunct to lumbar disc surgery, the authors began looking for longer and stronger internal fixation in some cases. When the length of the Knodt rod required reaches 9-10 cm, the rods begin to bow, bend, or otherwise lose their distraction forces. Distraction was slow and difficult. Years ago, the David Selby ratchet wrench was not available for rapidly distracting the Knodt rods with the forces necessary for certain types of collapsing spinal stenotic cases. The authors, therefore, turned to juvenile Harrington rods, which are somewhat stronger than the Knodt rods. The distraction technique for these threaded juvenile rods is even more difficult than with the Knodt rods. Therefore, the juvenile Harrington rods were quickly abandoned and a switch to conventional Harrington rods was made. The great distraction forces and the rapidity with which distraction was achieved were immediately impressive. If there was any distraction problem, it was over-distraction and loss of the lumbar lordosis.

METHODS

The Harrington rod hooks are considerably larger than the Knodt rod hooks. Placing these hooks under the first sacral lamina frequently was not possible because of variations in anatomy. Therefore, the lower Harrington rod hooks are bent to conform more closely to the lamina so there is less chance of an S2 nerve root irritation. The lower hooks of a Knodt rod cannot be bent easily without interfering with the threading mechanism. Smaller-size juvenile lower Harrington hooks are used when the larger ones of a conventional size do not fit. Despite
all of these changes, there were considerably more lower-hook problems with the Harrington rods than with the Knodt rods.

In order to compensate for the loss of lumbar lordosis, the Harrington rods were contoured. This required a switch to square-ended Harrington rods so that the curved rods did not rotate. Having the square-ended Harringtons may have caused more motion of the lower hooks and even added further to the lower-hook problems.

Because of occasional separation of the Harrington rod from its lower hook, drill holes through the distal end of the Harrington rod were used, through which a wire is threaded through the hooks (Fig. 1) so that the rod cannot be distracted from the lower hook. This, too, may add to extra motion of the lower hooks, and may increase lower-hook problems. Lower-hook problems with some type of pain, CSF leak, paresthesia, numbness, or other reason for removal of the rods, had increased to 10% of the cases.

It is possible to reduce lower-hook problems to nearly nothing if one is willing to not use the hooks in cases where there is a snug fit. If the hooks are only used where a dissector can be fully passed on all sides of the Harrington hook (Fig. 1), there will virtually be no nerve root irritation at the S1 on S2 levels. There will, however, be a fair number of cases in which the hooks cannot be used, and therefore the value of distraction rod fusion is lost.

Because of all of the above potential problems with sacral hooks into the S1 lamina, alar hooks for three-, four-, and five-level fusions in the lumbar spine were adopted for use. It is almost impossible, because of the angle, to do one- and two-level fusions with alar hooks. Three-, four-, and five-level require a minimal of rod contouring. It is also possible to get three-point fixation by leaving in one lamina for an intersegmental wire to give the rod a middle point of fixation. The lumbar curvature can thus be maintained (Figs. 2 and 3). Without this middle or third point of fixation, contouring the rods for lumbar lordosis is of little or no value. It is necessary to contour the rods in a "C" shape to
get a direct purchase on the proximal lamina as well as the ala of the sacrum.

Using a double-segmental wire around a retained lamina to secure the Harrington rods as well as a wire around the proximal spinous process and upper hooks, no rods have been displaced in over 50 cases.

Problems with the alar hooks have not been significant. Some have migrated slightly further laterally. Distraction is rather vigorous and time is allowed for "creep" before further distraction, and then the distraction is tested prior to closing. There is occasionally no room between the L1 transverse process and ala of sacrum to place the hooks. A hole is fashioned with a small chisel in such a case, to make room for the hooks. The alar hooks also occupy much of the space that had previously been used to create the fusion site from L5-S1. It is necessary to spend more time decortication and saving the superior facet of S1, lateral face of S1 superior facet and the L5 inferior facet.

The proximal wire around the proximal hooks is also used as a C washer (Fig. 2). The wire passes around the remaining spinous process of the most proximal vertebra. The remainder of the spinous process can be used for bone graft. The wire is then passed laterally around the upper hooks and circumferentially around the rod before being tied to its opposite side.

Fashioning the upper hook site and inserting them can sometimes be difficult if the rods are not passing straight up the midline. If the rods are angled, the hooks will engage each other in the midline and displace one another. The hook site is made as far laterally as possible. If the facet joints are coronal in positioning and there is no stenosis, the superior facet can be left in place and used as a guide or protector of the dura as the hook is inserted into the facet joint under the lamina and inferior facet of the proximal vertebra to be fused. Extreme lateral positioning or angulation laterally may cause the rods to displace laterally, which has not happened thus far. Inserting the upper hook occasionally displaces a fragment of bone into the vertebral canal. It is a small fragment, but should be removed and can be reached with a small Kerrison or pituitary rongeur or a small angled curette.

The question is frequently asked: how much distraction can one safely apply? No one knows the answer. The stability of every individual spine is different, as is the amount of distraction that will eliminate lordosis. One has to rely on such things as preoperative flexion-extension films, evaluation of the stability of the spine at the time of surgery, the amount of disc material removed, the amount of osteoporosis present, and the amount of posterior elements removed. In general, the distraction with Harrington rods takes the distraction force until the rods are well seated and neither one is moving with manual wiggling. At that point, further distraction takes almost the full strength of an average man's grip to further distract. The intervertebral foramen can be inspected and the facet joints observed as the distraction occurs, to see that they are not being excessively opened or distracted.

By the time one has accomplished a wide bilateral decompression, the only available space aside from the interbody space for bone graft is that of the transverse processes and "lateral faces" of the superior facets. This is the same area that is used for Knodt rods and for intertransverse fusions (Fig. 2). The transverse processes are decorticated using Wilse transverse process retractors for exposure, and then thoroughly decorticking the transverse process and "lateral face" of the superior facets. One has available a large amount of bone gleaned from the posterior elements that have been removed. This bone is frequently enough to perform a one-level fusion and sometimes adequate to perform a two-level fusion. The quality of such bone is poor compared to bone obtained from the iliac
crested. It is generally best to obtain iliac crest bone with good quality corticocancellous strips.

When it is not possible to preserve a lamina of one of the vertebrae being fused for fixation with the double intersegmental wires, some form of wire fixation is advisable to prevent rod displacement, migration, and maintenance of lumbar lordosis. There are a few options. The superior facets, intervertebral foramen, and pedicle are generally still available. A wire can be placed out through the intervertebral foramen (Figs. 4A and 4B) and around the facet, and even around the transverse process, and brought over the rod for security. The longer the rod and fusion, the more important it is to gain this type of fixation.

Segmental wiring is well known to those using Luque rods and Harrington rods for scoliosis and fractures with multisegmental wiring. The value and importance of securing stability are well known. The principles are applied to Harrington rods with as many segmental wirings as possible and necessary for the particular case of instability, osteoporosis, scoliosis, or lumbar curvature. Tightening wire from an oblique direction creates forces that can displace the rods. The forces should maintain the rods in their normal distracted position.

When there is great worry about the quality of bone or the security of fixation, one can also use methyl methacrylate over the proximal hooks, wire, and spinous process for additional fixation.

At times, the rods were placed at one level more proximal than is being fused in order to provide a free lamina for further segmental wiring. It may be indicated to remove such rods at a later date to allow a nonfused segment to regain motion.

An alternative hook site to the ala or the S1 laminar position is in the first sacral pedicle at the base of the superior facet. The superior facet has to be removed and a hook site fashioned in and under the hard cortical bone at the base of the superior facet of S1. A Knodt rod hook seater is a good way of fashioning such a hook site. A burr or chisel can also be used. This position is less secure than the ala or lamina. With segmental wiring, however, it has served as an adequate hook site without having displacement rods. A pedical screw can also be placed at S1 to provide a seat for the Harrington rod (Figs. 5A and 5B).

Complications

Aside from the complications of displacement of rods and irritation of the S1 to S2 nerve roots, the only serious complication has been breaking the S1 lamina and displacing the rods into the vertebral canal. The only case of this complication caused considerable contusions of the S1 nerve root with six months of significant paresthetic pain. Placing the distal hooks so that they rub against each other in the midline and entrap dura can create a cerebral
spinal fluid leak. Pseudomeningoceles have developed from this problem. The hooks need to be totally free of any entrapment of dura or neurologic tissue. The space available for the distal hooks can be calculated with the use of a CT scan. It is easy to evaluate the space with a dissecting instrument. A large-sized dissecter such as a Penfield 3 or "hockey stick" should be able to pass the tip of the distal hook. Severe osteoporosis or thinning of the S1 lamina by spina bifida or other similar conditions contraindicates the use of the sacral lamina hook.

Any dural leak with rods in place has a high potential for more free space for a pseudomeningocele to develop. Care in not creating dural holes and repairing them completely when they occur is very important.

Excessive thinning of the proximal lamina can cause fracture of the lamina or facet with distraction forces. One has to judge the amount of bone that can be removed, which is one half of the lamina. If there is osteoporosis, more should be left. Central spinal stenosis at the proximal level rarely contraindicates the use of the upper hooks. If there is significant dural or root compression with the large proximal hooks, they should not be used. Placing them into the facet joint is much safer. One set of Harrington rods was removed because of stenosis produced by the proximal hooks.

Over-distraction and loss of lumbar lordosis can give a painful postural problem. With two levels of fusion, this is rarely significant and can be overcome with lumbar extension exercises, physical therapy, and mobilization. When excessive distraction is done, multiple levels lose their lordosis and the patient is forced into lumbar kyphosis and cannot stand fully erect. Patients develop disabling postural pain above the level of their fusions and may need to have the rods removed or even have a lumbar osteotomy. Conversely, patients with excessive lumbar lordosis, obesity, and collapsing osteoporotic lordosis do not even need to have the rods contoured, because maximal distraction still does not bring them to a normal lordosis.

Displacement of rods rarely produced a major problem. Of course, the security of having distraction is lost, and if it occurs early, the patients usually experience some increased pain secondary to sudden instability. There is then the threat of progressive stenosis before the fusion becomes solid, and patients usually require bracing and decreased activity. Usually, the rods displace out of the vertebral canal rather than into it, and they do not always need to be removed.

Breakage of Harrington rods can, of course, occur when there is motion because of pseudarthrosis or when rods are placed across a segment which is not fused. A broken rod rarely produces significant symptoms, but is easily removed, as is a displaced Harrington rod. Patients are able to leave the hospital in a day or two after removing the rods, which generally takes less than 30 minutes.

Stenosis, degenerative change, and disc hernia-
tion of spinal levels above the Harrington rod fusions can certainly occur. The authors guard against this with education, strengthening, back-school training, and monitoring roentgenograms with flexion and extension each year. Prior to spinal fusion, a discogram at the next proximal level is done. Disc herniation at fused levels has occurred in the past, but is rare. The authors have not experienced any herniations at levels of Harrington rod fusions to date.

RESULTS

Prior to 1983, at the authors' hospital, 30 cases of three-, four-, and five-level Harrington rod fusions were done on severely disabled patients who were housebound or bedridden for three to six months. All of these patients had two or more of the following conditions: osteoporosis, severe obesity, multioperated backs, multilevel herniated discs, spondylolisthesis, scoliosis, and spinal stenosis. All of these patients had two or more of the following tests positive: myelogram, computed tomography scan, electromyogram, neurologic deficit, and positive response to selective nerve-root blocks. All patients improved. No patients returned to full normal activity. No one was left bedridden or housebound. One patient, who had a previous stroke, still requires a walker. No other patients are housebound or require more support than a cane. All felt that the operative procedure was well worthwhile. The overall success rate by independent examination was that 89% of the patients improved and the patients rated their average amount of improvement as 62%.