

■ Technique and Results of Fixation to the Sacrum with Iliosacral Screws

Jean-Pierre C. Farcy, MD,* Bernard A. Rawlins, MD,* and Steven D. Glassman, MD†

This article describes the technique of iliosacral screw fixation, as well as a retrospective review of 28 consecutive patients who had spine fusion to the sacrum with iliosacral screws, with a minimum follow-up of 2 years. The study included 6 male and 22 female patients. Average age at the time of surgery was 43 years, and mean follow-up time was 3.5 years. There were no neurologic complications at final follow-up evaluation. Ninety-five percent of the patients had radiographic evidence of fusion. Three patients required iliosacral screw removal because of suboptimal intraoperative Kirschner-wire placement. Optimal intraoperative radiographic evaluation for accurate iliosacral screw placement is recommended. The use of iliosacral screws is also a useful addition to the armamentarium of the spine surgeon when fixation to the sacrum is required. [Key words: spine fusion, sacral fixation, iliosacral screw fixation, fusion rate]

The search for an optimal fixation technique for fixation to the sacrum began with the Harrington fixation system and sacral bars.¹³ The inadequacy of the system led to the development of the sacral alar hook by Moe^{16,21,24} and, later, the four-pronged staple by Cotrel.²⁴ High complication rates seen with these systems and the development of new spine instrumentation have led to additional fixation techniques to provide sacral fixation.^{3,4,7,8,23}

The use of plates and pedicle screws is a well-documented method of lumbosacral fixation.^{18,22} The Galveston^{1,2} and Dunn-McCarthy¹⁹ techniques are used to establish sacral fixation with Luque rods. Sacral screws, sacral alar screws, iliosacral screws, and the Galveston technique are methods used to provide fixation of Luque and Cotrel-Dubousset (CD) rods to the sacrum.^{6,10,11} This is but a sample of the numerous techniques available, which attests to the difficulty in obtaining fixation to the sacrum. In addition, it supports the contention that an optimal fixation technique still is not available. Continued objective documentation of the results with these techniques is necessary to solve the problem of an optimal fixation system and technique.

The aim of this study was to describe the technique of iliosacral screw fixation and to review the results of 28

consecutive patients treated by the senior author (JPCF) using this technique.

■ Technique

Exposure of the lumbosacral spine is obtained through a standard posterior midline incision. Routine exposure of the posterior spine to the transverse processes of the required spinal levels is performed. The sacral ala and posterior sacrum are exposed to the posterior iliac crests laterally, and a point is identified lateral to the inferior facet of L5. A skin and subcutaneous flap is elevated over the lumbosacral fascia from the midline incision to expose the posterior iliac crest. Subperiosteal dissection over the outer iliac crest gives access to a second point approximately 1 cm inferior to the superior iliac crest on the posterior gluteal line.

Through a stab-wound incision, a 1.5 mm Kirschner wire (K-wire) is introduced through the lateral aspect of the posterior iliac crest at the level of the second point, reappearing in the iliosacral space posterior to the sacroiliac joint. Right and left Beurrier connectors are available. The appropriate connector is selected and placed in the iliosacral space. The K-wire is directed in a plane parallel to the superior end plate of S1 and inclined 45° to the sagittal plane. The K-wire is then advanced through the iliac crest, the Beurrier connector, and into the sacrum at the level of the first point through the S1 pedicle in the direction of the sacral promontory. The placement of K-wires is performed bilaterally in the described fashion, followed by intraoperative confirmation of placement with radiographs in the anteroposterior and lateral planes.

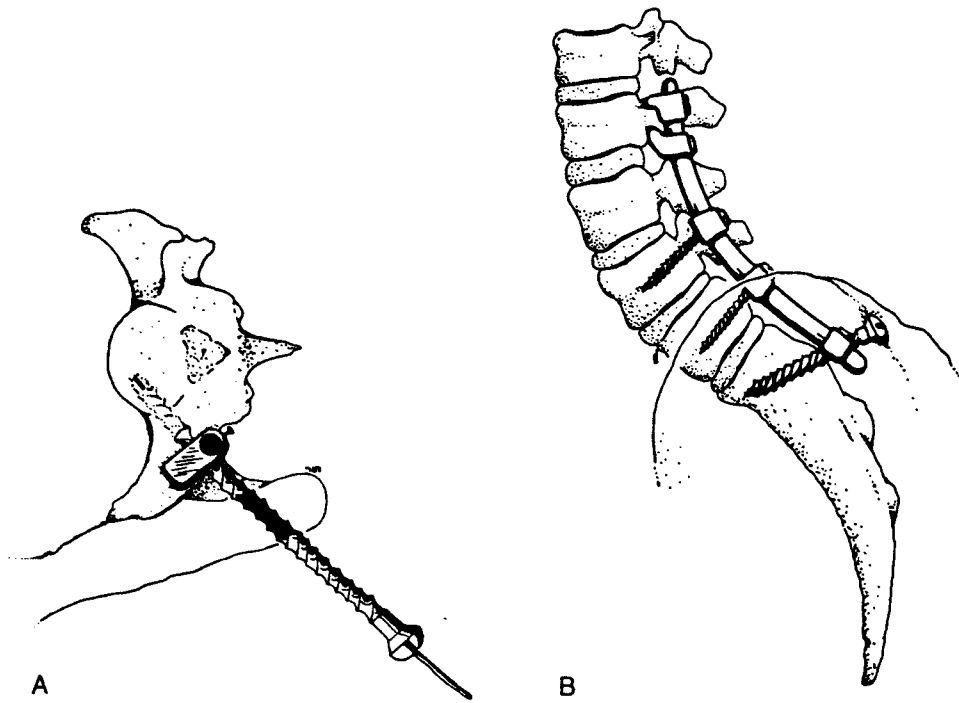
Adequate intraoperative confirmation of K-wire placement is crucial to optimum placement of the iliosacral screws. Pitfalls in placement of the iliosacral screws can be avoided by adhering to certain points when evaluating the intraoperative radiographs.

In the anteroposterior radiograph, the tip of the K-wire must be close to the midline of the sacrum without crossing it. In the lateral radiograph, the tip of the K-wire should not traverse the anterior cortex of the vertebral body of S1, but should approach this point. The tip of the K-wire must be seen at the level of the promontory, as close as possible to the S1 end plate in the sacrum. A K-wire tip found anterior to the body of S1 on a lateral radiograph implies pelvic penetration and the potential for rectal, nerve trunk, and vascular trauma. Any position posterior to the midline of the S1 vertebra on a lateral radiograph must be eliminated because of the weakness of purchase if close to the posterior wall of S1, as well as the concomitant hazards of being too close to the canal. A tip found posterior to the body of S1 implies penetration into the sacral canal with the possibility of dural tear and nerve root damage. Although there

From *New York Orthopaedic Hospital, Columbia Presbyterian Medical Center, New York, New York, and the †Spine Institute for Special Surgery, Louisville, Kentucky.

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Figure 1. **A**, Sketch demonstrating iliosacral screw placement over K-wire and through Buerrier connector in the transverse plane. **B**, Sketch in sagittal plane of iliosacral screw and CD construct using pedicle screws and hooks.



are numerous permutations of K-wire placement in the anteroposterior and lateral radiographs, when the K-wire tip is placed just short of the midline on an anteroposterior radiograph and just short of the anterior cortex on the lateral radiograph, placement is considered optimum. Kirschner-wire and subsequent screw placement into the superior end plate of S1 are also considered acceptable and might improve fixation by virtue of an additional cortical purchase.

Next, the protruding part of the K-wire is used to select a 7-mm fully threaded screw of appropriate length. Bone drilling and screw placement are accomplished manually with a cannulated hand drill and cannulated screw driver. Connection between the CD rods and the iliosacral screws is provided by the Beurrier connector (Figure 1).

No patient was placed in a brace after surgery. All patients were allowed to sit on Postoperative Day 1 and ambulate on Postoperative Day 3.

■ Materials and Methods

The charts and radiographs of 28 consecutive patients who had spine fusion to the sacrum with iliosacral screws, with a minimum follow-up of 2 years, were reviewed. The average age was 43 years (range, 12–79). The review included 6 male and 22 female patients. In all patients, Beurrier connectors were used to connect the CD rods to the iliosacral screws.

Twenty-three patients had pseudarthrosis after previous surgery. Pseudarthrosis occurred after spine fusion for scoliosis in 11 patients, failed lumbosacral fusion (other than scoliosis) in 7, surgery for spondylolisthesis in 4, and resection of neuroblastoma in 1. All previous surgery was performed by surgeons at other institutions. Five patients had neuromuscular scoliosis with pelvic obliquity.

Indications for fusion to the sacrum included pain in 23 patients, pelvic obliquity in 5, and progressive scoliosis in 5. A total of 55 iliosacral screws were placed in 28 patients. The

average number of levels instrumented was 8 (range, 3–14 levels). The average follow-up was 3.5 years (range, 2–6 years).

■ Results

Evaluation addressed the subjective relief of pain and radiographic evidence of instrumentation failure. Twenty-six patients (95%) had radiographic evidence of fusion; none had radiographic evidence of instrumentation failure. In the five patients with pelvic obliquity, there was a 60% reduction in the obliquity. All patients had improvement in the level of pain at the time of follow-up. No patient experienced a deterioration in neurologic function as a result of surgery. One patient required screw removal for radiculopathy; this case will be described below. All patients were able to ambulate before surgery and were able to stand after surgery with knees fully extended.¹⁷

There were three documented wound infections (10%), all in patients who underwent surgery for pseudarthrosis. One patient required further surgery and intravenous antibiotics. The other two infections were considered superficial and cleared with parenteral antibiotic therapy. Three complications were identified as related to poor iliosacral screw placement. Suboptimal radiographs and hence incomplete intraoperative radiographic evaluation was identified by the operating surgeon (JPCF) as the error in adequate placement of the screws.

Patient 1 was a 55-year-old woman who presented with pseudarthrosis after surgery for scoliosis at another institution. She had an anterior procedure with Zielke instrumentation and posterior instrumentation from T6

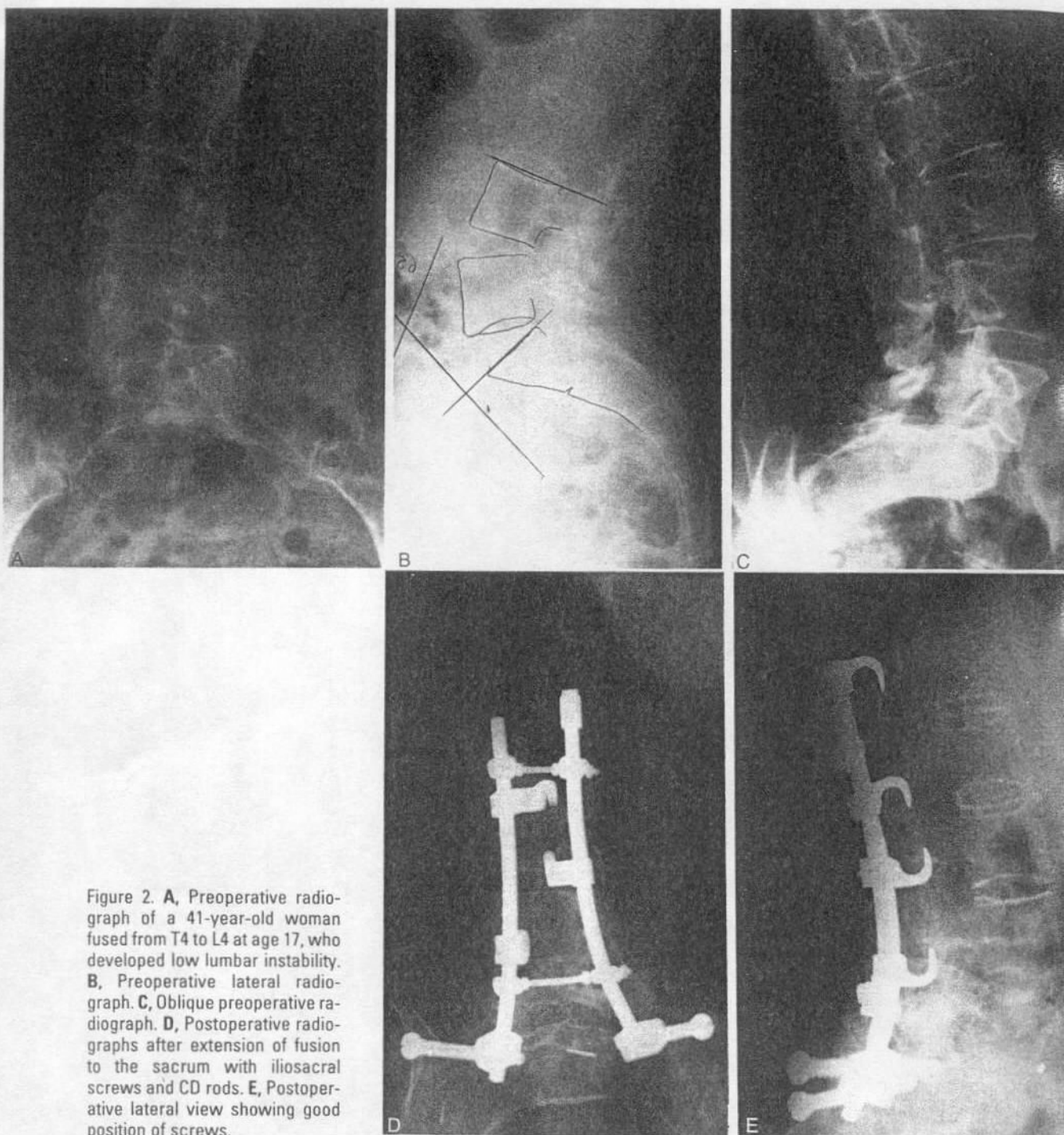


Figure 2. A, Preoperative radiograph of a 41-year-old woman fused from T4 to L4 at age 17, who developed low lumbar instability. B, Preoperative lateral radiograph. C, Oblique preoperative radiograph. D, Postoperative radiographs after extension of fusion to the sacrum with iliosacral screws and CD rods. E, Postoperative lateral view showing good position of screws.

to L3 using CD rods. The patient decompensated and developed a kyphosis below the fusion. She underwent repeat surgery with extension of the fusion to the sacrum and correction of the L3-S1 kyphosis using CD rods and iliosacral screws. After surgery, the patient developed pain, and radiographs showed that the right iliosacral screw had cut through the sacrum. A pseudomeningocele developed, and hardware was palpable. At revision, a cerebrospinal fluid leak was found related to a dural injury caused by the displaced screw. The screw was

removed, the dura repaired, and an attempted fixation to the ilium performed. After the cerebrospinal fluid leak healed, reoperation was necessary to obtain adequate fixation. Iliosacral screws were then reimplemented to allow compression between the upper construct and the sacrum, and the patient subsequently achieved fusion.

Patient 2 developed postoperative pain in a radicular distribution of the right lower extremity. Radiographic evaluation showed the hardware to be poorly placed. The patient had removal of the right iliosacral screw and total

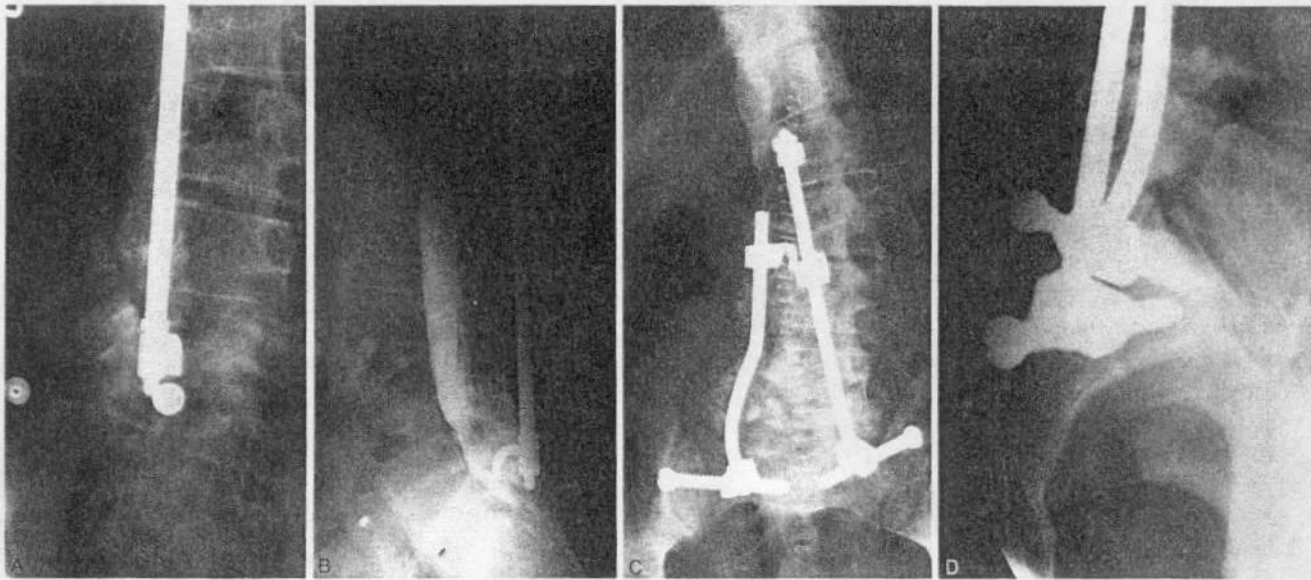


Figure 3. A, Preoperative anteroposterior radiograph of a 31-year-old man treated 15 years previously with Harrington distraction rod and fusion. Patient developed intractable low-back pain. Pseudarthrosis seen at L4-5. B, Lateral preoperative myelogram. C, Postoperative anteroposterior radiograph after fusion to the sacrum with CD rods and iliosacral screws. D, Lateral radiograph showing good position of screws.

resolution of his symptoms. At the time of surgery, there was no evidence of pseudarthrosis.

Patient 3 had radiographic evidence of excessive prominence of her iliosacral screws into the pelvis but had no symptoms. The screw and hardware were removed at another institution, at which time there was no intraoperative evidence of pseudarthrosis.

■ Discussion

Once the decision is made to fuse to the sacrum, there exist at least as many techniques to accomplish this as there are instrumentation systems. The present study set out to describe a technique initially described by Dubouset¹⁰ in 1973 at the meeting of the Groupe d'Etude de la Scoliose and presently used by the senior author for fusions to the sacrum. Here, some of the advantages and pitfalls of the technique are expressed in the results of 28 patients treated by this method.

The difficulty and increased pseudarthrosis rates associated with fusion to the sacrum have been well documented in the literature.^{3,4,8,12,14,16,23} The complication rates related to instrumentation failure have been documented to a similar degree.^{3,5,9,14-16,23}

Kostuik reported a 15% instrumentation failure at the Scoliosis Research Society meeting in 1978.¹⁵ This figure was obtained from the results of a poll of lumbar fusions gathered from members of the Scoliosis Research Society. In a more recent series of spine fusions to the sacrum, a 9% instrumentation failure rate was reported.¹⁶ Balderston et al reported a 40% instrumentation failure, using Harrington rods for nonparalytic scoliosis in adults.³ More recently, in a study of the clinical results of using

sacral screws with CD instrumentation for fusion to the sacrum, Devlin et al reported a 70% rate of instrumentation-related failure.⁹ Camp et al noted a 28% iliosacral screw failure in seven iliosacral screws placed in four patients, and a 44% failure rate in sacral screws.⁶ In a limited *in vitro* experiment that was part of the same study, they further demonstrated that iliosacral screws showed significantly increased mechanical stiffness to flexion than did sacral screws.

Our series presents one patient (4%) with an instrumentation-related complication. The inclusion of this patient in this category is debatable, given that failure was related more to screw placement than to actual instrumentation design. The classification of technique-related complication is probably more appropriate. In our study, three patients (11%) or four screws (7%) fell into this category. Nonetheless, increased mechanical stability of the construct is probably the most important factor contributing to decreased instrumentation-related complications.

Previous use of this technique required anchoring the CD rods to the iliosacral screw with hooks. In this method of attachment, hook dislodgement produced unacceptably high instrumentation-related failure rates. Consequently, with the development and availability of the Beurrier connectors, the attachment of CD rods with hooks to iliosacral screws has been abandoned by the senior author. Anchoring CD rods to iliosacral screws with either upgoing or downgoing hooks that only partially encompassed the screws allowed easy dislodgement. The Beurrier connectors completely encompass the screws in a nut-and-bolt fashion, making dislodgement impossible. The development of the Beurrier connectors

has significantly reduced the instrumentation-related complication rate with this technique.

Additional cortical purchase is known to increase the force required to cause pullout.²⁵ Cortical purchase at the outer and inner tables of the ilium and the entrance point to the sacrum provides increased stability to pull-out in the iliosacral screw technique. End-plate penetration of S1 provides an additional cortical purchase, adding a further degree of stability. The ability of the iliosacral screw technique to provide improved cortical purchase reduces the potential of pullout failure for this construct.

Purchase at the ilium and sacrum allows the longitudinal forces of correction to be distributed between two points rather than concentrated at a single point, as is found with hooks and sacral pedicle fixation. The sharing of a given load between two points reduces the force likely to cause cutting-out at the sacrum, a complication frequently found in osteoporotic patients when sacral hooks or screws are used for lumbosacral fixation. This presumption is contingent on the accuracy of screw placement, which is of paramount importance.

The possible complications of long-term immobilization of the sacroiliac joint with Luque and CD rods using the Galveston technique are not cause for undue concern with the iliosacral screw technique. Placement of iliosacral screws posterior to the sacroiliac joint does not violate the joint or preclude its motion.

The iliosacral screw has the additional advantage of more lateral placement to the longitudinal axis of the spine, providing a longer moment arm; thus, less force is needed to correct a given spine deformity. The iliosacral screw provides anchorage for CD rods to be placed in distraction or compression, providing better sagittal alignment with appropriate lumbar lordosis.

The learning curve associated with this technique cannot be overemphasized. The spinal canal and the structures anterior to the sacrum are easily penetrated, with resultant disastrous consequences.²⁰ The three complications stressed in this study were all attributed to suboptimal placement of the iliosacral screws. The most important aspect of placement is the difficulty in attempting to align the entry point on the ilium with the Beurrier connector and the entry point on the sacrum without entering the pelvis.

The technique of iliosacral screw placement has a significant learning curve, as demonstrated in the three patients requiring screw removal for suboptimal placement, but the technique offers additional stability and decreased instrumentation-related complications. We recommend optimal intraoperative radiographic evaluation for accurate iliosacral screw placement, and we suggest that the use of iliosacral screws is a useful addition to the armamentarium of the spine surgeon when fixation to the sacrum is required (Figures 2–3).

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Address reprint requests to

Jean-Pierre C. Farcy, MD
New York Orthopaedic Hospital
Columbia Presbyterian Medical Center
New York, NY 10032