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Radiographic Evaluation of the Postoperative Interbody Fusion Patient: Is CT the Study of Choice?

Williams et al are to be complimented for an excellent and thorough review of devices available for interbody fusion and of the radiographic findings pertinent to the evaluation of fusion healing. As the authors point out, interbody fusions are being performed by spinal surgeons with increasing frequency, and the interpretation of postoperative radiographs is an increasingly common and important task for the radiologist.

The authors emphasize the importance of CT in evaluating interbody fusions and have proposed a radiographic protocol consisting of scans done at 3, 6, and 12 months, with an additional scan at 24 months if a solid fusion is not seen earlier. No conventional radiographs are obtained. No alteration in the protocol is proposed, regardless of the device or material placed in the disk space. The same protocol is recommended, whether a metal cage is placed with bone morphogenic protein inside the cage or a segment of allograft bone is placed to fill the intervertebral space.

The routine adoption of this protocol requires discussion. Replacing conventional radiographs with CT scans and reconstructions entails a substantial increase in cost, 8-fold at this writer's institution, yet the authors provide no data to validate their protocol and few references to prove that CT offers a benefit worthy of the increased cost.

The reliability and sensitivity of CT scans or conventional radiographs for identifying fusion healing is not known. One study evaluating fusions in an animal model found a congruency between the extent of bony fusion in CT imaging and histologic assessment of only 14% (1). In that study, CT images significantly overestimated the extent of fusion but accurately identified the presence of a fusion in 83% of specimens.

There is no doubt that CT offers some advantage over conventional radiographs, especially with regard to identifying lucency around hardware and cystic changes within the endplates. One might anticipate, however, that other findings predictive of fusion failure such as subsidence, translation, or other change in alignment would be more likely to be identified on weight-bearing films, yet these are not part of the recommended protocol. Change in alignment on bending films also indicates implant loosening, but these, too, are not part of the authors' protocol.

One may also question why the authors chose to perform scans at 3-, 6-, and 12-month intervals. Regardless of the device or graft type used (cancellous bone from the iliac crest, allograft bone, or bone morphogenic protein are the most common options), no patient is likely to show healing of the fusion as early as 3 months after surgery, so a scan at this early stage seems unnecessary. The authors indicate that this early scan is helpful in determining whether the patient can safely return to work; presumably if loosening of the implants is seen, the patient would not be allowed to return to full duty; however, is the more expensive CT really better than conventional radiographs at identifying loosening? The references provided only suggest that CT is better at demonstrating bridging of the fusion bone—in other words, solid fusion healing. There is little evidence that CT better demonstrates loosening—or, for that matter, that restricted activity will allow solid fusion once the implants have loosened.

If a solid fusion is seen at 6 months, what is the benefit of the 12-month scan? Why do both, at twice the cost? Let us accept the assumption that a scan at 3 months showed no loosening and the patient returned to full activity. If the patient's clinical status is successful and he or she is free of pain, why obtain a scan at 6 months? For that matter, why obtain any radiographic study in this asymptomatic patient? What radiographic finding would change the asymptomatic patient's management? If the goal of the radiographic study is to prove that solid healing of the fusion was accomplished, why not wait until the 12-month interval when a higher percentage of patients destined for success are likely to have achieved a solid fusion? If the graft material used was allograft bone, an even longer interval might be appropriate, as this is the slowest to heal.

Finally, although it is clear that CT offers an enormous advantage by making it possible to visualize bone graft within a metal cage, its benefit is less obvious when the cage is made of a radiolucent material. With carbon fiber or polyetheretherketone cages, anteroposterior radiographs obtained with the radiographic beam oriented in line with the disk space can clearly visualize the intervertebral space. If trabeculae of bone are seen bridging the disk space without a gap, it is clear that fusion has been achieved without the need for a reconstructed CT (2). This is even more convincing when bone morphogenic protein is used, because early radiographs show lucency in the disk space, which is replaced by bone as healing occurs. Even when a metal cage is used, if bone is seen bridging the interspace anterior to the cage on a lateral view, it is clear that healing of the fusion has occurred. This has been described as the "sentinel" sign (3). A CT is not needed when these findings can be visualized on conventional radiographs.

The protocol proposed by Williams et al provides a reasonable starting point for postoperative evaluation of the patient who has undergone interbody spinal fusion; however, in light of the increased costs associated with CT imaging, as well as the advantage of plain radiographs for certain findings, it seems reasonable to individualize the postoperative radiographic studies obtained, rather than routinely obtaining 3 or 4 CT scans on each patient. The type of studies obtained and the timing of those studies should be based on the patient's clinical status, the type of device used, and the type of graft placed within the device. In this way, our limited resources for health care expenditure can be more effectively used and costs controlled.

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Response to Editorial

We appreciate the editorial comments regarding our article. The purpose of our paper is 3-fold: (1) to familiarize radiologists with the various fusion devices that may be encountered in clinical practice; (2) to describe findings on postoperative CT scans suggesting fusion complications that should be sought by radiologists interpreting these scans; and (3) to suggest a CT protocol for evaluating postfusion patients that should provide routinely high-quality CT studies, in light of the fact that CT protocols for these patients vary widely and produce inconsistent images. Our review of the literature confirmed no available standardized CT protocol to guide radiologists and spine surgeons in their assessment of interbody fusion.

The authors do not recommend replacing conventional radiographs with CT. We do, however, recommend augmenting radiographs with CT scans in most cases. Conventional radiographs are currently obtained on most patients at all follow-up intervals; however, for reasons mentioned in the body of the paper, conventional radiographs are often inaccurate in their ability to assess interbody fusion. There is no current class 1 data demonstrating that a lack of motion on flexion and extension films is predictive of fusion. Lack of motion on radiographs is only "lack of motion" and is not predictive or indicative of solid bony union.

Two of the authors have extensive surgical experience using multiple devices made of different materials. Their experience has created doubt that variations of material used in interbody devices can alter the speed of union (1–4). There are no data in the literature to back up claims to the contrary. There is mention of the "sentinel sign" as a means of determining radiographically that fusion has occurred. The sentinel sign, as seen on conventional radiographs, is often an indicator of nonunion. The sentinel sign is merely an expression of "Wolff's law" of bony healing. It is a physiologic way of increasing bone growth in areas of continued instability, similar to the abundant growth seen in fracture callus and may be present in patients with a failing fusion. It is also suggested that the protocol should be altered on the basis of the type of material used for the implant, an assessment with which we disagree. The choice of a particular implant material should not require any change in the protocol, because the device material does not seem to alter any of the signs associated with failure. These signs of failure include lysis of bone around the implant, cystic changes, and so forth and are independent of implant material or the type of bone stimulating factor used to promote fusion. Femoral ring allografts are often the most difficult to assess by using conventional radiographs. This difficulty with assessment is due to the low probability of obtaining views exactly parallel to the implant in both anteroposterior and lateral planes. For all of these reasons, the authors would not alter the protocol on the basis of the type of implant used.

We share the concerns regarding cost. In this discussion, however, one must also take into account the cost of revision spinal fusion surgery, which in 2003 ranged from $43,000 to $72,000, plus surgeon's fees, depending on the number of levels treated (5). In deciding how quickly to advance a patient's clinical status (work, rehabilitation, etc), the spine surgeon must obtain the best possible information. Although, as of this writing, we have not confirmed specific CT findings that will positively predict fusion success, we believe that the findings on the 3-month CT may ultimately be shown to be predictive of fusion failure. This important information obtained via CT at 3 months and 6 months may alter the course of care.

There are also comments that, according to Cook et al, CT scan correctly identified the presence of fusion in 83% of cases and underestimated the presence of fusion in the remainder of the study group. Cook et al attempted to estimate the extent of surface area fused by CT scan and correlate this finding with histology. Although CT in this study tended to overestimate the percentage of the anteroposterior diameter of the fusion mass as compared with histology, there is no indication that this has any clinical relevance. The extent of trabecularization of the fusion mass at one point in time is not predictive of outcome. Only with serial assessments and the comparisons detailed in the protocol can the surgeon determine that healing is advancing, and verify the extent and quality of fusion improvements over time.

The comment that significant subsidence and translation may be identified on conventional radiographs is correct, and this usually represents catastrophic failure of the bone implant interface. This patient population will usually require revision surgery, with no need for additional CT information to evaluate gross failure. CT in this circumstance would still be useful, however, to identify the amount of structural compromise of the bone and to help plan revision alternatives. The question is raised, “Why obtain any scans in asymptomatic patients?” The standard of care in following skeletal treatment is to obtain and review repeated serial examinations. All surgeons perform serial radiographs to determine fracture healing, often in asymptomatic patients. No one questions this assessment. The cost of a spinal fusion far exceeds the cost of fracture immobilization. Only further study will reveal whether the information obtained on CT will be enough to alter care and to provide patient benefit and savings.

Radiology is not predictive of an outcome; it can only identify static anatomic findings associated with one biologic point. CT scans are simply not capable of accurately determining the percent of completion of a biologic process. CT is incapable of predicting future mechanical and biologic factors that may influence the ultimate outcome of a solid arthrodesis. Only with serial analysis (similar to evaluation of fracture healing) can one determine that the desired clinical end point has been achieved. Although further study is needed, we believe that serial CT scanning will ultimately prove to be the most cost-effective administration of health care in this challenging group of patients.

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