Brief Report

Comparison of Plain Radiographs and CT Scans in Instrumented Posterior Lumbar Interbody Fusion

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ABSTRACT

The success of posterior lumbar interbody fusion has been analyzed primarily by plain radiography. There are no widely accepted criteria for fusion, except for lack of motion, which can be obviated by instrumentation, and the appearance of continuous bridging bone in the interspace. To determine the accuracy of plain radiography in detecting posterior lumbar interbody union, the radiographs of instrumented posterior lumbar fusion performed at 22 levels were compared with reformatted computed tomography (CT) scans. Results revealed that although 17 of 22 interbody levels were classified as fused by radiograph, 10 of these 17 demonstrated a nonunion by reformatted CT scans taken an average of 13.8 months postoperatively. Only progressively increased density by radiograph correlated with a solid fusion by CT scan. We therefore conclude that plain radiographs are unreliable in reporting the results of posterior lumbar interbody fusion and that CT scanning may be more appropriate.

Cloward1 popularized posterior lumbar interbody fusion with his description of the procedure in 1953. The indications for the procedure range from spondylolisthesis and stenosis to degenerative disk disease and failed back syndrome. The benefits of posterior lumbar interbody fusion include preservation of disk height, wide foraminal decompression, complete discectomy, and biomechanical restoration of both the posterior and anterior columns within a single surgical approach.1-4

However, a significant number of complications have been associated with this procedure. Excessive epidural bleeding, postoperative collapse of bone graft, and retropulsion of graft causing neural compromise are some of the complications associated with this technically demanding procedure.2,7 In addition, Wetzel and LaRocca8 reported chronic radiculopathy caused by epineural fibrosis due to excessive nerve manipulation in their evaluation of failed posterior lumbar interbody fusions.

Another concern is the high prevalence of pseudarthrosis. Posterior lumbar interbody union rates have been reported to range from 88% to 93% by some authors2,8; however, this rate of successful union has not been achieved universally among all surgeons. In response, various modifications of the procedure have been introduced to improve fusion rates.

Furthermore, detecting lumbar arthodesis can be a difficult task. Plain radiography is the most routine method for evaluating union despite the fact that its accuracy in detecting posterior lumbar fusion has been estimated to be only 69% by comparison to direct intraoperative evaluation.10 Flexion and extension radiography also is a common means of determining pseudarthrosis; however, it is of little value when rigid instrumentation is used.

Computed tomography has proven to be highly sensitive and reliable in verifying lumbar fusion.11-13 Computed tomography coupled with reformatted views give a detailed assessment of the graft-bone interface. Rothman and
Glenn\textsuperscript{14} have demonstrated the accuracy of reformatted CT scans in confirming interbody arthrodesis. Three-dimensional CT also has become popular in evaluating posterior fusion but may actually overestimate bone union secondary to the image summation that occurs with 3-D reconstructions.\textsuperscript{13} The present study assesses the validity of routine plain radiography in determining posterior lumbar interbody fusion when compared with reformatted CT.

**MATERIALS AND METHODS**

Posterior lumbar interbody fusion and posterior lateral fusion using autogenous iliac graft and pedicle screw instrumentation was performed on 14 patients. Both single- and multiple-level fusions were performed for a total of 22 interbody fusions. Eight patients underwent fusion at both the L4/L5 and L5/S1 level; the remaining patients underwent fusion at the L5/S1 level only.

The average age of patients was 40 years at the time of surgery. Follow-up averaged 18 months (range: 12 to 27 months). Computed tomography with reformatted views was performed on all fusion levels an average of 13.8 months postoperatively. Computed tomography scans consisted of both contiguous curved axial and reformatted sagittal views sectioned in 3-mm and 2-mm slices, respectively.

During the postoperative course, plain AP and lateral radiographs of the lumbar spine were obtained periodical-ly for all patients. All studies then were reviewed by the senior author (S.M.). Plain films evaluated bridging bone and trabeculation, fragmentation of the fusion, the graft-host interface, and progressive increasing density of the graft over time. Computed tomography scans examined bridging bone, fragmentation, and the graft-host interface. Criteria for fusion on CT was bridging bone and loss of the bone-graft interface in at least three consecutive cuts.

**RESULTS**

Although 17 of 22 (77\%) interbody levels were classified as fused by plain radiography, 10 of these 17 demonstrated nonunion by reformatted CT images (Figs 1 and 2). These 10 interbody levels demonstrated bridging bone and trabeculation of graft by radiograph; however, reformatted CT scans revealed complete graft fragmentation without obliteration of the graft-host interface. Only progressively increased density by radiograph correlated with a solid fusion when compared with computed tomography.

**DISCUSSION**

The rate of nonunion associated with posterior lumbar interbody fusion continues to be a problem for surgeons and prompts the use of adjunctive devices to aid in fusion. Various reports have claimed greater than 90\% posterior lumbar interbody fusion rates using allograft bone when coupled with posterior interpedicile screw and plate fixation.\textsuperscript{15,16} Brantigan,\textsuperscript{17} however, in his evaluation of posterior lumbar interbody fusions using allograft bone augmented with pedicle screw/plate instrumentation and posterior lateral fusion, concluded that allograft bone failed to provide the biological activity and structural support for successful union.

In response, a carbon fiber implant that is packed with cancellous bone has been developed to replace the use of allograft bone in posterior lumbar interbody fusions.\textsuperscript{18,19} The implant combines rigid mechanical support with the superior osteogenesis of autogenous bone in comparison to allograft. In addition, the carbon cages are radiolucent, enabling radiographic assessment to fusion, which is a distinct advantage over titanium cages. Early reports using the carbon cage implants have been encouraging.\textsuperscript{2}

Electrical stimulation has also been employed to increase interbody union rates. Merli\textsuperscript{20} has reported an interbody fusion rate greater than 90\% when augmented with direct current regardless of whether patients smoked. Mooney\textsuperscript{21} applied external stimulation in the form of pulsed electromagnetic fields to improve interbody fusion and reported a 92\% union rate compared with a 65\% success rate achieved in a control group.

**CONCLUSION**

Accurate detection of interbody union in cases of posterior lumbar interbody fusion is essential regardless of the adjunctive measures used or whether autograft or allograft is used. Our results indicate that plain radiography is unreliable in reporting results of posterior lumbar interbody fusion and that multiplanar CT may be more appropriate. Additionally, we found progressively increasing density of graft and graft-host interface to be the most consistent sign of posterior lumbar interbody fusion by plain radiography.

We therefore recommend that the surgeon approach the reported posterior lumbar interbody union as deter-
minded by plain radiography with caution. We also advocate the use of multiplanar CT, with an emphasis on sagittal reformations in all situations in which interbody fusion is questionable on plain radiographs.

REFERENCES

EDITORIAL DISCUSSION
ORTHOPEDICS: You compared the evaluation of posterior lumbar interbody fusion on patients from 12 to 17 months following surgery and found that 17 of 22 were classified as fused by radiograph, but 10 of the 17 demonstrated nonunion on reformatted CT scans. This is a good article in that it demonstrates the fallacy of the success rates quoted by various authors for fusion based on plain radiographic evaluation in the face of rigid internal fixation, which prevents micromotion. This is a good article for surgeons who are following their patients for research purposes; the article does not correlate any of the radiographic or CT images with clinical success of the fusion. If a patient is doing well following surgery, we do not think CT is necessary even if the radiographs are equivocal; however, if the patient is doing poorly following surgery, then radiographs cannot be used to document solid fusion, and CT scan is necessary. Can you comment on this?

Siambanes & Mather: We are in full agreement that routine CT scans are unnecessary in the postoperative evaluation of all patients following posterior lumbar interbody fusion. Indeed, a significant number of patients who develop pseudoarthrosis actually may be asymptomatic. Therefore, CT evaluation is warranted only in the patient who is doing poorly postoperatively to determine if symptomatic pseudoarthrosis exists. All of the patients reviewed in our study underwent reformatted CT scanning to investigate some level of postoperative pain causing concern.

However, to eliminate pseudoarthrosis as a potential source of persistent symptoms, proper studies must be assessed. We have found that plain radiography is an unacceptable means in detecting pseudoarthrosis following instrumented lumbar interbody fusion and that reformatted CT scans, while not as definitive as operative exploration, are a reliable indicator of osseous union. We therefore recommend reformatted CT scans be used rather than plain radiography, to assist the surgeon in determining if painful pseudoarthrosis exists and if further operative intervention is required.