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Clinical Study

A comparison of dynamic views using plain radiographs and thin-section three-dimensional computed tomography in the evaluation of fusion after posterior lumbar interbody fusion surgery

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Abstract

BACKGROUND CONTEXT: Accurate evaluation of the postsurgery status of interbody fusion is important in deciding the patient's treatment. Dynamic plain radiographs are used as a convenient method, but the accuracy is not so good.

PURPOSE: This study aimed to evaluate the usefulness of dynamic flexion-extension radiographs as a method for evaluating fusion, by comparing it with three-dimensional thin-section computed tomography (CT).

STUDY DESIGN: Prospective controlled study.

METHODS: We conducted a prospective study with 108 patients (158 levels) who, diagnosed with severe spinal stenosis and Grade I and Grade II spondylolisthesis, underwent posterior lumbar interbody fusion (PLIF) surgery, with follow-up by dynamic plain radiographs, functional rating scale, and three-dimensional (3D) thin-section CT for 1 year after surgery. In the plain radiographs, we looked for less than 3° of lordotic angle change, less than 3 mm of translation between vertebral bodies, and no presence of halo signs; satisfying all the criteria was regarded as fusion (Group A), whereas failure to satisfy any condition was referred to as probable nonfusion (Group B) and if none were satisfied as nonfusion (Group C). The patients were classified into fusion or nonfusion groups based on CT. Correlation between plain radiographs and CT groups was analyzed. Moreover, clinical assessment and cross-comparison between observers were done.

RESULTS: In 158 levels, 95 (60.8%) levels were classified into the fusion group by plain radiographs and 131 (83%) levels by CT. When we analyzed the results of each groups, in Group A, 78 (81.3%) levels belonged to the CT fusion group and 18 (18.7%) levels to the CT nonfusion group, in Group B, 51 (89.5%) and 6 (10.5%) levels, and in Group C, 2 (40%) and 3 (60%) levels, respectively. For each of the CT fusion group, a cross-comparison using dynamic radiographs reconfirmed 78 (59.5%) levels for Group A, 51 (38.9%) levels for Group B, and 2 (1.6%) levels for Group C; for the CT nonfusion groups, 18 (66.7%) levels, 6 (22.2%) levels, and 3 (11.1%) levels were for Groups A, B, and C, respectively. In clinical evaluation, all groups showed clear postsurgery improvement, but there was no statistically significant difference. In terms of observer-to-observer error and agreement between diagnoses, CT showed a statistically higher level of correlation than plain radiographs.

FDA device/drug status: Not applicable.

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CONCLUSIONS: Dynamic flexion-extension radiographs cannot be seen as an objective standard in the evaluation of fusion after PLIF surgery. It would be desirable to confirm the fusion status by thin-section 3D-CT for an objective analysis.

Keywords: PLIF; Flexion-extension views; Interbody fusion; 3D-CT

Introduction

With regard to stenosis and spondylolisthesis, posterior interbody fusion surgery was first described by Cloward [1] in 1953 for the purpose of eliminating spinal instability and relieving pain and is now widely used, with reports of excellent postsurgery results. Such results are because of the fact that posterior lumbar interbody fusion (PLIF) removes the fundamental lesion including the disc, enables direct decompression of the spinal canal, and restores interbody distance, while achieving solid interbody fusion [2]. Although some authors argue that there is no correlation between the degree of fusion and the clinical result [3,4], continuing or recurring symptoms in PLIF-operated patients are sometimes reported to be related to pseudoarthrosis between vertebral bodies [5–7], making it clinically important to determine postsurgery interbody fusion. However, there are no generally accepted radiological imaging methods for evaluating fusion, and there are arguments over the standards for diagnosing fusion. Recent advances in imaging techniques have enabled a more precise determination of fusion, and, in particular, the use of three-dimensional (3D) thin-section multidetector-row computed tomography (CT) to measure the degree of bridge formation in the coronal and sagittal planes is being presented as the best method [8–11]. As methods for evaluating bone fusion, we have the ‘‘sentinel sign’’ [12] and the ‘‘posterior sentinel sign’’ [13] that are being used to confirm interbody fusion by observing the bridging bone that connects between the cages of the upper and lower end plates. However, this is not being used generally for patients postsurgery because of the high cost and lack of a universal standard on the time of scan. The most common method for evaluating fusion in a postsurgery follow-up is dynamic plain radiographs, in cases with almost no motion being defined as fusion [8,14]. Larsen et al. [15] also considered movement of less than 3° as solid fusion, and Brantigan [16] viewed movement of less than 1° as successful fusion. Nakashima et al. [17] defined pseudoarthrosis as a movement of 3° or greater, with a radiolucent zone near the implant that may include pedicle screws, and an unclear bridging bone, whereas Siambanes and Mather determined instability based on interbody motion of 5° or greater and translation of 3 mm or greater [18]. As we have seen, given that the standards are uncertain for each author and there can be measuring errors, the reliability of fusion evaluation using dynamic plain radiographs is questionable and there has not been an objective analysis on this issue. Thus, in the present study, we aim to determine the reliability of dynamic radiographs as a method for evaluating bone fusion, by comparing it with CT 12 months postsurgery, and also to determine the usefulness of CT as a fusion evaluation tool.

Materials and methods

We conducted a prospective study with 108 patients (158 levels) who, diagnosed with severe spinal stenosis and Grade I and Grade II spondylolisthesis at our hospital between October, 2005 and December, 2010, underwent PLIF surgery, with follow-up by dynamic plain radiographs, functional rating scale, and 3D thin-section CT (Ingenuity CT; Philips 128ch, Andover, MA, USA) for 1 year after surgery. Surgical treatment was performed by the same surgical specialists. Patients who were pregnant or had malignant tumors, hepatitis, abnormal blood test results, abnormal liver function, or metabolic bone disease were excluded. Dual-energy X-ray absorptiometry (Lunar, GE, USA) was performed preoperatively in all the patients. Before surgery and 3, 6, and 12 months after surgery, standing lumbar spine dynamic flexion-extension plain radiographs were taken, and for radiating pain, visual analog scale (VAS), functional rating index (FRI), and Korean Oswestry disability index (ODI) were checked; 1 year after surgery, 3D-CT was performed. Interbody fusion was determined by measuring the flexion-extension angle between the lower and upper end plates at the operated level and the position of the cage from the anterior margin of vertebral body on the dynamic radiographs and by observing the radiolucent zone (halo sign) near the pedicle screw and the cage [8,14,17]. We used a picture archiving communication system (Marosis M-view; Marotech, Seoul, Korea) for measuring and cross-comparing dynamic radiographs. To determine fusion, we looked in the dynamic radiographs for less than 3° of lordotic angle change, a distance of less than 3 mm between the anterior margin of the vertebral body and the anterior end of the cage, and a lack of halo sign greater than 1 mm around the cage and the pedicle screw; satisfying all three criteria was deemed complete fusion (Group A), whereas failure to satisfy one or two was referred to as probable nonfusion (Group B) and if none were satisfied as nonfusion (Group C) [15–18]. Evaluation of fusion from 3D-CT was done by checking the bony bridge in the coronal and sagittal reconstruction planes and its connections to the upper and lower end plates, with defects in any position, or a connection of less than 1 mm, being classified as nonfusion.