J Orthop Sci (2005) 10:137–144
DOI 10.1007/s00776-004-0873-5

Journal of
Orthopaedic Science


*Original article*

# Intraoperative insertion torque of lumbar pedicle screw and postoperative radiographic evaluation: short-term observation

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**Abstract** The correlation between the insertion torque of a lumbar pedicle screw and the mechanical stability of the screw in the bone has been mentioned in in vitro studies. The purpose of this study was to confirm the factors affecting the insertion torque of such screws in vivo. Also, the contribution of insertion torque to the initial stability of the fusion area was to be analyzed in vivo. A series of 23 cases representing 50 lumbar vertebrae were included in this study, in which we examined bone mineral density using quantitative computed tomography (CT) prior to operation. Two screw shapes were utilized, with the insertion torque for each screw measured at two points in time. The correlation between insertion torque and mineral density was investigated. Screw positions were confirmed on postoperative CT scans, and the effect of the screw thread cutting into the cortex bone was investigated. Radiographic changes at three points during a period of 3 months were also measured, and we then evaluated the interrelations between these changes and insertion torque. Furthermore, the relation between insertion torque and instability at 3 months was investigated. Correlations of insertion torque and bone mineral density depended on screw shape. There was no correlation found with mineral density in the case of cylindrical screws. Insertion torque was not affected by the screw thread cutting into the cortex of bone. As for postoperative alignment changes, no definitive trends could be ascertained, and no interrelations with torque and alignment changes were observed. There is a possibility that insertion torque was related to early-stage stability, but no statistical relation could be determined.

**Key words** Insertion torque · Bone mineral density · Quantitative CT (QCT) · Pedicle screw · Intraoperative measurement

## Introduction

Lumbar fixation with pedicle screws has become a commonly used method. To maintain the initial alignment of the operation, including the correction operation, patients are obliged to limit activity or utilize orthotic equipment. This is because pain or neural complications might occur if there is a change in the alignment of the fixation level. If there is a method to predict whether intraoperative alignment can be maintained for a long period, we can set a proper orthotic period, which is useful for improving quality of daily life. As regards pedicle screw fixation, the screw strength, rod bending stiffness, and screw-rod sliding strength were the factors found to contribute to initial alignment maintenance, but they were fixed for each system respectively. If the operating surgeon aims for fusion in situ using a polyaxial pedicle screw system, the only one feeling which the operator can recognize is the strength due to the screw–bone interface,[17] and this can be measured as moment during screw insertion.

Many authors have reported the correlation between screw pull-out strength and insertion torque;[3,8,10,13,14,16,17,19] and insertion torque can be affected by bone mineral density (BMD),[1,5,8,10,13,16,19] screw design,[6,14] insertion method,[3,5,12] and the lumbar geometric factor.[17] However, regarding the lumbar operation, few reports have been seen regarding the factors that affect insertion torque, and no report has been seen regarding whether insertion torque of pedicle screws contributes to both bone union and postoperative alignment maintenance. Therefore, in this study we analyzed the factors that affect insertion torque use with a custom-made torquemeter driver in vivo. Also, postoperative radiographic changes were analyzed regarding whether insertion torque could be an index for the strength of the initial fixation stability.

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Received: June 1, 2004 / Accepted: December 20, 2004

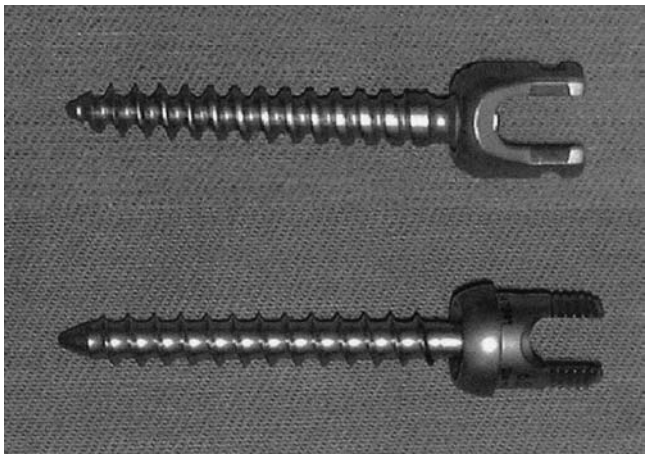

**Fig. 1.** Designs of two types of pedicle screw: XIA LP system (Stryker Spine, Cestas, France; *top*) and Moss Miami system (Depuy Spine, Raynham, MA, USA; *bottom*)

## Materials and methods

The objects were 5 men and 18 women who underwent lumbar pedicle screw fixation using the XIA LP system (Stryker Spine, Cestas, France) or the Moss Miami system (Depuy Spine, Raynham, MA, USA) (Fig. 1) in whom insertion torque could be measured intraoperatively from July to September 2003. The XIA LP group contained 15 patients (17 disc levels), and the Moss Miami group contained 8 patients (10 disc levels). There were 13 posterolateral fusions (PLFs) and 4 posterior lumbar interbody fusions (PLIFs) in the XIA LP group and 8 PLFs and 2 PLIFs in the Moss Miami group. Selection of the system was made randomly during this period. Those for whom bone mineral density (BMD) values could not be obtained preoperatively were excluded. As for fixation methods, we generally selected PLF in situ; but in the case of vertical constriction of nerve roots, we selected PLIF for decompression. All patients wore a soft corset during all activity at least 3 months following the operation. The average age of these patients at the time of operation was 68 years (range 49–86 years). The number of inserted screws was 99.

As regards screw size, in the XIA LP group there were 54 screws that were 45 mm long with a 6.5-mm outer diameter, 4 screws that were 40 mm long with a 6.5-mm outer diameter, 4 screws that were 50 mm long with a 6.5-mm outer diameter, and 1 screw that was 45 mm long with a 7.5-mm outer diameter. The core diameter in the XIA LP group was increased from 2.9 mm to 5.1 mm (in the 7.5-mm outer diameter screw the core diameter was increased from 3.6 mm to 6.1 mm) gradually, and screw thread width gradually increased up to 1.4 mm. The screw pitch was 3.0 mm and fixed. The total number of screws in the XIA LP group was 63.

In the Moss Miami group, the total number was 36; the outer diameters of the screws were 6 mm for all. The core diameters were 4.06 mm, thread widths were 1.26 mm and fixed, and screw pitches were 3.0 mm and fixed (Fig. 1). There were 34 screws that were 45 mm long and 2 screws that were 40 mm long. Both systems were made of titanium alloy (Ti-6Al-4V).

### *Measurement of insertion torque*

Insertion of pedicle screws was performed in a uniform manner as follows: the insertion point was initially drilled, and a pilot hole was made using a curette with 4 mm diameter. After confirmation of no pedicle penetration using a sounder, tapping was made to the halfway point (20–25 mm) of the screw hole. A custom-made torquemeter driver was used, and torque values were measured. This torquemeter had been validated for accuracy by Nakamura Mfg. (Yamanashi, Japan) and proven as compatible with Japan national standards (proof nos. A3325 and 020409). Torque values were measured twice for each screw: at the middle point of the insertion (middle torque) and at the final point of the insertion (final torque).

### *Radiographic assessments*

The BMD of the fusion vertebrae were measured as the equivalent mineral density (EMD; equivalent to hydroxyapatite) in all cases, using quantitative computed tomography (QCT) at the center of each fusion applied vertebral body. Phantom B-MAS 200 (Kyoto-Kagaku, Kyoto, Japan) was used; CT values were acquired by CT Hi Speed NX/I (General Electronics, Milwaukee, WI, USA); and EMD was calculated by the regression line.

The CT examinations were repeated early after operation to confirm screw position. Each case was classified by screw position into one of two groups: "no cortex cutting" group (screw was set completely in spongiosa); "cortex cutting" group (screw thread was cutting into the cortex of the vertebral body or a pedicle was found) (Fig. 2).

Lateral radiographic views were obtained just after operation (prone position on a Hall frame: intraoperative), just after standing and after 1 and 3 months. For the latter three points of time, radiographs were obtained in the standing position. Slip rate, disc angle, and average disc height were measured at each point of time (Fig. 3). Furthermore, a radiolucent zone around the screw was observed; the mobility of the fusion level determined by functional radiographs was also measured 3 months after operation.