The correlation between insertion torque of pedicle screws with bone mineral density values in posterior lumbar pedicle screw fixation

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ABSTRACT

INTRODUCTION:
In a pedicle screw fixation, the degree of osseointegration between a screw and the bone is an essential factor for the stability and fusion. In patients with osteoporosis, however, there is a high possibility for a pedicle screw loosening. Owing to this, there is a difficulty in determining the surgical indications. Previous biomechanical studies have reported that a pedicle screw fixation has a higher degree of relationship with the bone mineral density (BMD). Some experiments confirmed findings that insertion torque was found to be a strong correlating factor in terms of screw pull-out strength. Nevertheless, there are also some reports that there is no consistent relationship between the torsion force during a pedicle screw fixation and that during the removal of a screw. It has been known, however, that the initial stability of a pedicle screw is a very crucial factor for the successful treatment outcomes in the spinal fusion. Therefore, the prediction of initial fixation force of a pedicle screw prior to the surgery would be essential in making a treatment plan for the insertion of a screw and reducing the rate of surgical failure. Given the above background, we attempted to identify the correlation between the BMD and the torque during a pedicle screw fixation in patients who are indicated in posterior lumbar pedicle screw instrumentation. Then, we also attempted to clarify the predictable torque depending on the BMD during a pedicle screw fixation.

METHODS:
Surgical and measurement methods
The current study was conducted in 181 patients who underwent dual-energy X-ray absorptiometry (DEXA, Lunar, GE) during a period ranging from November of 2006 to December of 2009, received the posterior lumbar instrumentation using a pedicle screw by a single surgeon; and intraoperatively had an insertion torque of pedicle screw measured by digital torque gauge (DTDK-N50EX, Kanon, Japan). The pedicle screws were placed in the standard fashion by creating a starter hole medial to the accessory process of the pedicle and dilated by 2.5 mm dilator. Conventional 6.5 mm diameter by 40 to 45 mm length self-tapping pedicle screw from the Xia system (Stryker, USA) was placed. In a pedicle screw fixation, the torque was measured using a digital torque gauge.

Outcome measures and statistical analysis
In regard to the maximal insertion torque, an analysis was performed using Pearson’s correlation coefficient for the BMD at the corresponding surgical vertebrae, mean BMD at the lumbar vertebrae and mean BMD in the proximal femur. In patients who postoperatively underwent a 3-dimensional computed tomography (CT), an analysis was performed to identify the correlation between the internal diameter of a pedicle and the torsion force generated during a pedicle screw fixation. Besides, based on the mean BMD in the lumbar vertebrae, patients were classified into the normal group (T-value > -1.0) and the osteoporosis group (T-value ≤ -1.0) and the osteoporosis group (T-value ≤ -1.0). In this three groups, in regard to the maximal insertion torque, an analysis was performed using Pearson’s correlation coefficient for the BMD at the corresponding surgical vertebrae, mean BMD at the lumbar vertebrae and mean BMD in the proximal femur.

RESULTS SECTION:
In regard to the insertion torque during a pedicle screw fixation, there was a strong positive correlation between the left (16.6 ± 7.8 kgf·cm) and right side (17.1 ± 8.6 kgf·cm) (r=0.7). It also had positive correlations with the BMD at the surgical vertebrae (r=0.49), T-value at the surgical vertebrae (r=0.52), mean BMD in the lumbar vertebrae (r=0.32), mean T-value in the lumbar vertebrae (r=0.50), mean BMD in the proximal femur (r=0.45) and mean T-value in the proximal femur (r=0.42).

In patients with osteoporosis, the insertion torque during a pedicle screw fixation (14.0 ± 7.43 kgf·cm) had positive correlations with the BMD at the surgical vertebrae (r=0.45), T-value at the surgical vertebrae (r=0.44) and mean BMD in the lumbar vertebrae (r=0.31). But it had a weak positive correlation with mean T-value in the lumbar vertebrae (r=0.28).

In patients with osteopenia, the insertion torque during a pedicle screw fixation (15.1 ± 6.27 kgf·cm) had weak positive correlations with the BMD at the surgical vertebrae (r=0.18), T-value at the surgical vertebrae (r=0.24), mean T-value in the lumbar vertebrae (r=0.18), mean BMD in the proximal femur (r=0.16) and mean T-value in the proximal femur (r=0.14).

In normal patients, the insertion torque during a pedicle screw fixation (21.2 ± 9.05 kgf·cm) had positive correlations with the BMD at the surgical vertebrae (r=0.47), T-value at the surgical vertebrae (r=0.45), mean BMD in the lumbar vertebrae (r=0.53), mean T-value in the lumbar vertebrae (r=0.53), mean BMD in the proximal femur (r=0.47) and mean T-value in the proximal femur (r=0.45).

The insertion torque during a pedicle screw fixation was significantly lower in patients with osteoporosis and those with osteopenia as compared with normal patients. The mean torque generated during a pedicle screw fixation was 21.2 ±9.05 (sample size = 244).

Besides, a regression analysis formula for the insertion torque (kgf·cm) was found to be -1.3 + 16.1 X (the BMD at the surgical vertebrae), 9.6 + 7.87 X (mean BMD in the lumbar vertebrae) and -3.26 + 24.6 X (mean BMD in the proximal femur).

DISCUSSION:
There are several factors affecting the pedicle screw insertion torque. In other words, in cases in which a screw insertion point varied, other types of instrument were used, the size of dilator varied and there was a variability of the design of screwdriver handle which was specifically designed for the measurement, the magnitude of insertion torque might be affected. In the current study, however, the dilation was done using the same dilator with the use of the same instrument by the same surgeon. Besides, the same types of screwdriver handle were also used for the measurement. Thus, attempts were made to minimize the measuring errors due to the above factors. The insertion torque generated during a pedicle screw fixation had positive correlations with the BMD at the surgical vertebrae, mean BMD in the lumbar vertebrae and mean BMD in the proximal femur. Particularly in patients with osteoporosis and normal patients, this correlation was more notable as compared with patients with osteopenia. But there was no significant correlation with the internal diameter of a pedicle at the surgical sites. Besides, a variable degree of torque was observed during a pedicle screw fixation even at the same degree of BMD. The BMD therefore be used in predicting the accurate degree of a pedicle screw fixation. Because there is a positive correlation between the BMD and the fixation force of a pedicle screw, however, it can therefore be inferred that the assessment of BMD would be useful in determining the fixation of device and the number of fusion segments in patients who are suspected to have osteoporosis and indicated in a pedicle screw fixation.