

# 主論文

## **Accuracy of pedicle screw insertion in posterior scoliosis surgery: a comparison between intraoperative navigation and preoperative navigation techniques**

(側彎症手術における椎弓根スクリュー挿入精度の検討：術中ナビゲーションと術前ナビゲーションの比較)

### **【Introduction】**

Pedicle screws are widely used for the treatment of adolescent idiopathic scoliosis (AIS) because of the excellent fixation achieved within a shorter fusion length and their three-dimensional correction force. Accurate placement of pedicle screws in scoliosis patients is very important but difficult because of the rotation of the corpus vertebrae as well as the difference in the radii of the pedicles, deviation of the spinal cord, and thinning of the pedicles, all of which increase the potential risk of screw misplacement.

There are various navigation systems aimed at improving the accuracy of screw placement and avoiding neurovascular complications from screw misplacement. Clinical studies demonstrated improved accuracy in pedicle screw insertion when using a preoperative CT-based navigation system. The major limitation of this technique is associated with variable patient positioning. There has been a technological evolution in the past year with the use of intraoperative navigation. With this method of navigation, surgeons can avoid the position-variation problem and improve the efficacy of screw placement.

We conducted the current study to assess and compare the efficacy and accuracy of intraoperative navigation (O-arm or Arcadis navigation) and preoperative CT based navigation in AIS surgery and to analyze misplacement patterns of pedicle screws.

### **【Materials and Methods】**

#### Subjects

A retrospective study was conducted in patients with AIS who underwent surgical treatment at our hospital between January 2009 and June 2015. Inclusion criteria were (1) an AIS patient who underwent correction surgery, (2) single main thoracic or double thoracic curve patterns, and (3) an all pedicle screw-based posterior instrumentation. We excluded scoliosis patients who did not have AIS, who were surgically treated by an anterior approach or who had other curve patterns. For each patient, we measured the number of pedicle screws, the number of pedicle screws per vertebra in the apical region ( $\text{apex} \pm 2$  vertebrae), and the coronal Cobb angle of the main thoracic curve using pre- and postoperative full-length standing radiographs and CT, respectively.

#### Accuracy assessment of the pedicle screws

Postoperative CT images (1.25- or 1-mm thickness) of the instrumented segments were used for analyzing pedicle breaches in both groups. We classified pedicle perforations as either medial or

lateral according to the Gertzbein classification.

## **【Results】**

### Demographic data

The study group included 27 patients who underwent intraoperative navigation-based insertion of 492 pedicle screws and 40 patients treated with preoperative navigation based insertion of 626 pedicle screws. The mean ages at the time of operation were 16.1 years (range 12–24 years) and 16.2 years (range 13–25 years) for the intraoperative and preoperative groups, respectively. The angles of the main curve before and after surgery were similar between the two groups. The Cobb angle was corrected from 60.4 to 15.8 (correction ratio 74.6%) in the intraoperative group and from 59.5 to 16.6 (correction ratio 72%) in the preoperative group. The difference between the two groups was not statically significant ( $P = 0.410$ ). The two groups were similar before surgery with respect to apical vertebra rotation.

### Accuracy rate of pedicle screw placement

In the two groups, a total of 433 pedicle screws were implanted in the apical regions of patients' main curves. The accuracy of pedicle screw placement (grades 0, 1) was significantly higher in the intraoperative navigation group than in the preoperative navigation group (199/210, 94.8% vs 199/223, 89.2%, respectively;  $P = 0.035$ ). Overall, there was a significantly higher frequency of lateral perforation (36/1118, 3.2%) than medial perforation (17/1118, 1.5%). Furthermore, using intraoperative navigation significantly diminished the incidence of medial perforation (3/492, 0.6% vs 14/626, 2.2%,  $P = 0.027$ ).

### Misplacement patterns of pedicle screws

The most common location of misplacement was around the apex vertebra (T7–9) of the curve. Moreover, some misplaced pedicle screws were in the proximal thoracic spine at the apex of the thoracic curve (T3–T4) whether it was a structural curve or nonstructural curve.

## **【Discussion】**

The mechanics of AIS increases the difficulty of inserting pedicle screws because of the deformity of the vertebral bodies, their relatively narrower pedicles, and the spinal cord shift to the concave side resulting in a limited epidural safe zone, especially at the apical region.

The literature shows that preoperative CT navigation can achieve overall higher rates of accuracy in scoliosis patients. In our study, the perforation rate were 10.8% in preoperative group and 5.2% intraoperative group in apical region, because the major limitation of this technique is associated with the variable positioning of the patient. And the incidence of medial perforation was particularly high in the preoperative group.

In this study, 45% (24/53) of misplaced pedicle screws were in pedicle channels of less than 3 mm, which could be considered a planning error rather than a navigational error or technical error. As to the misplacement pattern of the pedicle screws, the apical vertebra was at about T7–9, and we

experienced a higher perforation rate at the apical region compared to the overall perforation rate in this study. Since the apical region is the most rotated region in AIS, it is difficult to control the inclined angle when inserting pedicle screws without encroaching into the concave or convex sides.

Another major benefit of intraoperative navigation is the decreased pedicle insertion time. The time required for the registration procedure and insertion of one pedicle screw was  $11.3 \pm 2.1$  min in the preoperative group, but only  $5.1 \pm 1.1$  min in the intraoperative group, because the surgeon can avoid the time-consuming repetitive calibration for each vertebra.

#### **【Conclusion】**

Both preoperative CT-based and intraoperative navigation systems provide sufficient accuracy and safety in pedicle screw insertion for AIS surgery. Intraoperative navigation systems facilitate pedicle screw insertion in the apical region and reduce registration time during AIS surgery which improves the efficacy and accuracy of pedicle screw insertion.