A COMPARISON OF PULLOUT STRENGTH OF PEDICULAR SCREWS BETWEEN DIFFERENT METHODS OF SCREW INSERTION IN POSTERIOR FIXATION OF THORACIC SPINE

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Abstract- Pedicle screws provide rigid fixation for instabilities in the lumbar and lumbosacral spine. Anatomical consideration and potential risk of neurologic complications are the reasons to hesitate using pedicle screws in the thoracic spine. Twenty moulages similar to human vertebrae were instrumented with Cotrel-Dubousset (CD) system pedicle screw by intratransverse process, extrapedicular and intrapedicular methods and pullout strength was measured. There was statistically significant difference between three techniques. By increasing the length of screw in any method, pullout strength increased. Average pullout strength in extrapedicular technique was less than two other techniques in dynamic state. The strongest technique for screw placement was intratransverse process technique. It seems that intratransverse process technique is safe for posterior fixation of spine.

Acta Medica Iranica 2008; 46(6): 447-450.

Key words: Pedicle, screw, spine, thoracic, intratransverse process, pullout strength

INTRODUCTION

Interesting progresses have been made in spine surgery, and now three types of instruments for posterior fixation of spine are available: wire or cable, hook, and screw. Recently, considering benefits of posterior fixation of spine with pedicular screws, these devices are more frequently being used (1).

Fixation devices may cause spinal cord or neurologic complications (especially hooks during rotation of rods) and these complications are always cause of concern for spine surgeons. Use of pedicular screws obviously improve results of posterior fusion of spine and may be chosen as gold standard in internal fixation of spine (2).

Received: 24 Apr. 2007, Revised: 30 May 2007, Accepted: 5 Aug. 2007

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Posterior instrumentation of spine in lumbar, thoracolumbar and sacral areas cause rigid and stable fixation of spine. Today, there is increasing desire for inserting screws in upper and middle areas of thoracic spine for selected patients with deformity (scoliosis, kyphosis), trauma, and infectious, degenerative and neoplastic disorders. However, morphologic studies show that pedicles in upper and middle segment of thoracic spine are small and this make screw insertion difficult.

For prevention of dangerous screw insertion, Dvorak *et al.* offers an extrapedicular screw insertion method (3). Statistical studies show that pullout strength of screws in this method is higher than intrapedicular method because there are more locations for penetrating cortical bone. This method has numerous benefits because screws are inserted far from spinal cord, decreasing risk of cord injury. However, they show that anatomy of posterior spine components is different between individuals and

clinical use of these methods must be with caution (3).

Today, trend is toward finding more reliable, stronger, and safer methods in posterior fixation of thoracic spine. Present study tries to define pullout strength of posterior fixation devices (pedicular screws), compare them with each other and finally selecting the most reliable and stable method that has the highest pullout strength. In this study, we present intratransverse process method and compare this with two other, extrapedicular and intrapedicular, methods.

MATERIALS AND METHODS

Preparation

We prepare our cases by one of these methods:

1- Using one complete thoracic segment of spine (12 vertebrae) of cadaver (with normal density). To achieve this, we obtained vertebrae from fresh cadavers and measure osteoporosis with dual energy X-ray absorptiometry (DEXA), confirming that density is in the normal range.

2- Using thoracic moulage simulated as natural bone with coverage of 2 mm resin of Epoxy GY 6010 with rigidity of Aradur 43 as cortical bone (20 vertebrae).

3- Using complete segment of ship thoracic vertebrae (10 vertebrae).

Instrumentation

We inserted pedicular screws of Cotrel-Dubousset (CD) system with three methods: 1) intrapedicular (standard method), 2) extrapediculer, and 3) intratransverse process method (Fig. 1).

We used different length of pedicular screws to occupy 60, 75 and 90 percent of vertebral length. All of them were fixed angle. Entrance port of intrapedicular screws was selected in dorsal aspect of lamina where pedicle is elongated and for extrapedicular technique it was selected in lateral 1/3 of tip of transverse process. Screws were entered convergently to avoid disturbtion of inner wall. In our method, intratransverse process, screws are inserted in line with transverse process convergently. All of the devices were inserted by one spine surgeon.

Vertebrae fixator preparation

For exact localization of pullout force to entrance part of screw, not to the other parts of vertebra and not creating shearing force and fracture of vertebra, a special fixator was planned and created to have these specialty and after testing, referred for final examination.

Biomechanical testing

After instrumentation of vertebrae, screws were attached to fixator and with biomechanical tensioner with 10000 Newtons pullout force with 10 mm per minute speed were pulled out and pullout strengths were measured. In each vertebra, a maximum of 2 screws were inserted (separately as one screw inserted in intact part of vertebral body). During extraction of screws, their pullout curves were drew (for each screw one curve).

Ethics Committee of our instutation approved the project. Statistical analysis was performed by SPSS software. Statistical significance was defined as $P < 0.05$.

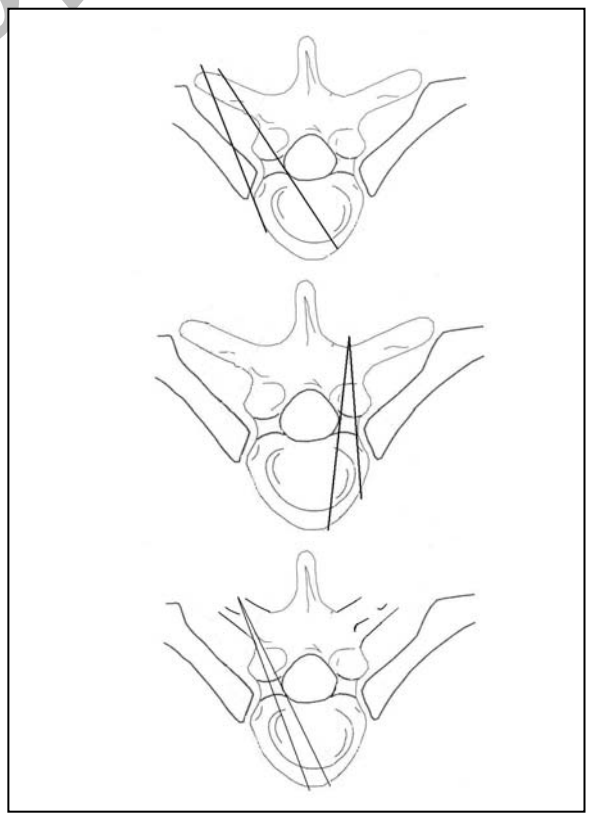

Fig. 1. Schematic pictures of three different methods of insertion of pedicular screw.

RESULTS

Because human and ship samples were not sufficient, we did not participate them in our study and for decreasing biases, study was restricted to simulated moulage.

After instrumentation, by study of different length of screws and different methods of screw insertion, it was cleared that pullout strength of different methods have meaningful difference ($P < 0.05$). By increasing the length of screw in any methods, pulled out strength increased (Fig. 2).

DISCUSSION

In present study, we try to find the best method of pedicular screw insertion regarding pullout strength. In Suk *et al.* study, reliability of thoracic pedicular screws were tested and analyzed in 4604 screws. They found malposition in 67 screws (1.5%) in 48 patients (10.4%). In 4 patients (0.8%), there were neurologic complications (one transient paraparesis and three dural injuries). They concluded that thoracic fixation with pedicular screws in comparison with hooks is a reliable method with high level of correction and confidence (4). Vaccaro *et al.* show that pedicular screw insertion in thoracic spine is indicated only where stability of spine is critical (5). In the second stage of study, they analyzed location of thoracic pedicular screws in cadaver (6). Of 90 screws, 37 had penetrated lateral cortices (5, 6). Study shows that in comparison with intrapedicular methods and hooks, pullout strength of screws in extrapedicular techniques is much higher. This finding may be duo to stronger bone implant fixation because of longer screws. This study also shows that in extrapedicular technique screw diameter is independent to pedicle size (5) and it causes more bone contact up to 50%. It means that screw diameter in extrapedicular method is higher than intrapedicular method (7-10).

Morgenstern *et al.* used USS system for posterior instrumentation of 12 thoracic vertebrae of cadaver and compared them with regard to stability. They found that extrapedicular and intrapedicular techniques had equal stability but considering complications, extrapedicular technique was safer (11).

In our study, we introduced a new technique named intratransverse process technique and compared it with extrapedicular and intrapedicular techniques. After instrumentation with each method, pullout strength of each one was measured. In comparison between mean pullout strength of screws in each of three methods, this strength was highest in intratransverse process method and lowest in extrapedicular method.

Considering results of present study, it seems that in dynamic states (as in ordinary living) intratransverse process technique is the most reliable method regarding pullout strength. On the other hand, in static states (suddenly applied forces to spine) the most reliable method is intrapedicular technique and the weakest one is extrapedicular

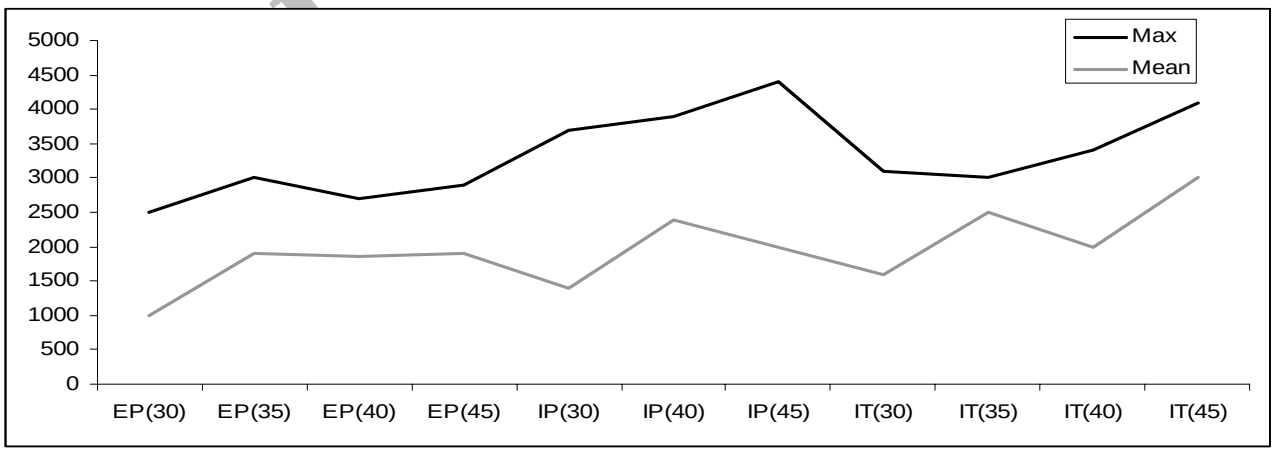

Fig. 2. Mean and maximum pullout strength of pedicular screw in three different methods. EP, extrapediculer method; IP, intrapedicular method; IT, intratransverse process method.

method. This could be duo to the fact that in intratransverse process technique, we can use longer screws with more bone screw contact, which leads to increasing pullout strength.

In conclusion, it seems that it is possible to use intratransverse process technique for posterior fixation of spine. It is a safe technique with lower chance of instrumentation failure rates. For coverage of all daily activities and instances, we suggest that it is better to use some screws with intratransverse process method and the others with intrapedicular technique. However, more study is needed to choose the best configuration and mixture of screws.

Conflict of interests

The authors declare that they have no competing interests.

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