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Technical Report

Percutaneous pedicle screw placement under single dimensional fluoroscopy with a designed pedicle finder—a technical note and case series

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Abstract

BACKGROUND CONTEXT: Minimally invasive spine surgery has become increasingly popular in clinical practice, and it offers patients the potential benefits of reduced blood loss, wound pain, and infection risk, and it also diminishes the loss of working time and length of hospital stay. However, surgeons require more intraoperative fluoroscopy and ionizing radiation exposure during minimally invasive spine surgery for localization, especially for guidance in instrumentation placement. In addition, computer navigation is not accessible in some facility-limited institutions.

PURPOSE: This study aimed to demonstrate a method for percutaneous screws placement using only the anterior-posterior (AP) trajectory of intraoperative fluoroscopy.

STUDY DESIGN: A technical report (a retrospective and prospective case series) was carried out.

PATIENT SAMPLE: Patients who received posterior fixation with percutaneous pedicle screws for thoracolumbar degenerative disease or trauma comprised the patient sample.

METHOD: We retrospectively reviewed the charts of consecutive 670 patients who received 4,072 pedicle screws between December 2010 and August 2015. Another case series study was conducted prospectively in three additional hospitals, and 88 consecutive patients with 413 pedicle screws were enrolled from February 2014 to July 2016. The fluoroscopy shot number and radiation dose were recorded. In the prospective study, 78 patients with 371 screws received computed tomography at 3 months postoperatively to evaluate the fusion condition and screw positions.

RESULTS: In the retrospective series, the placement of a percutaneous screw required 5.1 shots (2–14, standard deviation [SD]=2.366) of AP fluoroscopy. One screw was revised because of a medial

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wall breach of the pedicle. In the prospective series, 5.8 shots (2–16, SD=2.669) were required forone percutaneous pedicle screw placement. There were two screws with a Grade 1 breach (8.6%), both at the lateral wall of the pedicle, out of 23 screws placed at the thoracic spine at T9–T12. Forthe lumbar and sacral areas, there were 15 Grade 1 breaches (4.3%), 1 Grade 2 breach (0.3%), and 1 Grade 3 breach (0.3%). No revision surgery was necessary.

CONCLUSION: This method avoids lateral shots of fluoroscopy during screw placement and thus decreases the operation time and exposes surgeons to less radiation. At the same time, compared with the computer-navigated procedure, it is less facility-demanding, and provides satisfactory reliability and accuracy.

Keywords: Fluoroscopy; Minimally invasive spine surgery; Navigation; Pedicle screw; Percutaneous screw; Radiation

Introduction

Minimally invasive spine surgery (MISS) has become more accessible in clinical practice. The more intraoperative fluoroscopy that surgeons use during MISS for the guidance of instrumentation, the more ionizing radiation that surgeons are exposed to [1,2]. Ionizing radiation has been recognized as a carcinogen by the World Health Organization [3]. For spine surgeons, the greater radiation exposure occurs during percutaneous pedicle screw placement compared with minimally invasive transforaminal lumbar interbody fusion (TLIF), vertebroplasty or kyphoplasty, and percutaneous endoscopic lumbar discectomy [4]. Although surgeons' radiation exposure during MISS is within the safe level per the International Commission on Radiological Protection guidelines [5], less radiation exposure is still better.

In open surgery, freehand pedicle screw insertions are reported to carry a risk of screw malposition of up to 40% [6]. Neurophysiological monitoring has been used to guide the safe placement of screws [7]. Computer-assisted navigation systems may increase the accuracy of the positioning of screws [8–14], but one study with a good sample number revealed different results [15]. Both of these techniques required equipment with additional cost and personnel training, as well as prolonged operation time because of equipment setup and monitoring.

In 2010, as a resident, the first author of the current study attended a conference, the Joint Section on Disorder of the Spine and Peripheral Nerve of the American Association of Neurological Surgeons/Congress of Neurological Surgeons. Professor Michael Y. Wang of the University of Miami shared his experience on posterior fixation for earthquake victims in Haiti while introducing a talk for an MISS course. He mentioned the difficulties of placing pedicle screws, especially percutaneous pedicle screws, at a field hospital, where the facility was limited and only an anterior-posterior (AP) X-ray machine was available.

Inspired by this talk, we developed an alternative method for percutaneous screw placement with only an AP view of intraoperative fluoroscopy. This method avoids changes in the fluoroscopy gantry angle, decreases the operation time, and exposes surgeons to less radiation. At the same time, it provides satisfactory reliability and accuracy.

Methods

Instrument design

One instrument that combined an awl, pedicle finder, and tapper was designed for this procedure. The instrument is composed of two parts (Fig. 1, Top). The first part has the characteristics of a metallic handle, a 120-mm long cannulated trocar that is 8 mm in diameter and another 40-mm anterior portion that is 3 mm in diameter. The anterior portion includes a 10-mm long shallow screw thread that provides low purchasing power while screwing the instrument to cannulate the pedicle. The second part is a cap that is fixed with a shortened Kirschner wire, and the Kirschner wire can be changed between operations. The instrument enables approximately 5 mm of the sharp tip of the Kirschner wire to be exposed (Fig. 1, Bottom). This anterior 40-mm slender portion assures proper path creation for pedicle screw insertion.

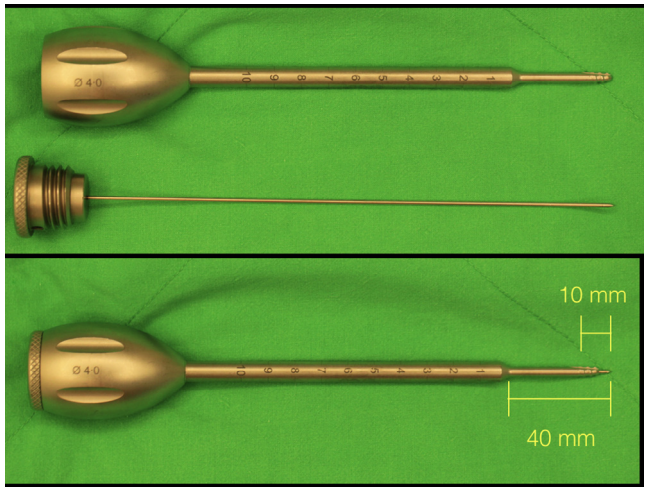

Fig. 1. (Top) The first part has the characteristics of a metallic handle, a 120-mm long cannulated trocar that is 8 mm in diameter, and another 40-mm anterior portion that is 3 mm in diameter. The anterior portion includes a 10-mm long shallow screw thread that provides low purchasing power while screwing the instrument to cannulate the pedicle. The second part is a cap that is fixed with a shortened Kirschner wire. (Bottom) The instrument enables approximately 5 mm of the sharp tip of the Kirschner wire to be exposed. This anterior 40-mm slender portion assures proper path creation for pedicle screw insertion.