MINIMALLY INVASIVE PEDICLE SCREW FIXATION USING INTRAOPERATIVE THREE-DIMENSIONAL FLUOROSCOPY-BASED NAVIGATION (CAMISS TECHNIQUE) FOR HANGMAN'S FRACTURE

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INTRODUCTION

Hangman's fracture increases in these days due to growing rates of motor vehicle accidents. Biomechanical studies have shown that the stability of C2-C3 pedicle screw fixation is superior to other internal fixations [1]. However the conventional open approach will strip large amount of muscles and ligaments, resulting in severe postoperative neck pain. Minimally invasive screw fixation is performed via a muscle dilating approach and significantly decreases iatrogenic soft-tissue injury. But small operating corridor used in minimally invasive surgery (MIS) makes instrumentation placement more difficult and increases the risk of instrumentation-related complications. The advent of intraoperative three-dimensional fluoroscopy-based navigation (ITFN) system permits safe and accurate instrumentation of cervical spine with the advantage of obtaining intraoperative real-time images and automatic registration [2]. However, few studies are available on its use in Hangman's fracture, not to mention its combination with MIS technique [3,4]. In this study, we compare two navigation methods treating Hangman's fracture to evaluate the accuracy and feasibility of MIS techniques incorporating with ITFN.

MATERIALS AND METHODS

From 2012 April to 2014 May, 20 patients with Hangman's fracture underwent C2-C3 pedicle screw fixation using ITFN. 6 patients (5 males and 1 female with an average age 36.5±12.9 years old) used MIS technique, the other 14 patients (11 males and 3 females with an average age 34.5±11.4 years old) using conventional open technique. All patients complained of neck pain. Visual analogue score (VAS) was 5.7±1.4 on average in CAOS-MIS group and 5.5±0.9 in CAOS-open group. Exclusive criteria for candidates included stable Hangman's fracture, too narrow bony trajectory for optimally placing pedicle screws showed on preoperative CT images, and decompression required even after traction.

Surgical technique

The patient was positioned prone with his head fixed by a Mayfield frame. The fluoroscopy was used to confirm appropriate reduction. The motorized C-arm acquired the three-dimensional images first and transferred them to the navigation workstation. Under the guidance of navigation, the entry points of the C2 and C3 pedicle screws on the skin were identified (Figure 1). A longitudinal incision was made between the two. With the use of standard muscle splitting dissection and sequential dilation techniques, an expandable tubular retractor could then be positioned. Guided by the navigation, the screw entry points were identified and the trajectories of C2 and C3 pedicle screws were tapped. The C2/3 articular surface was decorticated using a registered high-speed drill. Then, suitable pedicle screws were placed and so was the rod (Figure 2). The procedure was repeated on the contralateral side. Finally the motorized C-arm acquired the three-dimensional images again to verify the accuracy of screw placement.

Operative time, blood loss and postoperative neurovascular complications were recorded. The accuracy of screw positions was studied by postoperative CT scan, using a modified classification of Gertzbein and Robbins. All patients were followed up for at least 6 months with VAS scores evaluated and serial radiographs were performed to ascertain the fusion status.

RESULTS

The average operative time was 134.2±8.0 min (range 130-150 min) in CAOS-MIS group and 139.3±25.8 min (range 105-210 min) in CAOS-open group. The blood loss was 66.7±25.8 ml (range 50-100 ml) in CAOS-MIS group and 250.0±141.4 ml (range 100-500 ml) in CAOS-open group on average. There was no significant difference in operative time ($p>0.01$). But statistical difference existed in the blood loss with CAOS-MIS group significant less than CAOS-open group ($p<0.01$).

A total of 80 screws were inserted, 24 screws in CAOS-MIS group and 56 screws in CAOS-open group. No screw-related neurovascular injury was observed. Postoperative CT scan revealed 20 screws of grade 1 (83.3%) and 4 screws of grade 2 (16.7%) in CAOS-MIS group, meanwhile 50 screws of grade 1 (89.3%) and 6 screws of grade 2 (10.7%) in CAOS-open group. Fisher's exact test showed there was no statistical difference between these two groups ($p>0.01$).

There was no statistical difference in preoperative VAS between these two groups ($p>0.01$). Compared with the CAOS-open group (1.7±0.6), neck pain VAS at 6-month follow-up in CAOS-MIS group (0.3±0.5) was significantly lower ($p<0.01$). Solid fusion was demonstrated in all the cases by static and dynamic (flexion/extension) films in their 6-month follow-up.

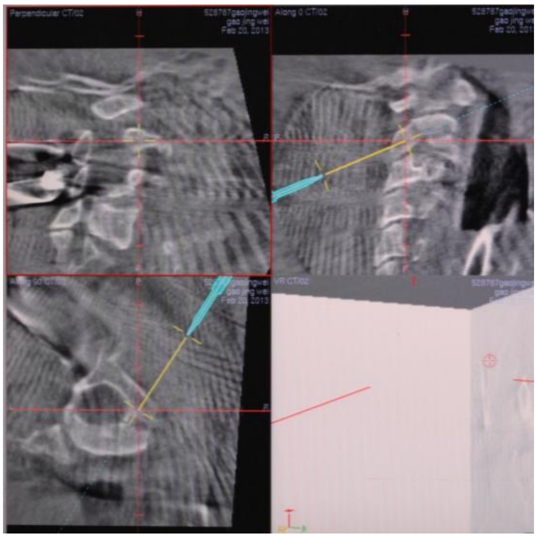

Figure 1: The entry points on the skin and orientation of trajectories for C2 and C3 pedicle screw were identified on the images of navigation system.

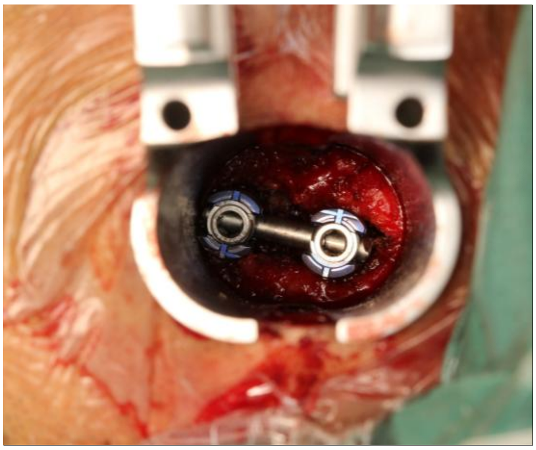

Figure 2: C2-C3 pedicle screws were placed along the pre-tapped paths and the rod was placed under direct visualization through an expandable tubular retractor.

DISCUSSION

Because the axes of the cervical pedicles to the sagittal midline plane vary between 25° and 60° [5], which makes a wide exposure of the spine necessary and may result in significant postoperative pain [6], muscle-sparing MIS approaches are well-suited for the surgery in this region. But one major problem of these techniques is the absence of anatomical landmarks, which reduces the information available to the surgeon. Virtual fluoroscopy, which can be used for guidance of percutaneous spinal screw placement, yields only two-dimensional information and does not offer the reconstructed axial anatomic views that can be so useful for precise screw placement [7]. The introduction of conventional CTbased navigation has been shown to improve the accuracy and safety of upper cervical instrumentation procedures [8]. But this technology cannot be used for completely percutaneous screw fixation because of the need for a manual, surgeon-dependent anatomic registration process. And because the images are obtained before surgery out of the operative room, the preoperative CT scanning may not reflect the actual intraoperative anatomical relationships of the patients with unstable fractures. ITFN represents the most recent technologic advancement in the rapidly evolving field of spinal image guidance. This technology is known for the advantages of obtaining intraoperative real-time images, automatic registration and three-dimensional views. With these characteristics, ITFN seems to be an inherent partner for MIS techniques. So we propose the conception “CAMISS” (computer assisted minimally invasive spinal surgery). In our study, CAOS-MIS group is proved to be superior to CAOS-open group in decreasing iatrogenic injury and comparable with CAOS-open group in operative time and accuracy of screw placement. So we believe CAMISS technique represents the most recent modification of spine surgery, especially in traumatic cases.

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