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ORIGINAL STUDY

Comparison of microendoscopic discectomy system and anterior open approach in treatment of unstable odontoid fracture with cannulated screw internal fixation

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This study intended to investigate the safety and efficacy of microendoscopic discectomy system compared with anterior open approach in the treatment of odontoid fracture with cannulated screw internal fiation. Thirty-two patients (25 male and 7 female) were enrolled and randomly assigned to different treatments. 15 patients were treated with microendoscopic discectomy system (Group MED) and 17 patients were treated with anterior open approach (Group AOA). The operating time, volume of blood loss, occurrence of complications, and fracture healing rate were compared. In Group MED, the mean operating time and blood loss volume were significant lower than those in Group AOA ($P < 0.05$). Nevertheless, all patients in both groups obtained bony union and cervical range of motion without significant difference statistically ($P > 0.05$). Three patients in Group AOA complained of transient dysphagia. We concluded that microendoscopic discectomy system for odontoid fracture treatment with cannulated screw is a safe, reliable and minimal invasive procedure compared with traditional open surgery.

Keywords : microendoscopic discectomy system ; odontoid fracture ; internal fixation ; cannulated screw.

INTRODUCTION

Odontoid fracture is fairly common among the cervical spine fractures, accounting for 9-15% in adult population (*10,34*). Odontoid fractures were divided into three types by Anderson and D'Alonzoare (*1*). Based on this classification, type II and III represent highly unstable entities (*5*). Conservative management included the application of cervical orthoses, halo vests and jackets. However, these therapeutic modalities showed a poor prognosis with the nonunion rates reaching 2.4% to 100% (*2,6,13,25*) in various dens fractures. The rationality regarding the posterior C1-C2 fusion, compromising axial rotation by 45°and flexion-extension by 15° (*14*) was still controversial. Since Nakanishi *et al* (*22*) started to adopt the technique of odontoid screw fixation in 1978, it has been wildly implemented for treatment of type II and some rostral type III odontoid fractures. According to the

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literature, anterior odontoid screw fixation was able to provide immediate stabilization with higher fusion rates to 80- 100% (*7,15,34*) and preserve the C1-2 rotation (*7,18,34*). Therefore, anterior screw fixation was recommended for the treatment of type II and shallow type III odontoid fractures (*7,18,28,29*).

Nevertheless, anterior retropharyngeal approaches could induce various major complications, such as neural injury, esophageal and pharyngeal perforation, hemorrhage, and airway obstruction (*30,33*). To minimize the surgical injury and avoid soft tissue damage, multiple new technical means have been developed to improve the odontoid screw placement. We applied modified microendoscopic discectomy system to treat odontoid fractures with cannulated screw internal fixation in our hospital from January 2005 to November 2011. Although this approach has been shown feasible and safe, no related prospective study was reported. Present study planed to evaluate the clinical outcomes of odontoid fractures treated by microendoscopic discectomy system or traditional anterior open approach prospectively.

MATERIALS AND METHODS

A total of 32 trauma patients aged 17 to 65 years were enrolled from January 2005 to November 2011. Fractures were confirmed by the aids of plain radiographs, computerized tomography (CT) and magnetic resonance imaging (MRI). All patients, including 29 type II fractures and 3 type III fractures, were randomly assigned to the microendoscopic discectomy system group (Group MED, n = 15) or the anterior open approach group (Group AOA, n = 17). Surgical procedures were performed by the same surgeon in our hospital. The parameters including operating time, volume of blood loss, occurrence of complications, and fracture healing rate were collected for assessment. The study was approved by Institutional Review Board and was conducted at the Department of Orthopaedics, 175th Hospital of PLA, Orthopaedics Center of PLA, Southeast Hospital of Xiamen University.

Microendoscopic Discectomy System anterior screw fixation

Microendoscopic discectomy system (METRx, Sofamor, Memphis, USA) was originally designed for lumbar discectomy via middle posterior access, and was not suitable for cervical spine operation through vertebral anterior approach, especially for upper cervical spine operation. We transformed the form of working channel and specially developed one type with 15°/20°/ 30°distal slope to accommodate the placement of cannulated screw fixation, which required 15° bevel inclination (Fig. 1). Meanwhile, the chisel was homemade with a length of 250 mm and various widths of 3, 4, and 5 mm respectively for convenient operation under microendoscopy.

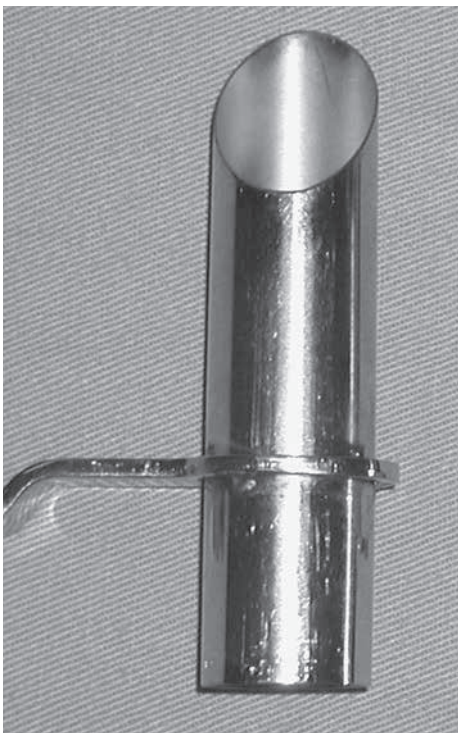


Fig. 1. — Modified working channel of microendoscopic discectomy system for internal cannulated screw fixation.

After induction of intranasal intubation anesthesia, the patient was positioned in a supine position with a pad under the shoulders to allow slight extension of the neck. Head was fixed with sand-bagson both-side to be maintained on the midline. A bandage roll was stuffed into mouth for ease to take mouth-open radiographs during operation. Fracture reduction was observed on anteroposterior and lateral views with C-arm radiography. When ideal reduction was achieved, the operation area was sterilized and draped. A small incision of 1.4-1.6 cm long was made on the right-hand edge of thyroid cartilage.

The skin, subcutaneous tissue and platysma were cut and the esophagus and trachea were bluntly pushed with index finger to the left side.A MED working channel was implanted using gradual expanding method. After working channel was placed, prevertebral fascia and bilateral longus could be found under direct vision. Electrocautery was prohibited if soft tissues were still found under endoscopy. A blunt nerve dissector was applied or the soft tissues were pushed away from the working channel with retractor to prevent damage to esophagus and blood vessels. After the establishment of the working channel, C2, 3 space was defined under fluoroscopy. Thereafter, we used a special homemade bone chisel to make an oblique groove on the middle of upper border of C3 vertebral body, and drill the guide wire to the center of the lower edge of C2 vertebral body. With 15° angulation, the guide was drilled to the center of the lower edge of the odontoid process under fluoroscopic guidance. The next steps were drilling with a hollow drill, measuring depth, tapping, screwing the cannulated screw under fluoroscopy, taking out the guide wire, removing the micro endo disc system and suturing the incision. A representative case is shown in Figure 2.

Anterior open approach screw fixation

According to Reilly *et al* (26), a transverse incision (5-6 cm) was made near the C5 level. The platysma and fascia of sternocleidomastoid were separated with vessel forceps, and with fingers for blunt dissection to reach the anterior surface of vertebral body tacking care of superior thyroid artery and superior laryngeal nerve. The carotid artery sheath and visceral sheath were pulled gently with retractors to expose the C2-C3 disc space . A small portion of anterior annulus of C2-C3 disc space was removed, along with the creation of a small recess into the anterior-inferior edge of the C2. A single cannulated screw was inserted into the C2 vertebral body across fracture line.

Postoperative Management

Intravenous antibiotics were administered to all patients and a drainage system was left in place for 24 hours postoperatively. Patients in Group MED were allowed to walk 48 hours after surgery and were immobilized with a soft cervical collar for approximately 12 weeks. Radiographic and CT scan controls were performed regularly after the surgery. No daily activity restriction was required afterfracture consolidation.

Clinical and Radiologic Evaluation

Operating time, volume of blood loss, fluoroscopy frequency during operation, occurrence of complications, healing rate of fracture and degree of neck motion at the final follow-up were collected for analysis. Lateral, open mouth, and flexion-extension lateral radiographs of C1-C2 were taken regularly after surgery to assess the union and alignment status of odontoid fractures. Bone healing was identified by formation of trabecular and cortical bony bridges at the fracture.

Statistical analysis

SPSS version 17.0 statistical software was adopted for statistical analyses. Data were shown as mean ± SEM. Student t test was used for comparison of continuous variables. A P value less than 0.05 was considered as statistically significant.

RESULTS

The demographic characteristics of patients are presented in Table I and show no statistically significant differences between the two groups ($P > 0.05$).

Table I. — Demographic characteristics and characteristics of fractures

	Group MED	Group AOA
No. Of patients	15	17
Mean age (year)	35.6 ± 4.2	39.8 ± 5.3
Sex (M/F)	12/3	13/4
Type II dens fractures	14	15
Rostral type III dens fractures	1	2
Displacement of fracture	2.8 ± 0.2	2. 9 ± 0. 15
Time between trauma and operation (d)	6.3 ± 2.8	7.0 ± 3.1

The parameters evaluated in bothgroups are listed in Table II.

The mean follow-up period was 39.6 months (range 16-58 months). The mean length of operative time was 75.7 minutes and mean blood loss volume was 20.5 mL in Group MED vs. 96.3 minutes and 100.5 mL in Group AOA ($P < 0.05$).

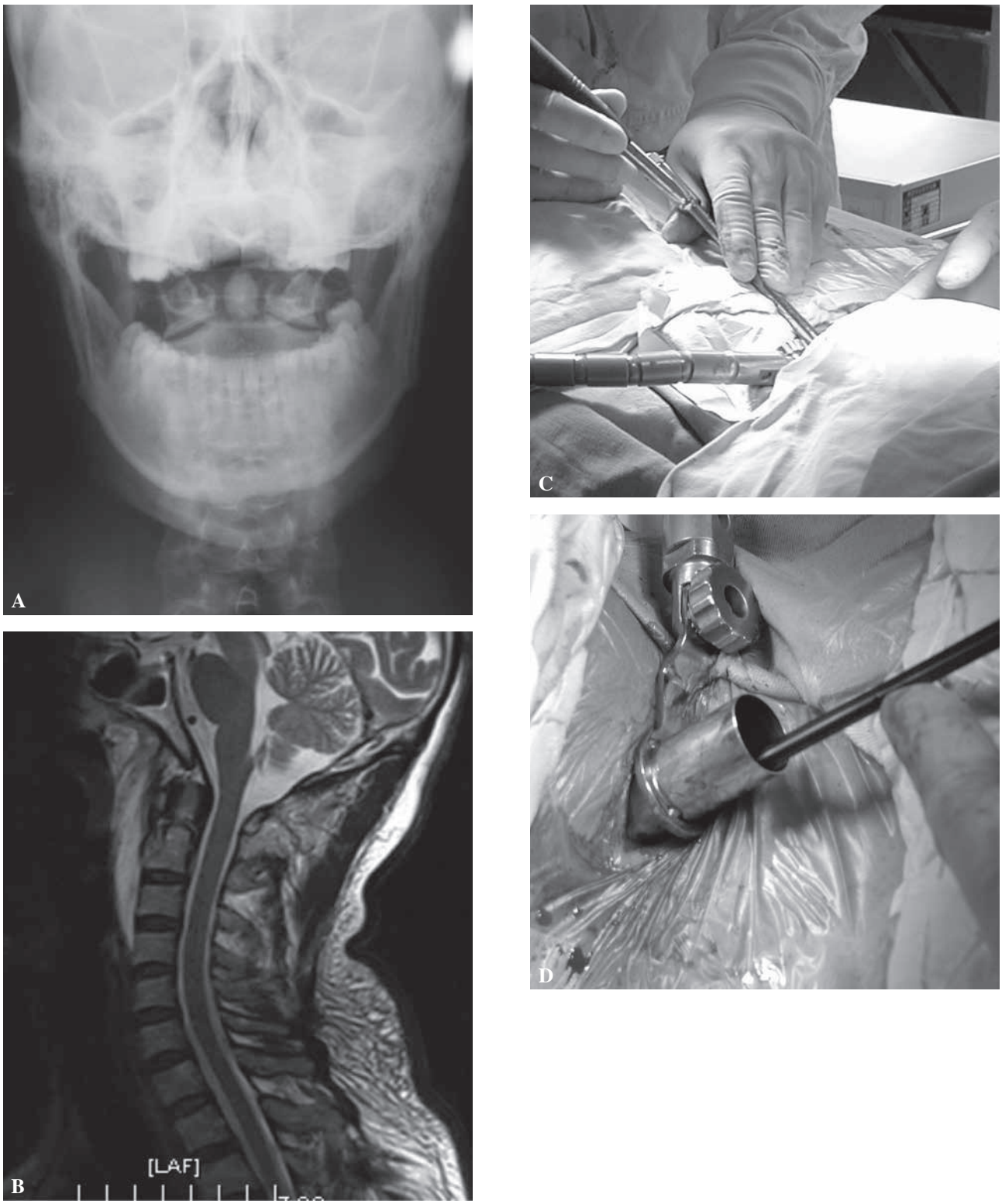
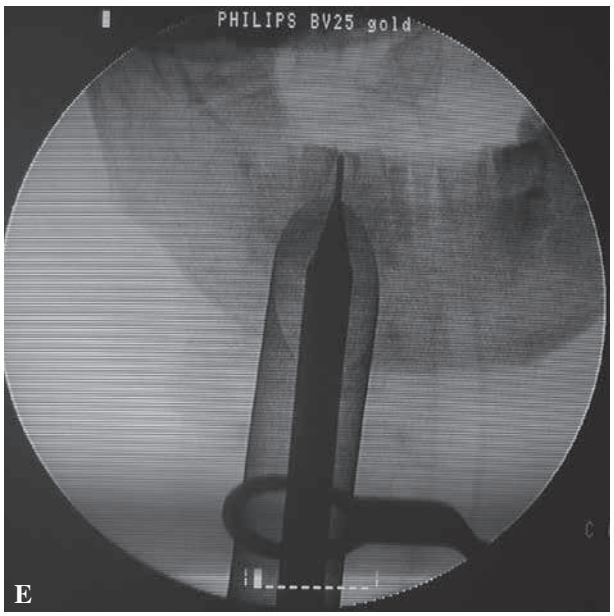
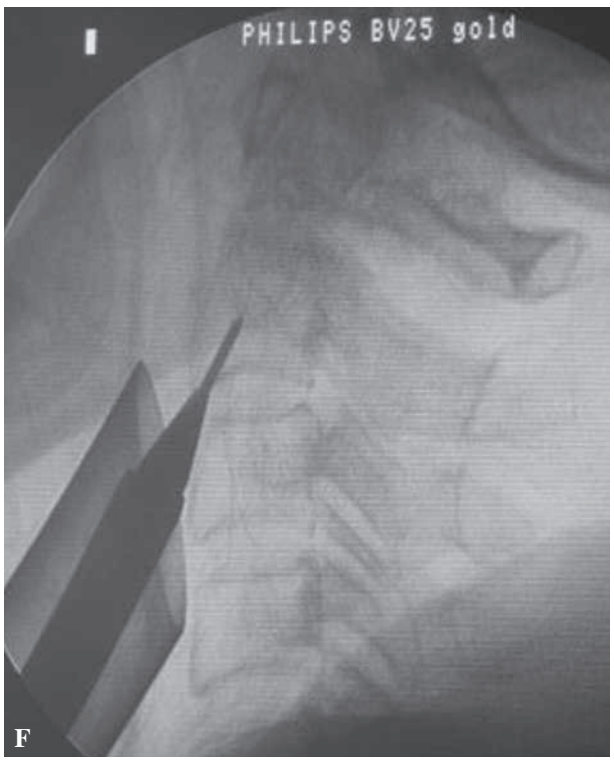


Fig. 2. — Anteroposterior radiographs of a 46-year old man with type II odontoid fracture (A).
The preoperative MRI showed type II odontoid fracture (B). Working channel was established with percutaneous approach (C, D).





Working tube was placed to the bottom edge of C2 vertebral body under fluoroscopy (E, F). The anteroposterior (G) and lateral (H) views at the second day after microendoscopic discectomy system anterior screw fixation of the odontoid fracture.

Table II. — Comparison of assessed parameters

	Group MED	Group AOA
Operating time (min)	75.7 ± 10.3*	96.3 ± 12.5
Intraoperative blood loss volume (mL)	20.5 ± 10.8*	100.5 ± 20.9
X-ray time (s)	12.7 ± 5.2	8.5 ± 3.2
Bony union rate	100%	100%
Neck range of motion (rotation/flexion-extension)	87.8° ± 8.7°/ 43.5° ± 10.1°	89.3° ± 10.2°/ 45.2° ± 12.2°

* $P < 0.05$.

In none of the patients occurred any surgical complications including screw malpositioning, vascular injury, esophageal perforation and airway obstruction. Three patients complained of transient dysphagia in Group AOA, however, the symptoms resolved spontaneously within 1-3 months. Solid fusion was demonstrated in all patients and neither screw loosening nor breakage was observed during the follow-up period.

DISCUSSION

Odontoid fractures account for 20% of all fresh cervical spine fractures (*10,21*). This region is responsible for most of the segmental axial rotation of the neck. It is well documented that this is a unique part from a biomechanical standpoint and is inherently predisposed to get traumatic injuries (*8*). The technique of anterior odontoid screw fixation was first reported by Bohler in 1982 (*4*). Allowing a near-anatomic or anatomic reduction, this technique provides a direct osteosynthesis of odontoid fracture and possess the advantage of preserving most of the physiologic atlantoaxial mobility (*19*). It has been recommended for the treatment of type II and shallow type III odontoid fractures. According to the literature, the bone fusion rate of odontoid fracture was from 85 to 100 % (*7,34*). In our series, all the patients obtained bony union. The postoperative cervical rotation and flexion-extension were 87.8° ± 8.7°/43.5° ± 10.1° in Group AOA and 89.3° ± 10.2°/45.2° ± 12.2°in Group MED respectively, which are similar values in both groups within normal ranges. Therefore, by comparison with posterior ortransarticular C1-C2 arthrodesis, this treatment probablyreduces the risk of degeneration of adjacent segments.

Minimally invasive surgical procedures with new devices have been used for anterior screw fixation (*3,15,19,29,34*). As early as 1999, Kazan *et al* (*19*) first described in detail a percutaneous technique with special instrument for anterior fixation of odontoid fracture in a cadaveric study. Wang *et al* (*34*) compared the methods of percutaneous and open anterior screw fixation in a prospective controlled study. Although the advantages of shorter operating time and lower intraoperative blood loss were clearly shown in percutaneous group, a steep learning curve greatly prevented the development of this technique. Hashizume *et al* (*16*) firstly reported a procedure of endoscopy- assisted anterior surgery for type II odontoid fracture. No complication happened in this surgery with a 2-cm skin incision. However, there is no report so far, to the best of our knowledge, comparing endoscopically assisted odontoid fracture screw fixation with traditional surgical procedure prospectively. The microendoscopic discectomy was designed originally for lumbar disc herniation surgery, and the tube spikes do not allow them to be used for cervical spine surgery, in particular to the upper cervical spine. We worked to transform the working channel and specially developed various distal slope of 15°/20°/ 30° to accommodate the hollow screw fixation, which required 15° inclination. The instrument and technique we developed have some unique benefits. Firstly, it may reduce the incidence of injury to the surrounding soft tissue, including the esophagus, trachea, vessels, and the recurrent nerve. In Group AOA, three patients complained transient dysphagia that could be induced by continuous traction during operation. The symptoms resolved spontaneously within 1-3 months. Secondly, this technique gives direct access to the target site like open surgery and enhance the visualization.

Carefull patient selection is important for achieving successful odontoid screw fixation. As a general concept, the contraindications of anterior screw fixation include short neck, significant cervical kyphosis, concomitant thoracic kyphosis, barrel chest deformity, disrupted transverse ligament, and

severe osteopenia. During operation, the entry site and trajectory of screw are pivotal for the success of anterior screw fixation as well. Therefore, the following requirements should be considered. Firstly, the screw thickness, length, and angle should be measured on X-ray and CT in advance to provide safe and strong anterior odontoid screw fixation (*20*). Secondly, displaced odontoid fractures must be reduced by using skull traction before surgery. The limit of fracture displacement was less than 3 mm in our cases at the time of surgery. Thirdly, the tube with working channel should be moved up and down slightly to the C2-3 disc space under fluoroscopic guidance before reaching the prevertebral area. In order to ensure an adequate screw trajectory, we used a specially designed chisel to create a shallow groove in the middle and at the superior border of C3 vertebral body. Guide wire and screw were directly inserted into the C2 inferior edge through working channel without removal of anterior annulus, disc, and bone. Preservation of C2-C3 disc space was ideal. Most surgeons worried that the resection of disc may aggravate the degeneration. Stulik *et al* (*31*) reported that even though a small portion of anterior annulus at C2-C3 disc space was removed, they did not find degenerative changes subsequently to the C2-C3 space during the period of follow up.

One-screw fixation may allow axial rotation of the odontoid around the screw, which could result in a lower fusion rate. Thus, from a biomechanical point of view theoretically, many surgeons prefer to use two screws (*23,24,27*). However, several studies revealed that there were no differences of biomechanical and clinical outcomes in fracture patients stabilized with one versus two odontoid screws (*9,11,12,32*). In addition, it is usually impossible to place two screws in a single odontoid fracture safely (*17*), especially in Chinese patients. In our study, we used only one screw and did not find adverse events. Therefore, we recommend to use a single screw for odontoid fracture fixation

Although no severe complications happened in Group MED, many potential risks existed during the operation including superior laryngeal nerve and superior thyroid artery injury, etc. According to the experience in our primary operative trials, this technique required a short learning curve and can be controlled quickly.

Our study indicated that the modified microendoscopic discectomy system with specially designed percutaneous working channel showed advantages of less blood loss, reduced surgical injuries, shorter operating time, higher fusion rate and neck motion in fixation of odontoid fracture with cannulated screw compared with conventional open surgical procedure. It is a feasible, safe, useful, simple and minimally invasive technique and worth to be applied in clinical practice.

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