

## Case Series

# Endoscopically-Assisted Percutaneous Unilateral Atlantoaxial Screw-Rod Nonfusion Fixation Treatment for Type II Odontoid Fractures in Geriatric Patients: Case Series and Technical Note

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**Background:** Considerable controversy exists regarding the optimal treatment for type II odontoid fractures in geriatric patients. Surgical intervention can help patients return to their prior level of function as rapidly as possible while avoiding the morbidity and mortality associated with prolonged and bedbound hospitalization. However, the optimal treatment is still a difficult choice for patients with increased risk from anesthesia.

**Objectives:** The objective of our study was to describe an innovative method of endoscopically-assisted percutaneous unilateral C1 lateral mass screw and C2 pedicle screw-rod nonfusion fixation for type II odontoid fractures in geriatric patients.

**Study Design:** A case series design and technical notes.

**Setting:** This study took place at Second Affiliated Hospital of Chongqing Medical University.

**Methods:** Seven geriatric patients (> 65 years) with type II odontoid fractures and an American Society of Anesthesiologists (ASA) score of 2 or higher received endoscopically-assisted percutaneous unilateral atlantoaxial screw-rod nonfusion fixation. After surgery, all patients were required to wear a rigid collar full-time for 12 weeks. Intraoperative data, the bone union time, American Spinal Injury Association (ASIA) scale scores, Neck Disability Index (NDI) scores, and postoperative complications were collected for assessment.

**Results** The surgical goal was successfully achieved in all patients, 3 of whom had high ASA scores ( $\geq 3$ ) and underwent surgery under local anesthesia. The operative time ranged from 112 to 169 minutes (mean, 131.1 minutes). No neurovascular complications were observed intraoperatively or postoperatively. All patients rapidly returned to their prior level of function and were followed up for 12 to 24 months (average: 16.9 months). Bone union was achieved in all patients.

**Limitations:** This study is limited by being a retrospective study.

**Conclusions:** Endoscopically-assisted percutaneous unilateral atlantoaxial screw-rod nonfusion fixation is a feasible technique for type II odontoid fractures in geriatric patients. This method offers a compromise between non-operative and operative treatment and allows geriatric patients to rapidly return to their prior level of function.

**Key words:** Endoscopically-assisted surgery; geriatric patient; percutaneous atlantoaxial fixation; type II odontoid fracture; unilateral nonfusion fixation

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**O**dontoid fracture is the most common individual cervical spine fracture in patients > 65 years of age (1-3). These fractures are commonly classified into 3 types according to the Anderson and D'Alonzo classification (4). Type II fracture is the most common fracture pattern of odontoid injuries in 82% to 90% of geriatric patients (2,5). This injury generally results from low-energy impacts, such as falls, in the geriatric population (5,6).

In recent years, the optimal treatment for type II geriatric odontoid fractures has remained controversial. Non-operative management in geriatric patients is associated with reported high nonunion rates of 21% to 62.5% (6-8). Geriatric patients are at a higher risk of nonunion due to a combination of osteoporosis, watershed blood supply, and high anatomic strain (2). Much of the morbidity associated with type II odontoid fractures has generally been considered to be due to the risk of nonunion and ensuing instability and neurologic injury (9). However, recent literature shows a significant decrease in mortality rates and an increase in positive outcomes with surgical intervention in geriatric patients with type II odontoid fractures (1,7,10,11).

Optimal treatment of geriatric patients with a type II odontoid fracture would help them return to their prior level of function as rapidly as possible while avoiding the morbidity and mortality associated with prolonged and bedbound hospitalization (7). Additionally, individual factors and associated comorbidities among geriatric patients and the safety of general anesthesia may require comprehensive consideration before any attempt at surgical treatment (10). An increased American Society of Anesthesiologists (ASA) score reportedly predicted significant increases in complication rates for morbidity and mortality postoperatively (12). Consequently, an optimal treatment that avoids the disadvantages of non-operative management and decreases the surgical risk is needed for patients with increased risk from anesthesia.

## METHODS

From July 2016 to July 2018, 7 geriatric patients who suffered type II odontoid fractures (Anderson and D'Alonzo classification) received endoscopically-assisted (Spinendos, Munchen, Germany) percutaneous unilateral atlantoaxial screw-rod nonfusion fixation treatment. The inclusion criteria were: (a) type II odontoid fractures with an intact transverse atlantal ligament, (b) fracture displacement that could be reduced by preoperative traction, and (c) an age greater than

65 years and an ASA score of 2 or higher. Five female patients and 2 male patients with a mean age of 73.1 years (range: 66-89 years) were included. The patient characteristics are presented in Table 1. Parameters including operative time, blood loss volume, surgical complications, and fracture union time were collected for assessment.

## Preoperative Preparation

All patients underwent computed tomography (CT) angiography of the cervical spine to preoperatively detect the occurrence of vertebral artery (VA) variation. The optimal entry point, screw path, and diameters and lengths of the screws were determined by multiplanar CT reconstruction. Cervical magnetic resonance imaging (MRI) was required when patients presented a spinal cord injury or when soft tissue damage assessment was needed.

## Surgical Procedures

All surgeries were performed by a senior spine surgeon. Three of the patients were estimated to be high-risk based on an ASA score of 3 or higher. Consequently, we performed surgeries under local anesthesia with proper sedation management in cooperation with the anesthesiologist in these 3 patients. Preoperatively, the patients were placed in the prone position on a radiolucent table with head immobilization in a carbon Mayfield clamp. The optimal position of the cervical spine depended on preoperative reduction. Subsequently, the skin entry point was marked using C-arm fluoroscopy to locate the surgical sites of the C1 lateral mass and C2 pedicle.

To insert the C1 lateral mass screw (LMS), an initial 8-mm incision was made at the level of the atlas above the lateral mass. To avoid neurovascular injury during the puncture process, the blunt end of a 2.0-mm Kirschner wire (K-wire) was used and adjusted to reach the posterior surface of the C1 lateral mass under C-arm fluoroscopic guidance (Fig. 1A). When an acceptable site was reached, a primary dilator was rotated carefully into the bone surface to avoid neurovascular tissue, and then the K-wire was pulled out, turned around and inserted into the lateral mass as a guide wire. Next, a working sheath was inserted along the guide wire (Fig. 1B). Subsequently, the remaining processes were performed under endoscopy in the same manner as in percutaneous endoscopic surgery.

Clear visualization was achieved with saline perfusion. Dissection and coagulation were performed

using low-energy radiofrequency to precisely identify the structures under a visual field magnified 10 to 20 times. We could clearly identify the C2 nerve root, lateral mass, and posterior arch (Fig. 2A1), and we could observe the paravertebral pulse from the VA (Supplemental Video). We selected the middle point of the interface of the inferior rim of the posterior arch and the posterior surface of the lateral mass as the screw entry point (13) (Fig. 2A2). After verifying the entry point under endoscopy, a cortex window was drilled using a high-speed burr. Occasionally, a small portion of the inferior aspect of the posterior arch was removed to facilitate screw placement. Then, an awl was used to create a screw path aiming at the lateral mass center with a cephalad angulation of 20° (13). After detecting the intactness of the screw path using a blunt probe and tapping with the relevant instrument (Fig. 1C), a guide wire was inserted into the pilot hole. Then, sequential dilating tubes were inserted along the guide wire, and the incision was extended to approximately 16 mm (Fig. 3A). The last tube with a 16-mm inner diameter remained in place to serve as a working channel. After verifying the pilot hole and the screw insertion direction on the same axis as the working channel under endoscopy, we removed the endoscope and guide wire. Then, a suitable screw was inserted along the working channel that was kept in the fixed axis (Fig. 3B,C). Using fluoroscopic assistance, the lateral trajectory of the screw point lay in the direction of the anterior C1 tubercle (Fig. 1D).

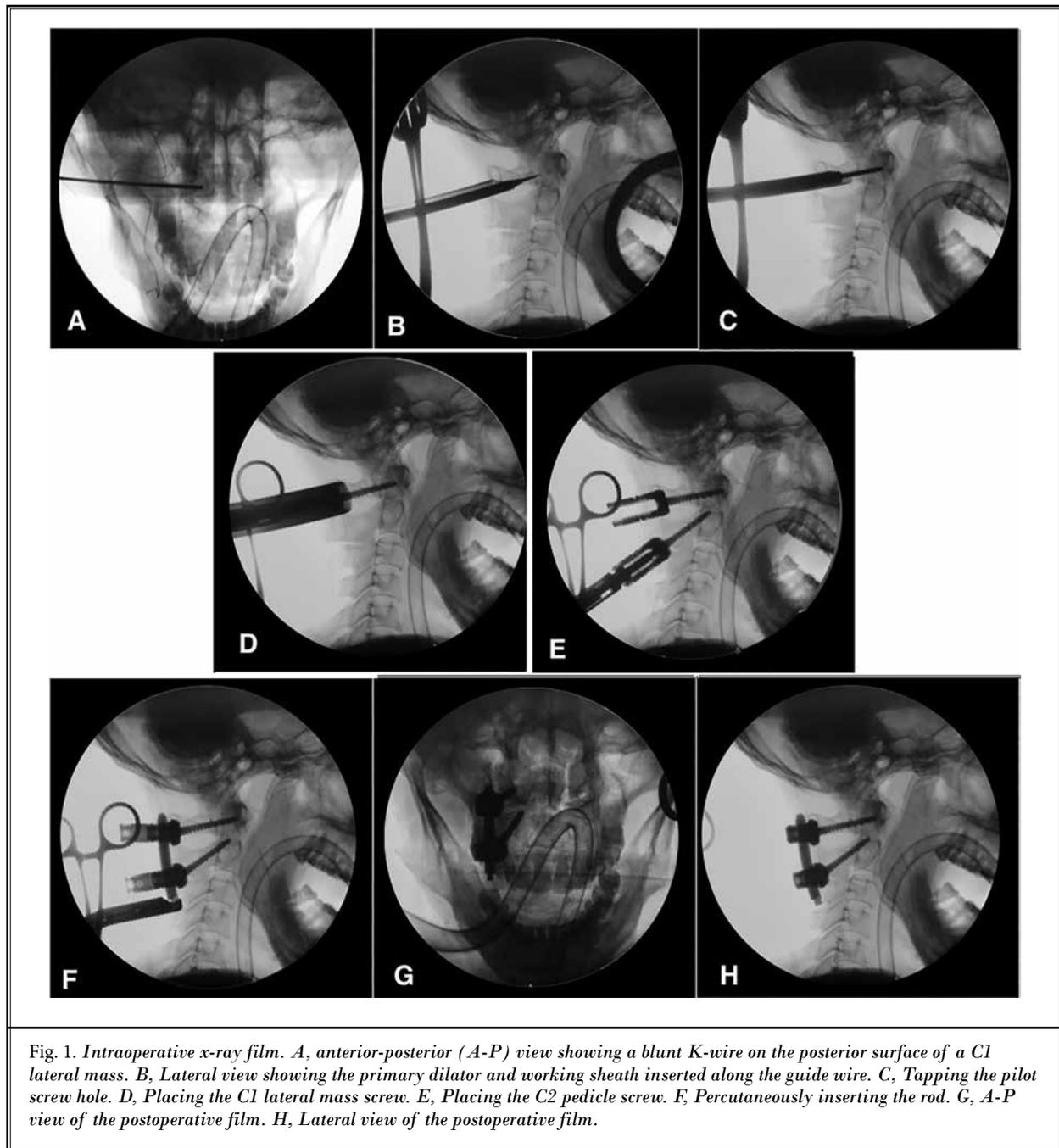
The same surgical technique was used for the C2 pedicle screw (PS). To prevent screw malposition, the medial border of the C2 pedicle was first identified using a right-angle detector to detect the border of the ligamentum flavum and lamina. The entry point was selected approximately 5 mm inferior to the superior border of the C2 lamina and 7 mm lateral to the lateral border of the spinal canal (Fig. 2C,D). The screw path was selected approximately 20° to 30° in medial and cephalad angulation toward the anterior edge of the C1-C2 joint under lateral fluoroscopic guidance (14) (Fig. 1E). After placing 2 screws, a rod was inserted through the caudal incision beyond the fascia and moved rostrally by gently pushing the muscles (Figs. 1F, 3D). Rod bending was performed depending on the position of reduction under lateral fluoroscopy. Then, the rod was fixed with blocker screws (Figs. 1G,H). Eventually, the 2 incisions were sutured with one stitch each, with a drainage tube remaining under the deep fascia (Supplemental Video).

In all patients, minimally invasive spine instruments, a screw-rod system (WEGO Co., Weihai, Shandong, China) with polyaxial screws composed of titanium with 3.5- to 4.5-

Table 1. Clinical data of the 7 patients enrolled.

Case	Age (y)	Gender	ASA score	Comorbidities	Operation time (min)	Anesthesia	Surgical complications	Hospital stay (days)	Follow-up (mon)	Prognosis	Union time (mon)	ASIA scale (Preoperation/Last follow up)	NDI
1	66	Male	2	Cardiac disease	169	General	No	7	24	Union	4	D/E	8
2	66	Female	2	Cardiac disease	143	General	No	7	21	Union	6	E/E	16
3	89	Female	4	Cardiac disease/ Diabetes mellitus	121	Local	No	9	18	Union	9	E/E	30
4	75	Female	2	Renal disease	130	General	No	6	15	Union	6	E/E	12
5	70	Male	3	Pulmonary disease	112	Local	No	7	15	Union	7	D/E	18
6	68	Female	2	Cardiac disease	115	General	No	7	13	Union	5	E/E	12
7	78	Female	3	Liver Disease	128	Local	No	7	12	Union	6	E/E	22
Mean	73.1	/	2.6	/	131.1	/	/	7.1	16.9	/	6.1	/	16.9

ASA, American Society of Anesthesiologists; ASIA, American Spinal Injury Association; NDI, neck disability index

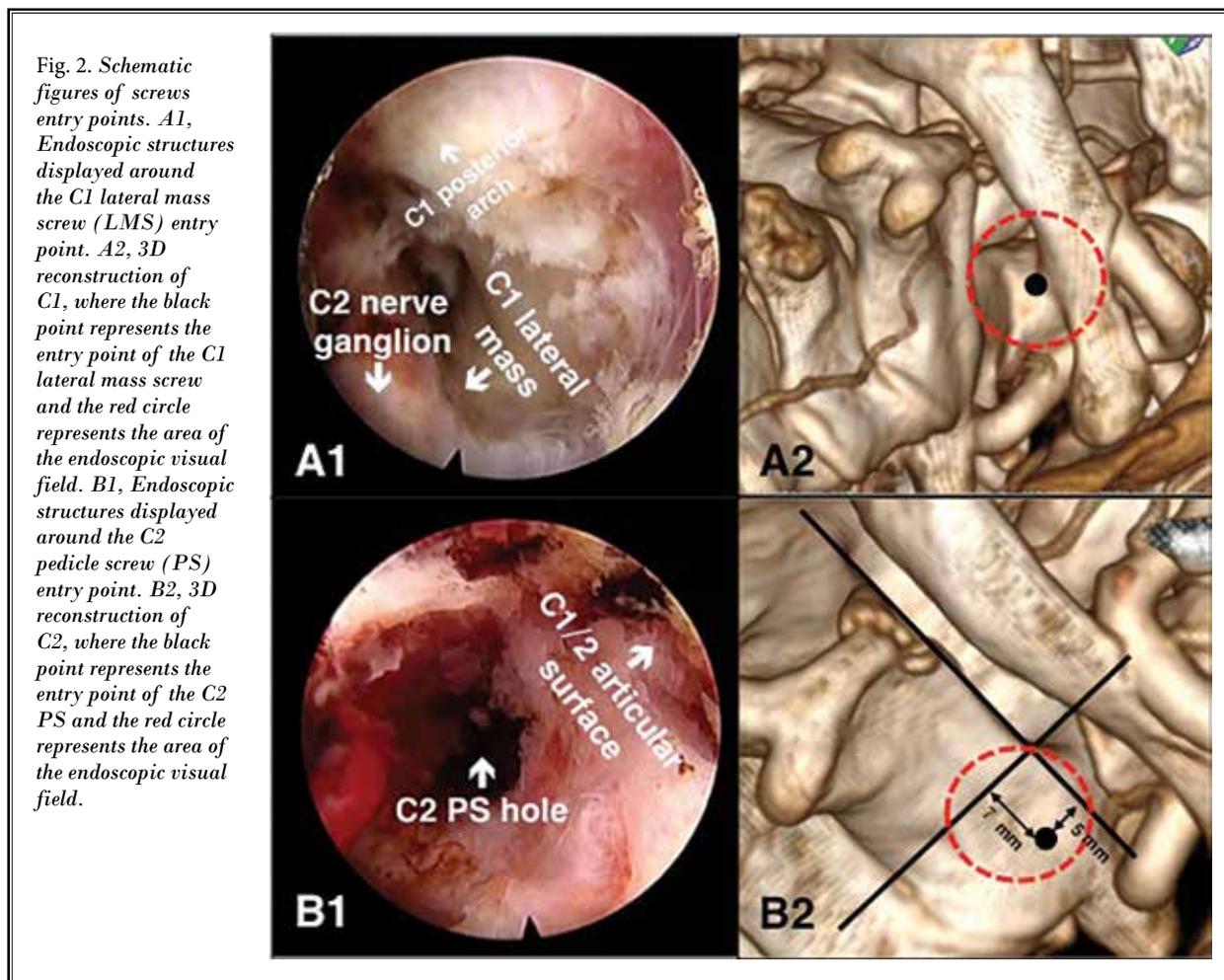


mm diameters and a connecting rod (3.2-mm titanium) were used for surgery.

### Postoperative Management

Intraoperative data on operative time, blood loss volume, and surgery-related complications were recorded. Thin-cut CT and x-ray were performed postop-

eratively in all patients (Fig. 4). Intravenous antibiotics were administered, and a drainage tube was left for 24 hours postoperatively if no complications occurred. Then, patients were allowed to walk and sit with immobilization in a rigid neck collar if their condition permitted. Patients were required to wear the neck collar for approximately 12 weeks after surgery. Routine



follow-ups were performed at 6 weeks and 3, 6, 9, 12, and 24 months postoperatively. The prognosis of bone union time, American Spinal Injury Association (ASIA) scale scores, Neck Disability Index (NDI) scores, and post-operative complications were collected for assessment. When fracture union was observed on CT examination, the patient was advised to undergo percutaneous endoscopically-assisted surgery for internal implant removal to retain atlantoaxial movement (Fig. 5).

**Ethical Considerations**

We received permission from the ethics committee of our hospital and written informed consent from all patients.

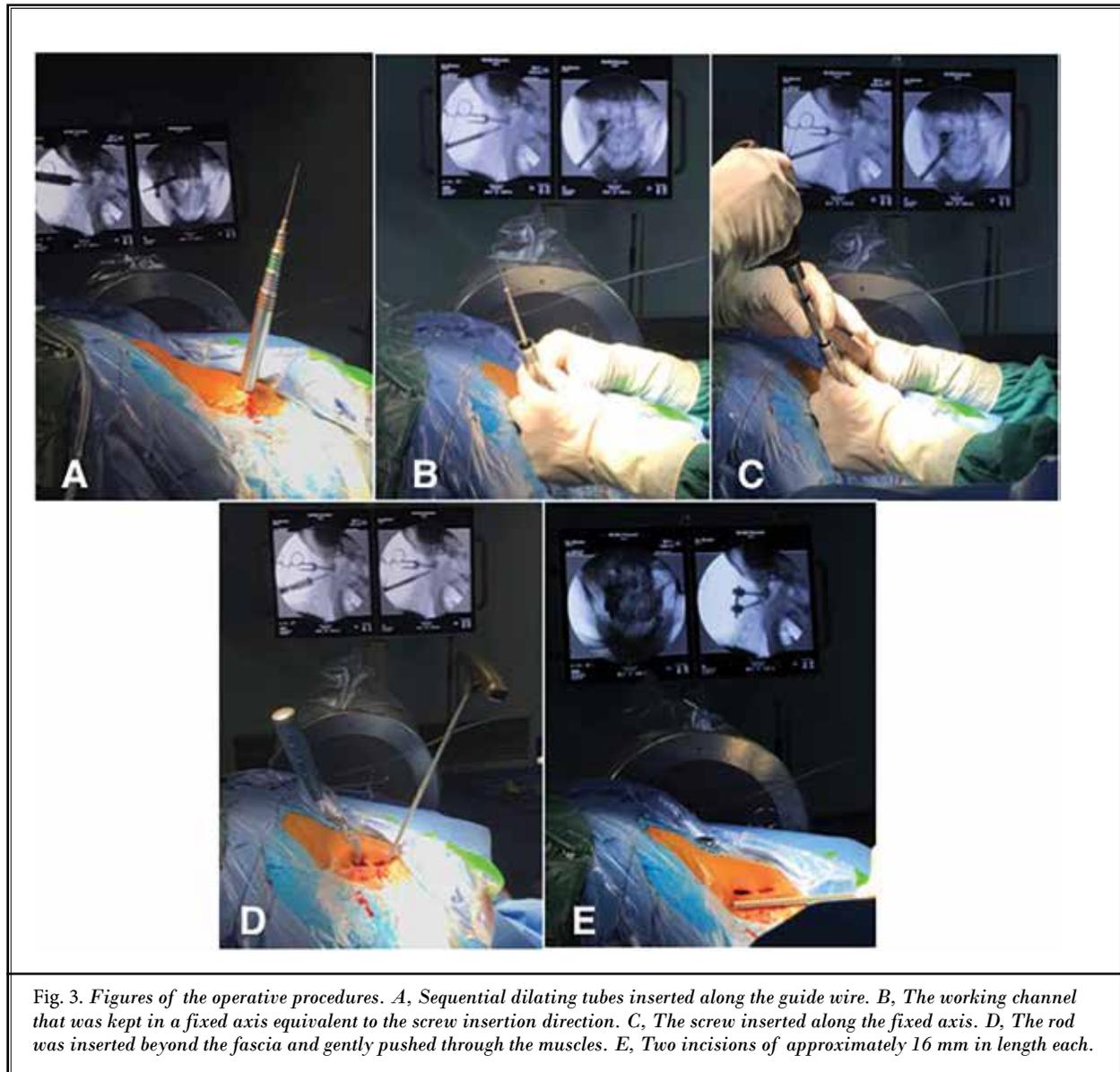
**RESULTS**

The surgical goal was successfully achieved in all patients, 3 of whom had high ASA scores ( $\geq 3$ ) and

underwent surgery under local anesthesia. The operative time ranged from 112 to 169 minutes (mean, 131.1 minutes). The total blood loss volume was less than 50 mL. No neurovascular complications were observed intraoperatively or postoperatively. All patients rapidly returned to their prior level of function and were followed up for 12 to 24 months (average, 16.9 months). Bone union was achieved in all patients, and the average union time was 6.1 months. Other clinical data, including ASIA scale and NDI scores, are presented in Table 1. No screw loosening or breakage occurred in any of the patients.

**DISCUSSION**

In recent decades, the optimal treatment for type II geriatric odontoid fractures has remained controversial. Optimal treatment of geriatric patients with type II odontoid fractures would help them return to



their prior level of function as rapidly as possible while avoiding the morbidity and mortality associated with prolonged and bedbound hospitalization (7). The current view suggests that for geriatric patients sustaining these fractures who are able to undergo general anesthesia, the benefits of surgery outweigh the associated risks (10). However, an increased ASA score predicted significant increases in complication rates for morbidity and mortality postoperatively (12). Consequently, an optimal treatment that avoids the disadvantages of non-operative management and decreases the surgi-

cal risk is needed for patients with increased risk from anesthesia.

Posterior C1-C2 fusion is the most common operation for type II odontoid fractures. This procedure is performed via posterior open surgery and has been shown to yield a good fusion rate and clinical outcome. However, posterior C1-C2 fusion has the innate disadvantages of considerable soft tissue invasion, blood loss, risk of neurovascular injury (15), and loss of atlantoaxial motion (16,17). Therefore, in recent years, posterior C1-C2 nonfusion fixation has been progres-

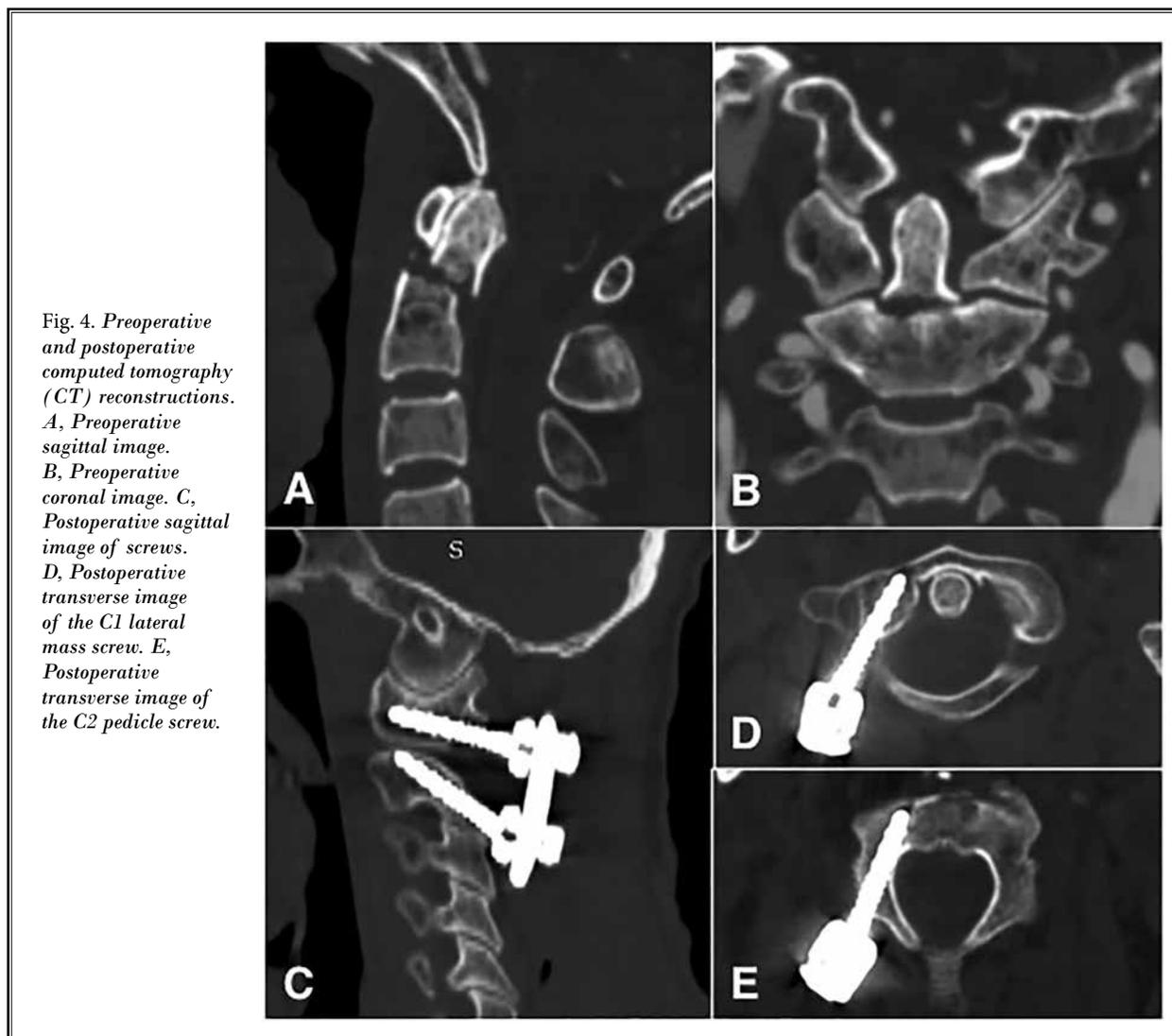


Fig. 4. Preoperative and postoperative computed tomography (CT) reconstructions. A, Preoperative sagittal image. B, Preoperative coronal image. C, Postoperative sagittal image of screws. D, Postoperative transverse image of the C1 lateral mass screw. E, Postoperative transverse image of the C2 pedicle screw.

sively applied to treat odontoid fractures with an intact transverse ligament. Posterior temporary fixation can retain the motion of C1-C2 and achieve similarly good clinical outcomes as with anterior screw fixation in the treatment of type II odontoid fractures (16). Overall, most authors suggest that the anterior odontoid approach should primarily be considered in younger patients with good bone quality, amenable fracture obliquity, and an appropriate body habitus (10). In addition, anterior retropharyngeal approaches pose a risk of severe complications, such as spinal cord injury, esophageal and pharyngeal perforation, arterial injury, and airway obstruction (18). Meanwhile, anterior odontoid screw fixation requires highly technical skills and is

not suitable for special fracture types that extend from anterior-inferior to posterior-superior or for obviously comminuted fractures (19). For the above reasons, we ultimately selected posterior nonfusion fixation as the primary surgical strategy.

Recently, percutaneous PS placement using minimally invasive instruments has been shown to decrease blood loss, reduce soft tissue invasion, and minimize postoperative pain in the thoracic and lumbar spine (20). A few recent articles have reported the percutaneous screw technique in the cervical spine, which was performed under 3-dimensional fluoroscopic guidance with tubular dilator retractors in all cases (21-23). Three-dimensional navigation can help doctors perform sur-

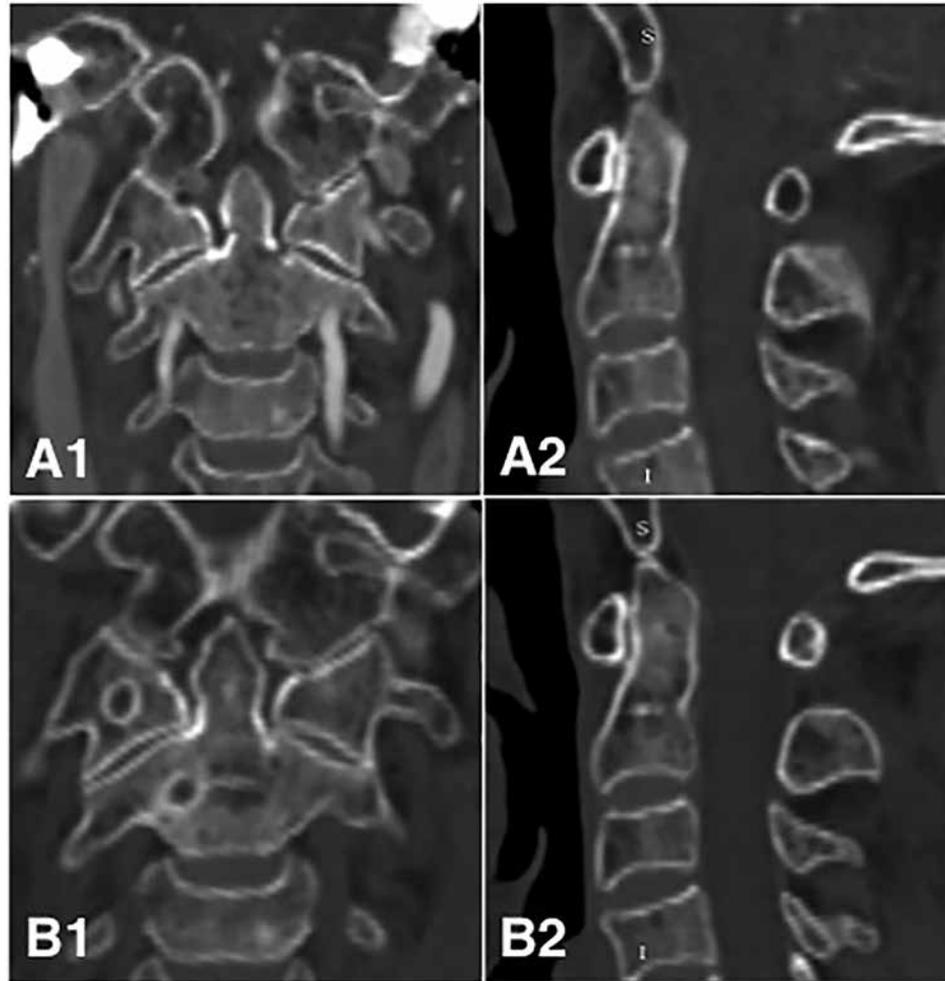


Fig. 5. Computed tomography (CT) reconstruction of pre-operation and after internal fixation removal. A1, Preoperative sagittal image. A2, Preoperative coronal image. B1, Sagittal image after internal fixation removal. B2, Coronal image after internal fixation removal.

gery efficiently and safely, reducing the risk and complications of spinal surgery. Due to the high cost of the equipment and high technical requirements, only a few large hospitals currently own such equipment, which is a main limitation of clinical application. In recent years, the percutaneous endoscopic technique has gradually received approval from spinal surgeons. Compared with traditional surgery, the percutaneous endoscopic technique has the main advantages of clear visualization of anatomical structures, a rapid postoperative recovery, and less damage to soft tissues. To the best of our knowledge, percutaneous atlantoaxial screw-rod fixation has not been previously reported. Performing

percutaneous procedures only relying on fluoroscopy is technically challenging. Therefore, assistance from percutaneous endoscopy to achieve percutaneous atlantoaxial screw-rod fixation is reasonable, and the clear visualization of anatomical structures under endoscope will provide significant help for screws placement.

To achieve the goal of permitting patients to return to their prior level of function as rapidly as possible while avoiding the morbidity and mortality associated with prolonged inactivity and hospitalization (7), unilateral screw-rod fixation was performed as a limited means of internal fixation with less invasiveness and a reduced operative time. Meanwhile, the additional use

of a rigid cervical collar postoperatively may improve the fracture union rate.

Generally, a C1 LMS poses risks of injuring the paravertebral venous plexus and the C2 nerve root. Occasionally, injury of the venous plexus may result in persistent venous bleeding, and nerve injury may present as nerve dysfunction in the distribution of the C2 nerve, including neuralgia, numbness, dysesthesia, and paresthesia. Therefore, we used the blunt side of a K-wire to locate the lateral mass to avoid C2 nerve root injury. Furthermore, continuous perfusion of saline under percutaneous endoscopy can generate hydrostatic pressure to stop venous bleeding. Meanwhile, coagulation is performed using low-energy radiofrequency to maintain a clear visual field to precisely identify structures under endoscopy. Therefore, blood loss is reduced, and the magnifying effect of the endoscope helps to precisely identify the screw entry point to ensure the screw's appropriate placement.

Although we successfully treated a few patients with type II odontoid fractures using this technique, we need to further follow the patients' clinical outcomes,

especially complications, the NDI, the union rate, and mortality, to comprehensively assess this novel technique. Additionally, knowing whether internal fixation devices should be retained or removed in these geriatric patients requires long-term clinical observation.

## CONCLUSION

Endoscopically-assisted percutaneous unilateral atlantoaxial screw-rod nonfusion fixation is a feasible technique for type II odontoid fractures in geriatric patients. This method offers a compromise between non-operative and operative treatment and helps such patients to rapidly return to their prior level of function.

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