Endoscopic Transcorporeal Approach and Channel Repair for Cervical Disc Herniation: 2-Year Follow-Up Study

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Research Article

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Abstract

Objective To investigate the 2-year follow-up outcomes of patients with cervical intervertebral disc herniation (CIVDH) after percutaneous full-endoscopic anterior transcorporeal cervical discectomy (PEATCD) and channel repair.

Methods From Oct. 2016 to Mar. 2017, 24 patients with central/mediolateral CIVDH was treated with PEATCD and channel repair. Of the 24 cases, five interventions were performed at C3-C4 level, 11 were performed at C4-C5 level, and 8 were performed at C5-C6 level. Clinical outcomes were evaluated by Neck Disability Index (NDI), Japanese Orthopaedic Association (JOA), and Visual Analog Scale (VAS). Radiographic outcomes were measured with X-rays, computed tomography (CT) and magnetic resonance imaging.

Results All the 24 procedures were completed successfully with an average operating time of 86.40±8.19min. Neck collar was advised for 3 weeks for all patients. No procedure-related complications were observed except for the swollen neck in 5 patients, which rehabilitated within 2 hours without sequela. The final scores of NDI, JOA, and VAS were improved significantly compared to those of preoperative assessments, 7.74±7.31 *VS.* 52.11±22.10, 16.04±0.68 *VS.* 9.08±1.31, and 0.52±0.65 *VS.* 6.73±1.45, respectively, $P<0.05$. Mean disc height was decreased from preoperative 5.43±0.52 mm to final 5.05±0.43 mm, without related-symptoms. No bone plug migration or channel collapse was measured during postoperative periods. All the channels were absent 12 months postoperative.

Conclusion The most outstanding advantages of PEATCD with channel repair were “functional preservation” and “anatomical protection” for cervical spine, and which is a safe, feasible, effective, and minimally invasive surgery that offers an alternative for patients with CIVDH.

Introduction

Anterior cervical discectomy and fusion (ACDF) is still the standard surgical procedure for patients with cervical intervertebral disc herniation (CIVDH) due to its excellent clinical results and good fusion rates since it was introduced by Smith and Robinson in the 1950s [1–5]. However, long-term follow-up studies showed the fusion-related complications such as degeneration of adjacent segments, graft subsidence, implant failures, pseudarthrosis, rejection reaction, or access-related complications [6–10]. In order to avoid these complications caused by intervertebral fusion, various modifications were reported to minimize surgical disturbance to the biomechanics of cervical spine [11–17].

As a functional spine surgery, anterior transcorporeal herniotomy was completed via a bony channel through vertebral body, which was first reported by George [18]. In anterior transcorporeal approach, the surgical damage to disc was minimized, the intervertebral fusion was unnecessary, and the cervical motion segment was retained. With the development of surgical technique and instruments, the transcorporeal approach had been modified by several surgeons [19–28]. However, the disadvantages of

bad surgical vision and difficulty manipulation caused by the narrow channel were still existed, even operating microscope was introduced by Sakai and Nakai [21,25].

As the widespread application of endoscopy, its advantages of minimal invasion and better surgical vision had been widely accepted. In 2009, Ruetten first reported endoscopic transdiscal approach for CIVDH and acquired good clinical results [17]. However, significant loss of disc height and accelerated degeneration at the operated segment was shown in the long-term follow-up studies, which was attributed to the directly iatrogenic damage to disc [17,29,30]. In 2016, Deng first performed anterior transcorporeal approach under endoscopy [31]. And following we reported the good clinical results of percutaneous full-endoscopic anterior transcorporeal cervical discectomy (PEATCD) [32]. Nonetheless, the bone defect was still existed even 1 year after operation, as the report of previous study [21,32]. The collapsing risk of vertebral body would increase if the defect was existed persistently, especially for the situation that a relatively larger bony channel was created for sufficient decompression. After overall consideration, we performed PEATCD with channel repair for patients with central or mediolateral CIVDH. And we will share our limited experiences of this technique and report its clinical and radiological results.

Results

Surgical findings and clinical results

All procedures were completed successfully by the same surgeon. Surgical findings and postoperative course are shown in Table 1. 5 patients suffered postoperative swollen neck and recovered completely within 2 hours, which did not induce negative effects. And this complication was attributed to the lengthy operating time under continuous irrigation (> 60 min). No manifestations of dysphagia, dyspnea, heamatoma, esophageal perforation, vascular injury, or nerve injury were recorded. At each follow-up stage, neurological examination was conducted for each patient and the follow-up scores of NDI, JOA, and VAS were recorded in Table 2.

Radiologic results

Table 1
Surgical characteristic and surgery-related complications

Surgical Characteristic	PEATCD (n = 24)
Mean operating time (range), min	86.40 ± 8.19 (70–108)
Mean operating time under endoscopy (range), min	56.46 ± 7.50 (77 – 70)
Mean postoperative hospital stay (range), day	1.38 ± 0.61 (1–3)
Mean volume of removal disc (range), grams	0.80 ± 0.18 (0.4–1.1)
Complications	
Postoperative swollen neck	5

Table 2
the follow-up results of NDI, VAS and JOA postoperative. The NDI take a turn for the better at final follow-up stage (P < 0.05). The pain 24 months postoperative also got a significant improvement (P < 0.05). And the JOA scores improved gradually at postoperative periods (P < 0.05)

	Pre	Post-1m	Post-3m	Post-6m	Post-12m	Post-24m
NDI (%)	52.11 ± 22.10	31.28 ± 11.83	23.96 ± 10.02	18.07 ± 8.99	13.43 ± 7.67	7.74 ± 7.31
VAS	6.73 ± 1.45	3.00 ± 0.95	1.94 ± 0.86	1.25 ± 0.67	0.77 ± 0.75	0.52 ± 0.65
JOA	9.08 ± 1.31	11.83 ± 1.40	13.69 ± 1.24	14.55 ± 2.17	15.82 ± 0.63	16.04 ± 0.68

All the bony channels were established at the caudal vertebrae. Postoperative MRI showed that the localized lesion preoperative was completely removed (Fig. 1). In this study, the 24 channels were repaired with autogenous bone plug, and the defect was disappeared 12 months after operation and no migration of the repaired bone was observed (Fig. 2). Variation of IDH during follow-up periods were recorded in Table 3. No cervical instability, channel collapse, or kyphotic changes was observed in cervical spine at final follow-up stage.

Table 3
the variation of IDH during the postoperative periods. Loss of IDH was significant at final follow-up period (P < 0.05), but no more than 2mm. And the degeneration terminated (P > 0.05) 12 months after operation

	Pre	Post-1m	Post-3m	Post-6m	Post-12m	Post-24m
IDH (mm)	5.43 ± 0.52	5.24 ± 0.53	5.14 ± 0.48	5.09 ± 0.45	5.07 ± 0.45	5.05 ± 0.43

Disscusion

Functional spine surgery

As we all know, ACDF has become the standard procedure for many years for the treatment of CIVDH [2,4,5]. However, complications related to intervertebral fusion were also well-known [6,7,9,10]. As a functional spine surgery, anterior transcorporeal herniotomy owns some advantages as follows [20–23,25,28]. First, it is less invasive to disc because of the different surgical approach; there will be no injury if the lesion locates behind the vertebral body rather than disc space. Second, it can preserve the mobility of cervical spine and decrease the burden of adjacent discs. In this study, we combined these advantages of anterior transcorporeal approach and endoscopic system together to perform PEATCD with channel repair for patients with single-level central or mediolateral soft CIVDH.

Channel repair

Before this study, we have reported the follow-up outcomes of PEATCD without channel repair and acquired excellent clinical efficacy [32]. In order to achieve a better surgical vision and further guarantee adequate decompression, especially for some broad-based herniation, we created the bony channel with a diameter about 8 mm, which is relatively larger compared to the previous literatures [21,25,28,32]. According to previous study, the stress on the drilled vertebra was positively correlated with the channel diameter. And the risks of bone fracture would increase significantly when the channel's diameter was over 8 mm (with partial endplate excision) [33]. In this study, we repaired the channel with autogenous bone plug harvested by trephine with a view to the risk of collapse, which greatly promoted the healing of channel according to the radiological results and relevant literatures [21,32]. Before grafting, properly shortening to the implant was necessary in order to preserve spinal cord from oppressing. And the parallel relationship of the anterior surface of vertebra and repaired bone must be verified visually under endoscopy. The details about how to shorten the bone plug were depended on the sagittal diameter of the drilled vertebral body on preoperative CT images or lateral cervical plain radiographs. In our study, all the bone plugs were shortened by 1/4 to 1/3.

Surgical technique

Overall the surgical process, the potential vascular injury, esophageal perforation, or spinal cord injury was worrisome. Two-finger technique was first adopted to pull aside the esophagus and vessels, which could create a safe area for inserting K-wire into the anterior surface of target vertebra. Iohexol contrast agent, which was injected into gastric tube before location, could sufficiently delineate the esophageal tract under C-arm fluoroscopy. Subsequently, we could determine whether the esophagus was impaled by K-wire through observing the relative position of K-wire and esophagus under C-arm. Additionally, ultrasonic examination was also helpful for surgeon to confirm the safety of operating area if the carotid pulsation couldn't be palpated clearly with two-finger technique. Based on our limited experiences, the channel's entrance should be as close to the center of the target vertebra, which could avoid damage to the longus colli muscle and reduce intraoperative soft tissue bleeding, potential postoperative heamatoma, and the incidence of cervical sympathetic nerve injury because of the position of the nerve

along the lateral border of the longus colli muscle. Besides that, it should be as close to the inferior endplate of the drilled vertebra, which could make less damage to the superior endplate during trephination.

Establishment of an unobstructed bony channel

Intraoperative trephination must be attentive and its depth should be dynamically monitored by C-arm. The posterior border of drilled vertebra was the terminal of trephination. The trephination deeper, the higher risk of spinal cord injury. However, the bone plug would not be taken out together with the trephine if the trephination was not deep enough. If the bone plug fails to come out with the first attempt, under no circumstances should the surgeon try to repeat the dislodging procedure, which greatly increased the risk of spinal cord injury. In such cases, endoscopic system was installed and the channel was drilled visually with high-speed diamond at the previous drilling area, which was created with trephine. It was forbidden to take out the bone plug directly and violently with forceps under endoscopy because of the possibility of tearing the dura.

Surgery-related complications

In endoscopic anterior cervical surgery, the medial retraction to soft tissues with substantial pressure is unnecessary, which would greatly decrease the incidence of dysphagia and injury of recurrent laryngeal nerve. In this study, no other surgery-related complications were recorded except for the swollen neck in 5 patients, which disappeared within 2 hours without any sequela. According to our observation, this complication in the 5 cases was attributed to the lengthy operating time under continuous irrigation (>60 min). For patient with swollen neck, close observation was necessary in postanesthesia care unit until the edema was disappeared and the patient was completely awake with autonomous respiration. And during the observation period, close attention must be payed to identify edema or heamatoma through monitoring whether the swell was further exacerbated. Besides that, the drip stand height in all operations was controlled between 60 cm to 70 cm and extra perfusion pressure was forbidden during the process of endoscopic manipulation in case of mediastinal effusion [34].

Indications

Strict indications for patients with CIVDH were crucial in PEATCD with channel repair. In this study, all the patients were diagnosed with single-level central or mediolateral soft CIVDH. Patients with lateral CIVDH or foraminal stenosis were more suitable for posterior endoscopic operation [17,29,35,36]. Different with anterior endoscopic transdiscal cervical discectomy, limitation from IDH (>4mm) or anterior osteophytes was not applicable for the implementation of PEATCD with channel repair because this technique was conducted through the bony channel rather than disc space. However, posterior osteophytes or calcific herniated disc was excluded because of the possibly unsatisfactory surgical effect [21]. Patients with

severe obesity and short neck were also excluded for the difficulty palpation of carotid artery. The location of operated level was also important for operation. Intraoperative manipulation may be obstructed by the mandible if the herniation was at C2-C3 segment. As the clavicle may impede the operation at C6-C7 segment. Based on our limited experiences, the best indication for PEATCD with channel repair was the patient with single-level central or mediolateral soft CIVDH at the levels from C3-C4 to C5-C6 and without spinal canal stenosis or posterior osteophytes.

Conclusion

The most outstanding advantages of PEATCD with channel repair were “functional preservation” and “anatomical protection” for cervical spine, and which is a safe, feasible, effective, and minimally invasive surgery that offers an alternative for patients with CIVDH.

Methods

Patient characteristics

This retrospective study was approved by the Ethics Committee of the Affiliated Hospital of Zunyi Medical University and the informed consent was obtained from all participants. In this study, PEATCD with channel repair was performed for 24 consecutive patients from Oct. 2016 to Mar. 2017. The demographic characteristics, clinical data, and treatment level are shown in *Table 4*. The quality of life and clinical outcomes were evaluated using Neck Disability Index (NDI) and Japanese Orthopedic Association (JOA). Visual Analog Scale (VAS) was applied to record the arm and neck pain. In this study, 21 patients experienced failed conservative therapy for at least 12 weeks, the other 3 accepted surgical treatment directly because of the insufferable discomfort.

Table 4
summary of demographic characteristics, clinical date, and treatment level

Sex	Male 14, female 10
Mean age (range), years	54.69±9.91 (35-77)
Mean duration of symptoms (range), weeks	19.25±3.94 (14-28)
Indications for surgery	
Radiculopathy	9
Myelopathy	15
Arm or neck pain	
Arm	8
Neck	9
Arm and neck pain	7
Treatment level	
C3-4	5
C4-5	11
C5-6	8

Patient selection

The inclusion criteria were as follows: failed conservative therapy for at least 12 weeks; single-level central or mediolateral soft CIVDH; and the neurologic symptoms were induced by the identified CIVDH. The contraindications were as follows: patients with cervical spinal canal stenosis or multiple-levels CIVDH; cervical instability; disc herniation accompanied by foraminal stenosis or lateral disc herniation; calcification of the herniated disc; posterior osteophytes; patients with severe obesity or osteoporosis; previous surgery at the same segment; the herniation was induced by trauma; or neck infection.

Surgical instruments

The spinal endoscopy system (SPINENDOS GmbH., Munich, Germany) was comprised of a 4.3 mm working channel, an outer sheath with a 6.9 mm diameter, a 30°-angled scope with a continuous water irrigation system, a trephine with a 6.6 mm inner diameter and a 7.6 mm outer diameter, a trephine protection tube with a 7.7 mm inner diameter and a 8.5 mm outer diameter, and a low-temperature radiofrequency ablation system (ArthroCare Co., Sunnyvale, CA, USA). The intraoperative nerve monitor

was (NIM-ECLIPSE System, Medtronic, Inc., USA). The drill was made by NOUVAG AG, Goldach, Switzerland.

Preoperative preparation

Preoperative static and dynamic plain radiographs were necessary to understand the alignment of cervical spine. Magnetic resonance imaging (MRI) on sagittal and cross section was used to ensure the pathological level and the specific position of herniated disc, which was instructive for the creation of channel. Preoperative computed tomography (CT) examination was also essential, which was beneficial for excluding patients with calcified herniated disc or posterior osteophytes. According to the exact position of herniated disc, the surgeon could simulate the bony channel on plain radiographs or three-dimensional CT images and make it precise. A gastric tube was inserted preanesthesia and the iohexol contrast agent was injected to observe the esophagus outline under C-arm.

Operative technique

All procedures were completed under general anesthesia and approached from the left side. The operating process was monitored dynamically with C-arm fluoroscopy and electroneurophysiologic monitoring. The patients were placed in a supine position with neck in right slight extension. The operated level was identified primarily under C-arm and a K-wire was prepared for following location. With the help of two-finger technique, a safe window was created for anchoring the k-wire into target vertebra under C-arm, then the entrance and trajectory of the bony channel could be traced out through the extended line of K-wire (Fig. 3a and 3b). An incision about 8mm was made and the serial dilators, working cannula and trephine were introduced in order (Fig. 4a). The trephine was screwed gradually, which was dynamically monitored with C-arm fluoroscopy and the bone plug could be taken out together with the trephine by moving it gently in all directions (Fig. 4b and 4c). Then the endoscopic system was installed. After that, high-speed diamond was used to dispose of the residual bone at the bottom of channel (Fig. 4d). A blunt hook was helpful for surgeon to identify the posterior border of the vertebra (Fig. 4e). After clearing up the residual bone, the soft tissue at the bottom of channel was the herniated disc fragments. The posterior longitudinal ligament was presented after the herniated lesion was removed with rongeur and forceps. Further surgical exploration was obligatory if there was still visually oppressing on the posterior longitudinal ligament under endoscopy. If not, the palpation along the surface of posterior longitudinal ligament with blunt hook must be conducted, which was to examine not only the tension but also the integrity of posterior longitudinal ligament. It was beneficial to open it for further searching the herniated nucleus pulposus if there was a crevasse on posterior longitudinal ligament. Decompression was sufficient when the dural sac re-expansion became apparent (Fig. 4f). After successful decompression and adequate hemostasis, the endoscopy was withdrawn and the bone plug harvested previously by trephine was inserted into the working cannula, then the endoscopy was introduced again to propel the implant visually and slowly until the anterior surfaces of the vertebra and

implant was parallel (Fig. 5a and 5b). The endoscopic system was withdrawn if there was no active bleeding. Drainage tube was not required.

Postoperative and follow-up care

In order to achieve favorable healing of the damaged posterior annulus fibrosis and decrease the recurrence rate of disc herniation, a neck collar was advised for 3 weeks for all patients. All the 24 patients completed follow-up observation at 1, 3, 6, 12, and 24 months after surgery. At each stage, the scores of NDI, JOA, and VAS were recorded. MRI was conducted to confirm the decompression 1 week postoperative, and CT images were used to observe the bony channel at 1 week, 3 and 12 months after operation. Static and dynamic plain radiographs were also conducted to evaluate the intervertebral disc height (IDH), cervical lordosis, and the cervical stability at preoperative and final follow-up stage.

Statistical analysis

Student's t-test was used for comparison of the paired data. The results were presented as the mean ± standard deviation and considered significant when the $P < 0.05$.

Declarations

Data Availability

The authors declare that all the data in this manuscript are available.

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Author Contribution Statement

QD and WJK composed and revised the manuscript and figures, respectively. WBL performed the surgery and ZJX also participated as an assistant. GRC and JA collected the clinical materials and completed the table design.

Additional Information

Conflicts of interest statement

All the authors declare no competing interests in this study.

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Informed consent

All methods were carried out in accordance with relevant guidelines and regulations.

All experimental protocols were approved by the Ethical Committee of Zunyi Medical College.

Informed consent was obtained from all participants include in this study.

Trial registration

Numbers: ChiCTR1800016383. Registered 29 may 2018. Retrospectively registered. Trial registry: Chinese Clinical Trial Registry.

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Figures

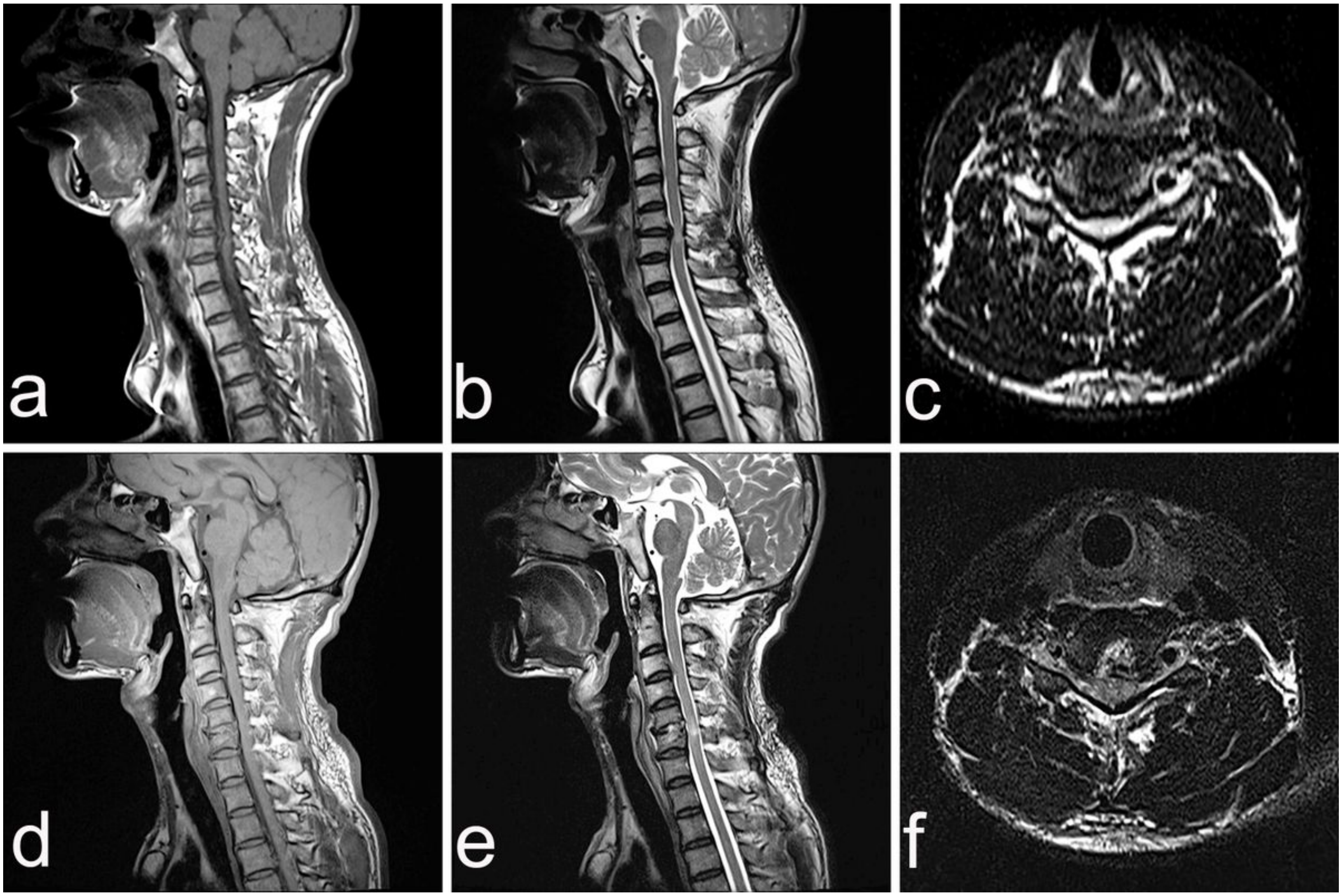

Figure 1

The preoperative MRIs revealed a broad-based disc hernia at C5/6 and postoperative MRI findings showed that the hernia mass was cleared. Preoperative MRI, T1 and T2 weighted sagittal views (a and b). Preoperative MRI, T1 weighted axial view (c). Postoperative MRI, T1 and T2 weighted sagittal views (d and e). Postoperative MRI, T1 weighted axial view (f).

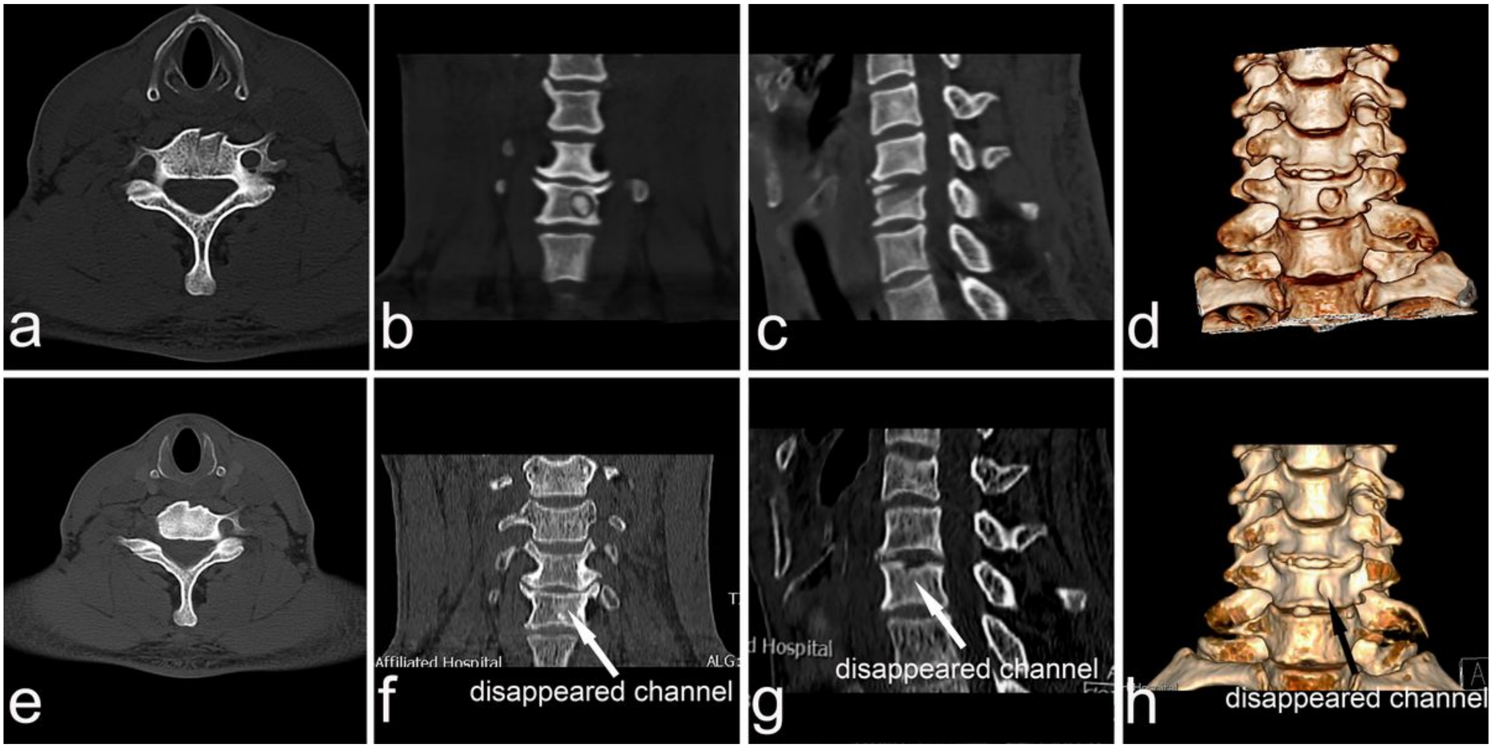

Figure 2

The CT images immediately postoperative showed the tunnel was satisfactory and orientation and no migration of the bone plug was observed (a, b, c, and d). The channel was disappeared 12 months after operation, the arrow (black or white) indicated the disappeared channel (e, f, g, and h).

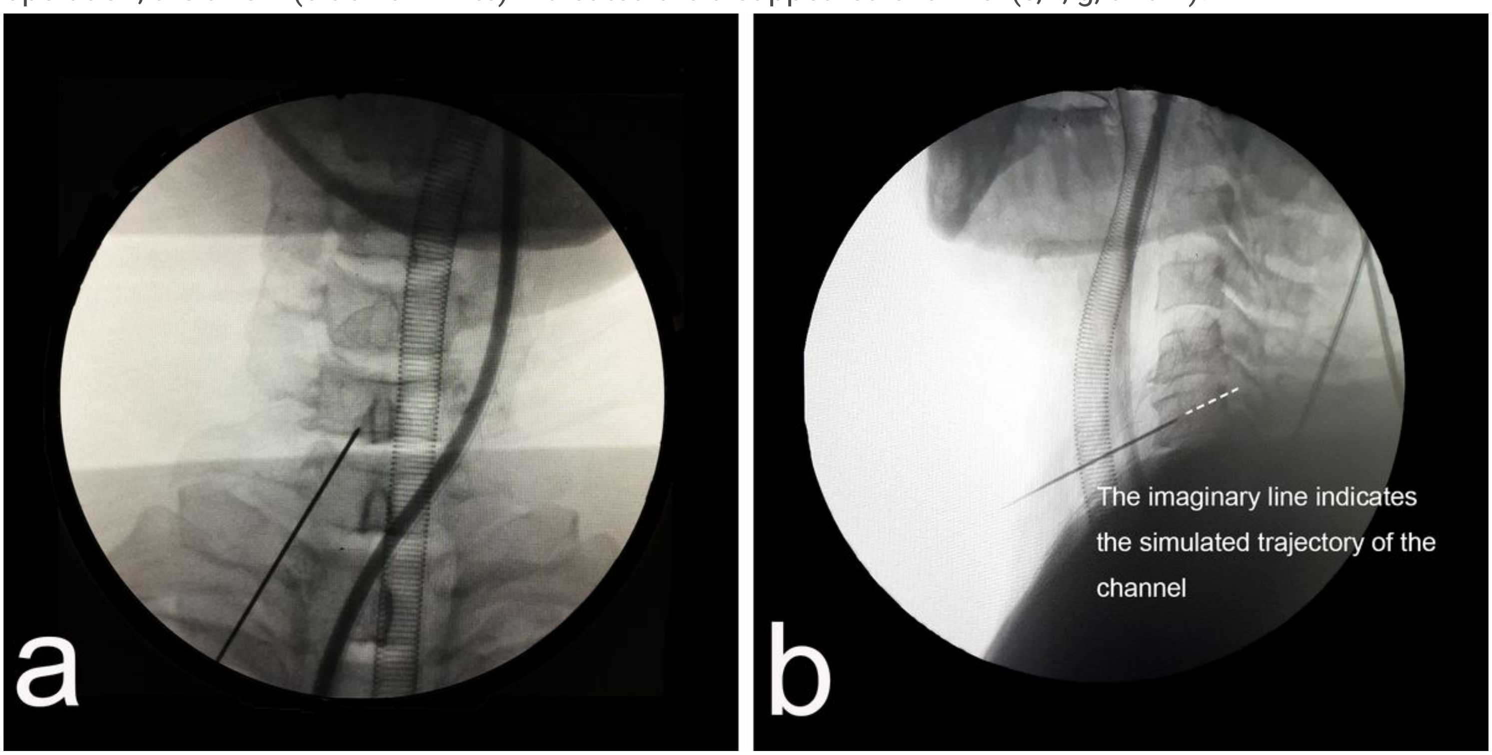

Figure 3

3a and 3b The radiographs intraoperative under C-arm revealed the precise site of the K-wire and esophagus.

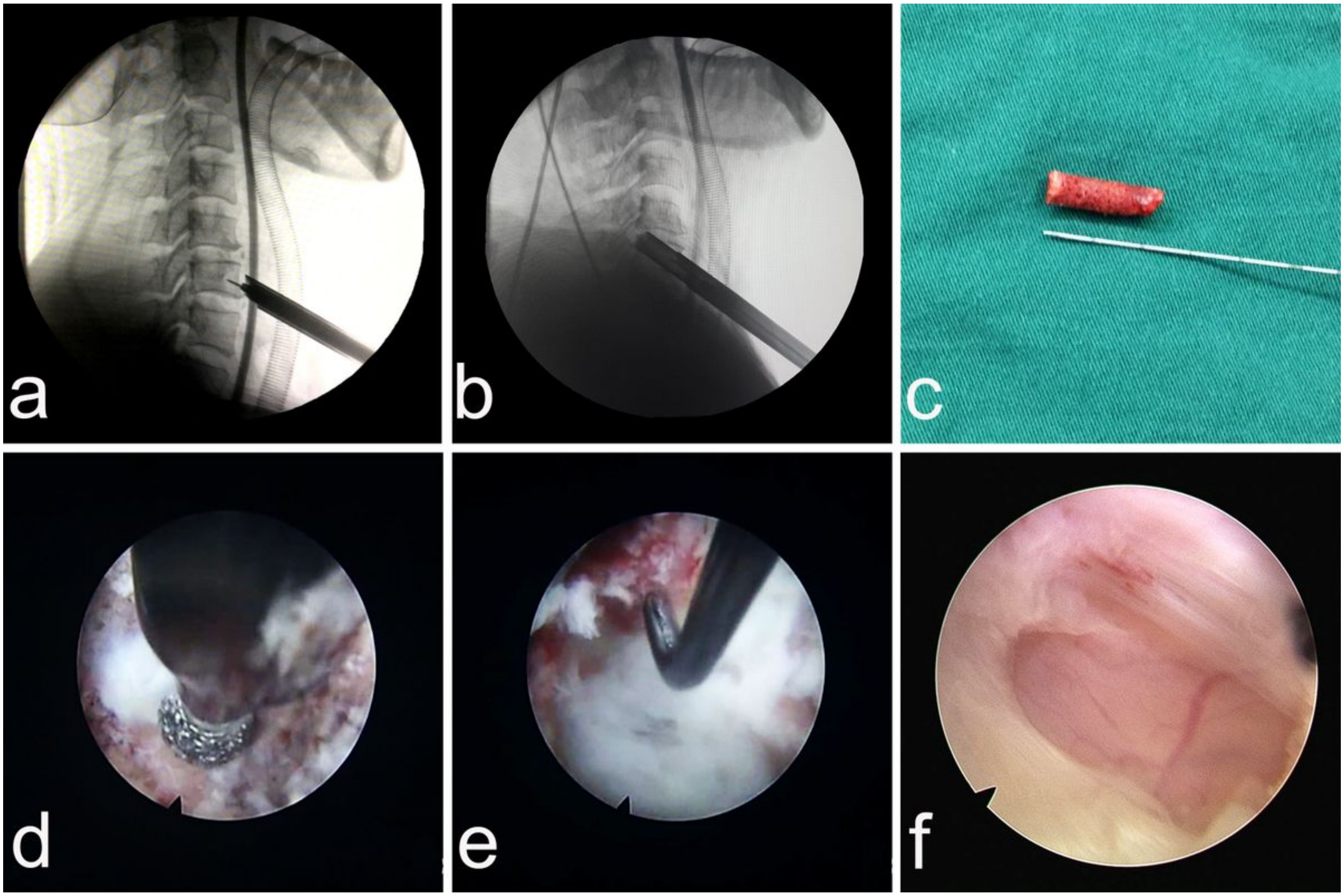

Figure 4

The serial dilators and working cannula were inserted in order before trephination (a). The posterosuperior border of vertebra was the terminus of trephination (b). The harvested bone plug (c). A high-speed diamond burr (d) was used to drill the remnant, and a hook (e) was applied to determine the posterior border of vertebra. No compression was observed after decompression (f).

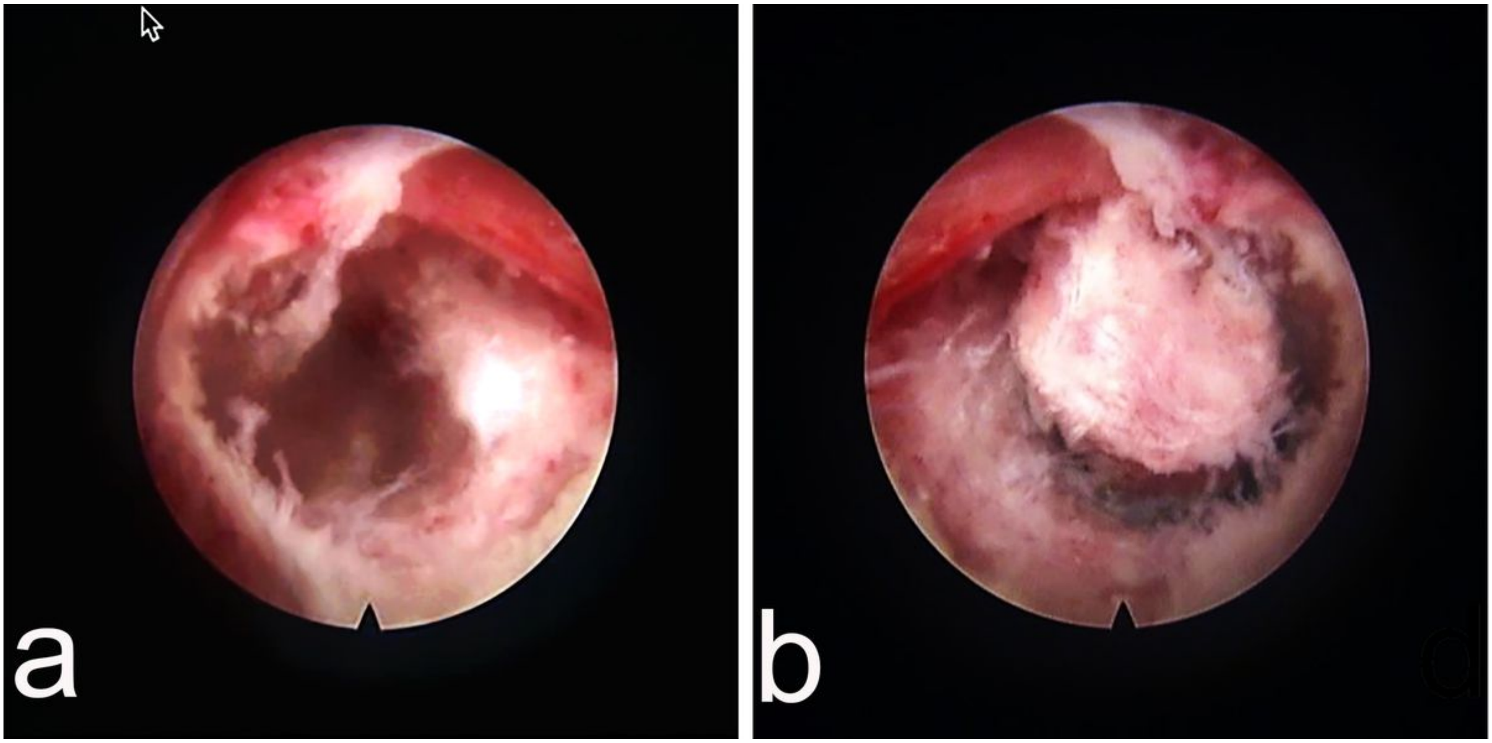

Figure 5

The bone plug was grafted into the tunnel (b) when there was no active bleeding (a).