An adjustable and stable assistant-free anterior cervical retractor system for microscopy- assisted anterior cervical discectomy and fusion

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Research Article

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Abstract

Background

Anterior cervical discectomy and fusion (ACDF) is a standardized surgical strategy for treating cervical spondylopathy. This study aimed to introduce a newly developed retractor system and analyze its feasibility and safety in microscopy-assisted ACDF.

Methods

A newly developed retractor system was used in microscopy-assisted ACDF to treat patients with cervical spondylopathy. Demographic data and pre-, peri-, and postoperative clinical and imaging data were collected and analyzed retrospectively.

Results

A total of 48 patients were included in this study. Postoperative imaging data indicated sufficient decompression and good alignment. The Visual Analog Scale and Neck Disability Index score decreased preoperatively from 5.43 ± 1.12 and 29.77 ± 6.06 to 2.60 ± 0.78 and 11.75 ± 3.26 after surgery. The Japanese Orthopedic Association score increased preoperatively from 7.93 ± 1.37 to 12.22 ± 1.71 postoperatively. The C2–7 Cobb angles increased from 10.37 ± 6.79 to 14.58 ± 6.10 degrees after the procedure. No clinical or imaging-related complications were observed.

Conclusion

The newly developed retractor system showed good feasibility and safety for microscopy-assisted ACDF surgery, providing an option for clinical application.

Introduction

Since its first report by Robinson and Smith in 1958 [1], anterior cervical discectomy and fusion (ACDF) has proven to be an effective and well-standardized surgical strategy for treating patients with cervical spondylopathy (CS) [2]. Despite its advantages, ACDF may still have surgical complications common to anterior cervical surgery, such as nerve injury [3], esophageal fistula [4], dysphagia [5], and carotid artery compression [6]. By tracing the root cause of the aforementioned problems, the application of a retractor was possible [6].

Neurosurgeons continued to invent and refine spinal surgical instruments [7]. Different retractor systems have been previously reported [8–15]. However, continuous manual stabilization, limited exposure, and the inability of the assistant to visualize the procedure have not been adequately addressed. The

continuous tension needed for retraction make the assistant's hand sore, tired, and uncomfortable. Incorrect retraction could cause poor visualization of the surgical field, which can cause conflicts between the surgeon and assistant. Therefore, the development of a stable and safe anterior cervical retractor is needed.

Based on this need, our group developed a new, adjustable, and stable assistant-free anterior cervical retractor system (Fig. 1) that is widely applicable to anterior cervical surgery.

In the present study, we introduce a newly developed retractor system and report its feasibility and safety in microscopy-assisted ACDF in 48 patients with CS.

Methods

Patient data

This study was carried out with the approval of ethics committee of the Affiliated hospital of Zunyi Medical University. After obtaining the patient’s informed consent, demographic and clinical data were collected from electronic medical records. The inclusion criteria were: (a) age 18–75 years, (b) clear diagnosis of cervical spondylopathy identified with clinical symptoms and imaging data; and (c) no obvious remission of symptoms after long-term conservative treatment. The exclusion criteria were: (a) congenital cervical spine malformation, (b) serious ossification of the posterior longitudinal ligament, (c) prior cervical surgery, and (d) cervical trauma or tumor.

Before surgery, a thorough examination was performed to confirm the diagnosis. Additional evaluation included a Visual Analog Scale (VAS), Japanese Orthopedic Association (JOA) score, and Neck Disability Index (NDI); further, imaging examinations including plain radiographs, (Fig. 2a-b) magnetic resonance imaging (MRI), (Fig. 2c) and computed tomography (CT) were undertaken. (Fig. 2d)

Exposure procedure

The exposure was performed using the newly developed assistant-free retractor system. After successful anesthesia, the patients were placed in the supine position and the neck was slightly extended past neutral and rotated to the right. After sterile skin preparation and draping, the platysma and sternocleidomastoid muscles were separated, and the cervical vertebrae were exposed. The soft tissue in front of the vertebral body was cleared after confirming the segment using the C-arm. A mark was made using pliers 8 mm away from the tip of a 1.5-mm-diameter Kirschner wire (K-wire) whose tail end was shaped into a triangle (Fig. 1a). The pre-prepared K-wire was inserted on both sides of the vertebral body, 5 mm from the anterior median line, as deep as the pre-marked site was flush with the surface of the vertebra. The number of K-wires was adjusted according to the number of levels to be fused, with 2 K-wires used for each cervical vertebra. The K-wire was bent to 90 degrees at the skin, and two adjacent K-wires were fixed together with a no. 4 silk tie (Fig. 1b-c). One 250 ml normal saline bottle was used to overhang every 2 K-wires on the tracheal side for retraction, and one 100 ml normal saline bottle was

used on the carotid side. In addition, a cerebral cotton was placed behind the K-wire to protect the muscles and critical tissues (Fig. 1c).

Surgical procedure

After clear exposure of the surgical area, the procedures were performed under a microscope without assistants holding the retractor. Using microscopy, the cervical disc was removed, and the superior and inferior endplates were polished. The posterior longitudinal ligament was carefully identified and incised and the residual herniated nucleus pulposus was removed carefully. After sufficient decompression, a suitable fusion cage was selected and implanted. Correct placement was confirmed by C-arm, and then irrigation and closure were performed.

Preoperative and postoperative clinical and imaging data were evaluated and recorded. Surgical time and blood loss were recorded.

Data analysis

All data were processed using the GraphPad Prism 10 software. The data were recorded as mean ± standard deviation and analyzed using paired *t*-tests, with $P < 0.05$ considered statically significant.

Results

A total of 48 patients aged 52.19 ± 9.63 years were eligible and included in this study, including 28 men and 20 women. Twenty-four cases had cervical radiculopathy, 17 had cervical spondylotic myelopathy, and 7 had mixed cervical spondylosis. Basic data are presented in Table 1.

Table 1
Basic data of included patients($\bar{x}\pm s$, n = 48)

Gender (M:F)	**28:20**
Age (y)	52.19 ± 9.63
Duration of disease (m)	12.38 ± 14.33
Follow up (m)	21.50 ± 17.29
Type of cervical spondylopathy (CR:CSM:MIX)	24:17:7
Ossification of the posterior longitudinal ligament (n/%)	13/27.08
Number of surgical segments (S:D:T)	30:12:6
Type of cage (Ti:Z-P)	38:10
Note: CR: Cervical radiculopathy; CSM: Cervical spondylotic myelopathy; MCS: Mixed cervical spondylosis; S: Single segment; D: Double segments; T: Triple segments; Ti: Titanium plate; Z-P: Zero-Plant	

All procedures were performed successfully and safely (Fig. 3a). The patients were followed up for 21.50 ± 17.29 months, with no one lost to follow-up. Regarding the type of fusion cage, a combination of titanium plate and fusion cage was implanted in 38 patients, while 10 patients received Zero-plant fusion cage. (Table 1) In terms of perioperative data, the operative time for single segment was 84.00 ± 31.80 min, and blood loss for a single segment was 19.86 ± 10.41 ml. (Table 2) Patients were discharged at 5.33 ± 1.89 days.

Table 2
Operation time, intraoperative blood loss and postoperative length of stay ($\bar{x}$±s, n = 48)

Operation time for single segment (min)	**84.00 ± 31.80**
Blood loss for single segment (ml)	19.86 ± 10.41
Postoperative length of stay (day)	5.33 ± 1.89

Sufficient spinal cord decompression and considerable re-expansion were observed in the surgical segments, with no intervertebral discs remaining on MRI. (Fig. 3b). On postoperative day 3 (Fig. 3c) and the third month postoperatively, (Fig. 3d) anteroposterior and lateral radiographs indicated good cervical alignment.

For clinical scoring, the VAS and NDI were used that showed decrease from 5.43 ± 1.12 and 29.77 ± 6.06 points preoperatively to 2.60 ± 0.78 and 11.75 ± 3.26 points at postoperative day 3, respectively, (Table 3); the scores further reduced to 1.15 ± 0.57 and 3.14 ± 1.21 at the final follow-up. The JOA score increased from 7.93 ± 1.37 preoperatively to 12.22 ± 1.71 on postoperative day 3 and 15.13 ± 1.26 at the final follow-up. Similarly, the C2–7 Cobb angles increased from 10.37 ± 6.79 degrees postoperatively to 14.58 ± 6.10 degrees after surgery, while it decreased to 13.38 ± 4.31 degrees slightly at the last follow-up.

Table 3
Comparison of VAS, JOA, NDI scores and Cervical cobb angles between pre- and post-ACDF surgery ($\bar{x}$±s, n = 48)

Evaluation time	**VAS score**	**JOA score**	**NDI score**	**Cervical Cobb angles (°)**
Preoperation	5.43 ± 1.12	7.93 ± 1.37	29.77 ± 6.06	10.37 ± 6.79
Postoperative 3 day	2.60 ± 0.78*	12.22 ± 1.71*	11.75 ± 3.26*	14.58 ± 6.10*
Postoperative 3 month	1.41 ± 0.67*	13.97 ± 1.26*	5.89 ± 2.10*	13.71 ± 4.07*
Final follow-up	1.15 ± 0.57*	15.13 ± 1.26*	3.14 ± 1.21*	13.38 ± 4.31*
Note: VAS: Visual analogue scale; JOA: Japanese Orthopaedic Association; NDI: Neck disability index;				
*Compared with preoperation, $P < 0.05$.				

Notably, the experience and satisfaction of both the surgeons and assistants were very good.

Complications

At the final follow-up, no clinical complications had occurred, including nerve injury, cerebrospinal fluid leakage, vertebral fracture, arterial injury, or esophageal injury. No imaging-related issues such as instability or degeneration of adjacent segments were observed.

Discussion

In this study, we introduced a newly developed anterior cervical retractor system that is adjustable, stable, and does not require an assistant. We also analyzed the feasibility of microscopy-assisted ACDF using this system for the treatment of patients with CS. Our results showed that the VAS and NDI scores decreased significantly after surgery and decreased gradually over time to the final follow up, suggesting that pain and dysfunction were significantly improved, and daily activities were also improved. The JOA score increased postoperatively and continued to increase during follow-up, indicating that sensation and movement recovered well. Postoperative MRI confirmed adequate decompression of the spinal cord and nerve root, and radiography revealed sustained excellent cervical alignment and stability. Most importantly, no complications occurred in any of the patients, indicating the safety of the newly developed retractor system. In addition, both surgeons and assistants expressed good satisfaction with the retractor system, revealing good applicability.

In this study, the C2–7 Cobb angle variance was relatively large, which may be because we included patients with single, double, or triple levels of fusion. The C2–7 Cobb angle of patients with triple segments was usually significantly different from those of patients with a single segment, contributing to the large variance. Moreover, during follow-up, we observed a slight decrease in the C2–7 Cobb angle, which is consistent with previous reports [16]. The decrease in Cobb angle may be due to fusion cage sedimentation [1, 17]. A previous study found that patients managed with stand-alone cages were more prone to sedimentation than those treated with a plate and cage combination, and a higher subsidence rate was detected in patients who underwent surgery at levels C5–C7 than at levels C2–C5 [17]. We did not perform subgroup analysis due to limited case numbers.

As described, ongoing attempts have been made to improve the surgical exposure of the anterior cervical area, especially with retractor modification [8–10]. The poor stability and sustained difficulty of manual retraction can be overcome with a new modification. The retractor system used in this study had several advantages. First, it did not require additional force to maintain stability, which liberated the assistants and provided them with a clear view to observe and learn on the microscope screen, thereby improving their satisfaction and passion for joining the operation. Second, the exposed area was wide enough to guarantee the stability of the dissection planes between both the trachea and esophagus and the sternocleidomastoid and carotid sheath, which is critical for the exposure of herniated cervical disc tissue and the decompression of the spinal cord and nerve root [8]. With the development of microscopic technology, microscope-assisted surgery has attracted increasing attention in recent decades [18]. Microscopy has the advantage of clear identification of critical nerves and vessels in ACDF [2]; however, it

also increases the need for the exposure area and stability of the dissection plane. Due to its improved exposure over human assistance, the newly developed retractor system is suitable for microscope-assisted ACDF. Third, the length of the retractor system could be adjusted according to the actual number of spinal levels. Notably, this performance is particularly important in procedures with longer incisions because a large incision has an increased risk of wound infection and patient dissatisfaction [19]. Fourth, the retractor system was assembled in a short time, which is convenient and economical. Its usage is simple and the learning curve is very short. Finally, compared to a previous study [20], the use of the newly developed retractor did not prolong the operative time, which was closely associated with prolonged non-home discharge, length of stay, and increased transfusion requirements after ACDF [21].

It is worth noting that several key points deserve attention during application, including complete hemostasis, gentle operation, and avoiding damage to vital organs and blood vessels during insertion and withdrawal of the K-wire.

Limitations

To the best of our knowledge, this is the first report of an assistant-free, adjustable, assembled anterior cervical retractor system with several improvements. However, we must acknowledge the limitations of this study. First, this retractor system is currently under an active patent application and has not yet been patented or prepared as a finished product. Second, this system requires further simplification and standardization. Third, insertion of K-wire may injure the vertebral body, even fracture, which requires further evaluation. Finally, this was a retrospective study without a control group; therefore, the validity and clinical level of evidence were relatively low.

Conclusion

In conclusion, the newly developed anterior cervical retractor system introduced in this study was assistant-free, adjustable, and stable and showed good feasibility and safety for microscopy-assisted ACDF procedures.

Declarations

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Author contributions: JQ and JA conceived the original ideas of this manuscript, reviewed the manuscript and executed supervision throughout the process. JQ finished the operation. HQ, TL and LH prepared the manuscript and figures. All authors have read and approved the manuscript.

Data availability: Data are not publicly available, but can be requested through contacting the corresponding author (JQ).

Code availability: Not applicable.

Ethics approval: This study was carried out with the approval of ethics committee of the Affiliated hospital of Zunyi Medical University.

Consent to participate: The patient gave consent to be included in the study.

Consent for publication: The patient has given written informed consent for this case report to be published.

Conflicts of interest/Competing interests: The authors declare that they have no conflicts of interest.

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Figures

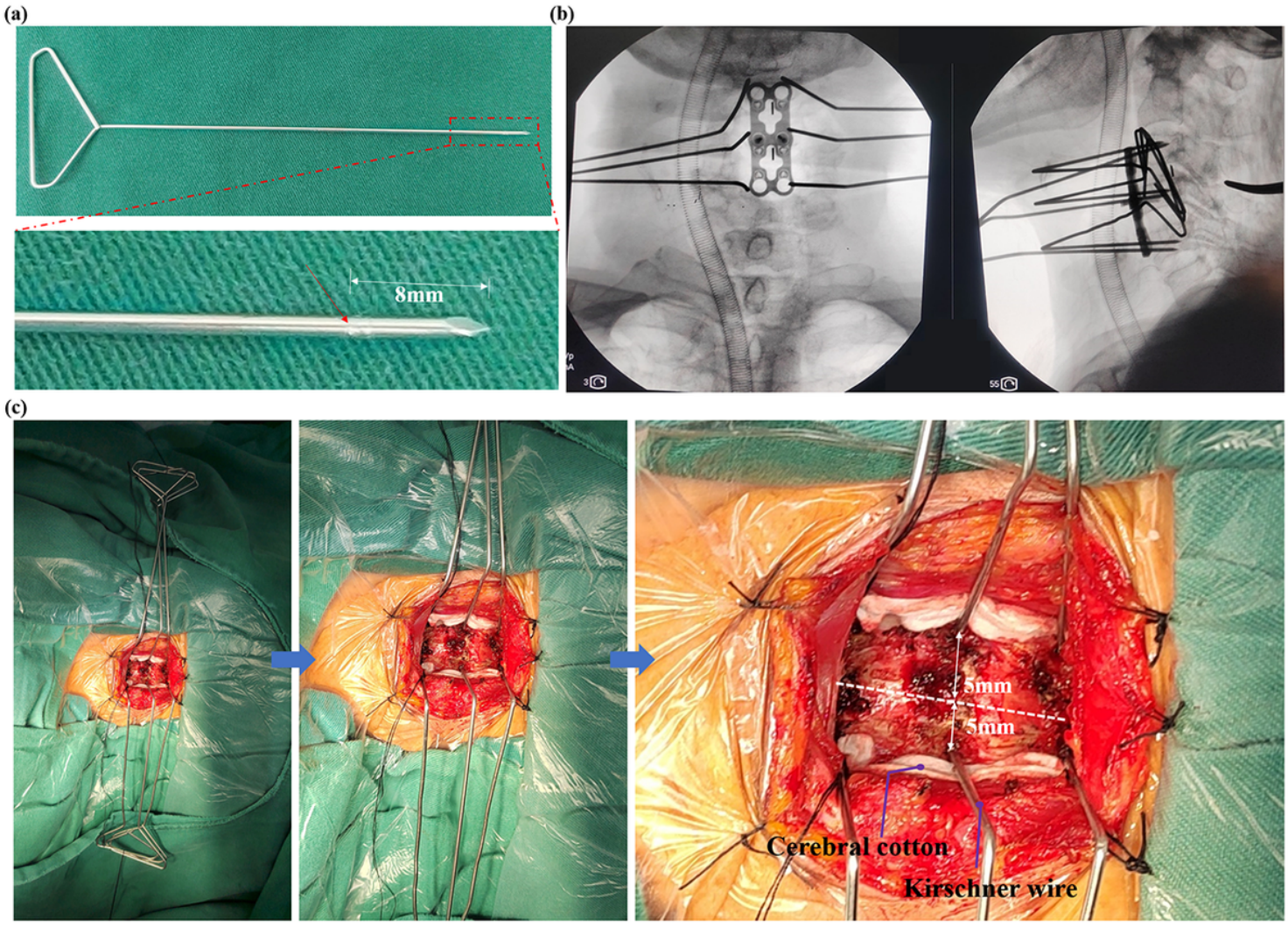

Figure 1

The newly-designed stable exposure system. (a) The general view of the pre-bent Kirschner wire (diameter=1.5mm) and magnification of the front-end mark with a depth of 8mm. (Red arrow indicated the mark made by pliers). (b) Anteroposterior and lateral image derived from C-arm machine showing the position and depth of the K-wire. (c) Demonstration of the exposure system in double-segment anterior cervical discectomy and fusion surgery.

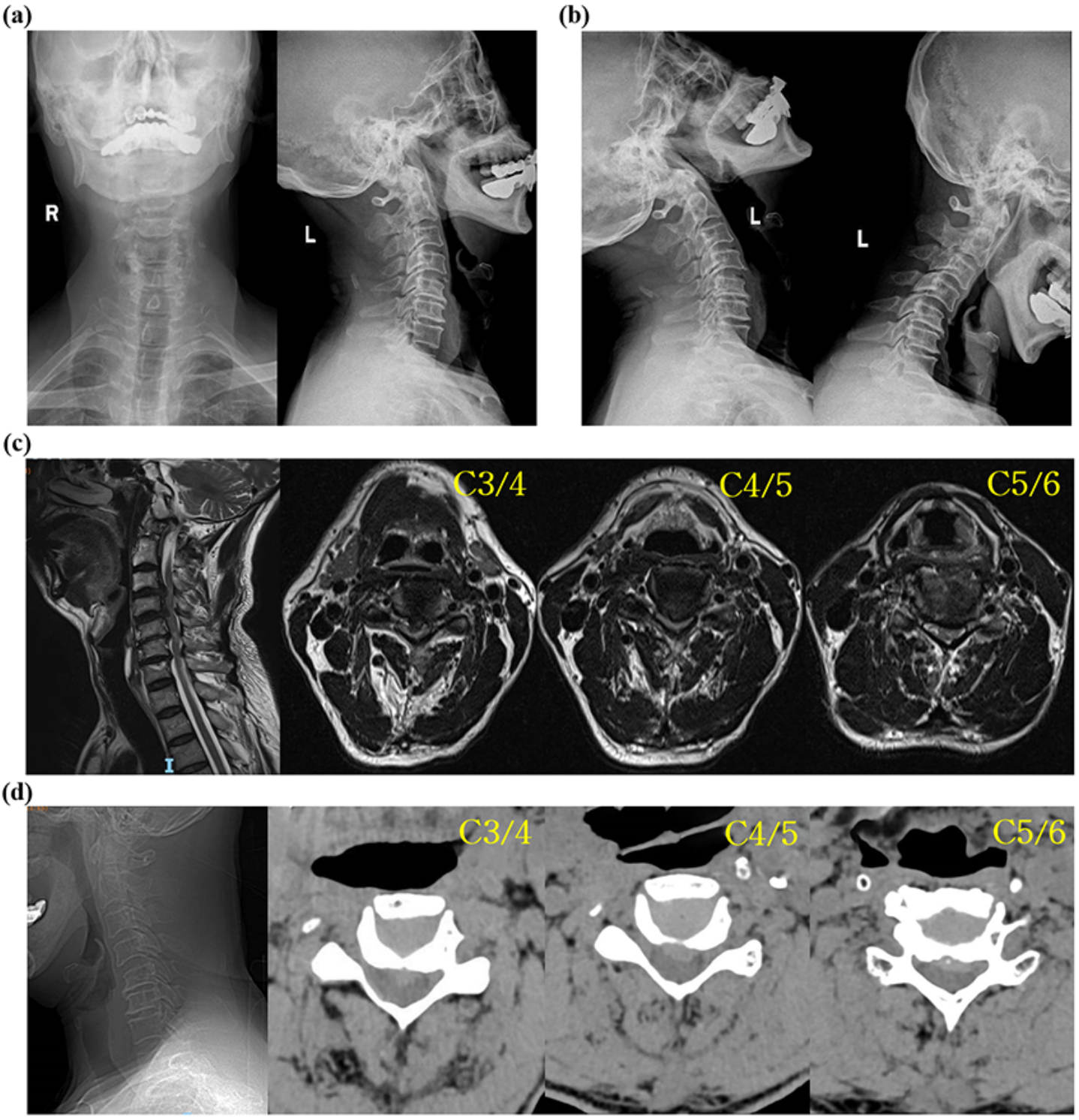

Figure 2

Preoperative imaging data. (a) Anteroposterior and lateral X-ray images. (b) Hyperextension and hyperflexion X-ray images. (c) Magnetic resonance imaging suggesting cervical disc herniation (CDH) in the C3/4, C5/6 and C6/7 levels. (d) Computed tomography confirming CDH.

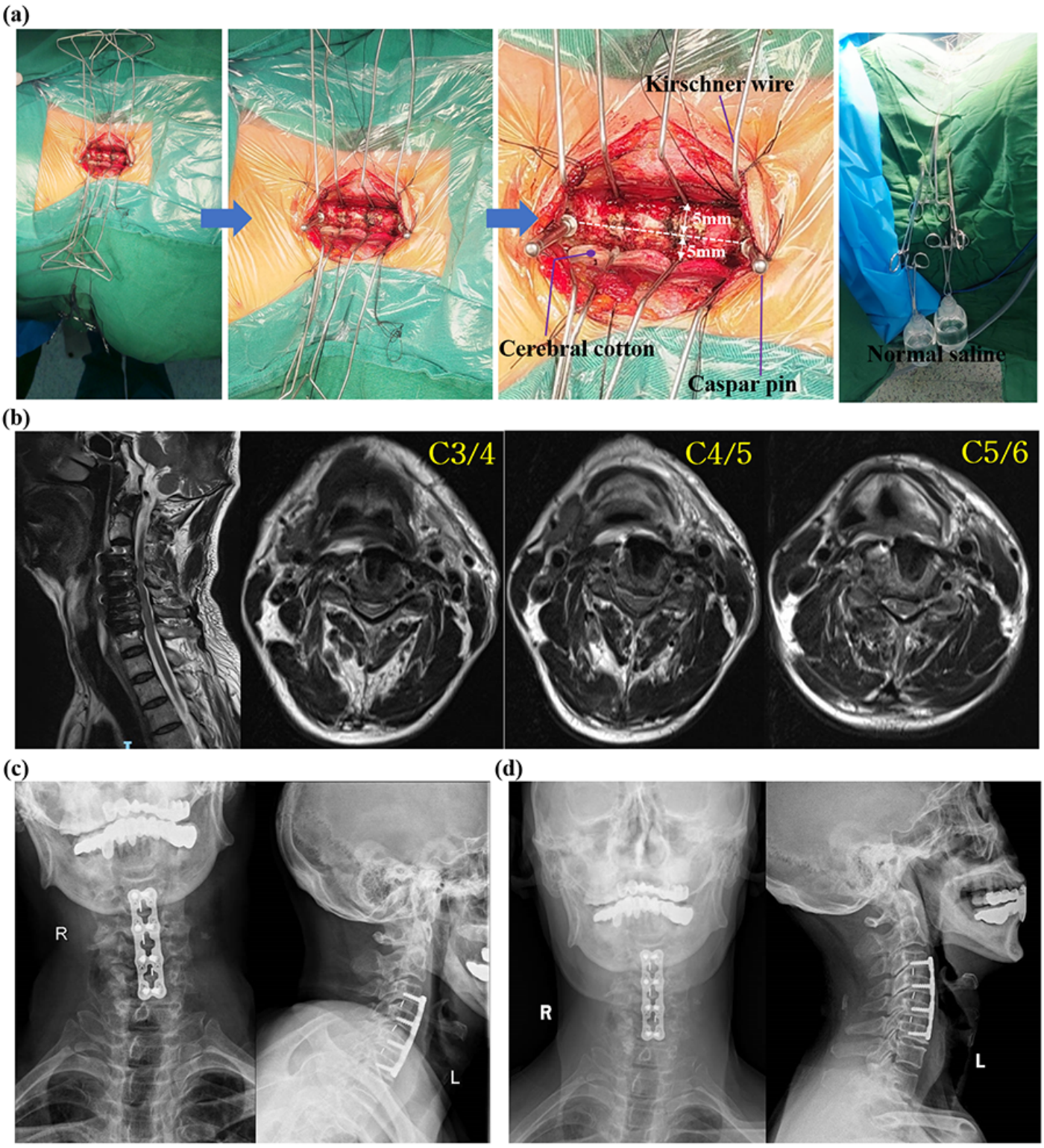

Figure 3

Intraoperative and postoperative data. (a) Intraoperative application of the newly-developed exposure system without needing help of an assistant. (b) Postoperative magnetic resonance imaging indicating thorough elimination of the herniated disc, sufficient decompression and dilation of the spinal cord. (c) Anteroposterior and lateral X-ray images showing well stability and alignment at one week after surgery. (d) X-ray images indicating good stability and alignment at postoperative 3 months.