Effectiveness of posterior percutaneous full-endoscopic cervical foraminotomy for cervical osseous foraminal stenosis

Zihan Zhang
Affiliated Hospital of Zunyi Medical University
Qian Du
Affiliated Hospital of Zunyi Medical University
Jun Ao
Affiliated Hospital of Zunyi Medical University
Jianpu Qin
Affiliated Hospital of Zunyi Medical University
WenBo Liao (wenbo900@sina.com)

Research article

Keywords: cervical vertebrae; radiculopathy; osseous foraminal stenosis; full-endoscopy; intervertebral foratomy; minimally invasive

Posted Date: November 11th, 2019

DOI: https://doi.org/10.21203/rs.2.17092/v1

Abstract

Background To evaluate the efficacy of posterior percutaneous full-endoscopic cervical foraminotomy for cervical osseous foraminal stenosis. Methods During October 2015 to October 2018, 30 patients with skeletal cervical canal stenosis who met the selection criteria were included in the study. All patients underwent percutaneous posterior full-endoscopic nerve root canal decompression. Pain visual analogue scale (VAS) and cervical dysfunction index (NDI) were used to assess the degree of pain relief. Results All patients were followed up for 2 days to 12 months, and the final follow-up was also significantly improved after surgery, and the difference was statistically significant ($P < 0.05$). At the last follow-up, the clinical efficacy was evaluated using the modified Macnab criteria. Conclusion Percutaneous posterior total endoscopic nerve canal incision can successfully complete the decompression of osseous neck canal stenosis. It can be used as a treatment option for patients with bony stenosis.

Background

Cervical spondylotic radiculopathy (CSR) is a disease characterized by cervical intervertebral disc degeneration and secondary pathological changes that lead to nerve root compression and irritation or dysfunction of the corresponding segmental nerve roots [1]. CSR is a relatively common type of cervical spondylosis and is one of the most common cervical diseases causing symptoms and signs of nerve compression. The nerve roots are relatively well protected and are not susceptible to external trauma [2]. However, since the nerve roots do not have a protective connective tissue sheath surrounding the peripheral nerve, they are sensitive to mechanical compression caused by lesions to the spinal canal [3]. The compression can generate either a direct mechanical effect on the nerve root or an indirect effect by impairing the blood supply to the nerve. Conservative treatment is effective in most patients with CSR [4]. Cervical osseous foraminal stenosis is a common cause of CSR. Surgical treatment is needed for patients who are not responsive to regular conservative treatment. The basic principle of surgical treatment for CSR is that the compressed nerve root should be completely decompressed [5]. Many surgical methods are available for the treatment of CSR, including traditional surgery and minimally invasive surgery. Surgical approaches generally include anterior and posterior approaches. Different surgical methods and approaches should be selected according to individual conditions [6]. However, traditional surgery may lead to injury to the adjacent vital organs, muscle detachment and excessive resection of the facet joints. Therefore, it often causes postoperative neck and shoulder pain and even cervical deformity and may even affect the stability of the cervical spine [7]. With the advance of science, technology and medical treatment, minimally invasive spinal surgery has evolved rapidly in recent years. Many researchers have employed the posterior approach to treat CSR and obtained good results through relatively minimally invasive methods.

With the development of the cervical endoscopic system, minimally invasive spinal surgery is increasingly used by surgeons. The full-endoscopic technique is well-accepted by spinal surgeons due to its minimal trauma and satisfactory clinical efficacy [8]. Usually, cervical osseous foraminal stenosis is closely related to hyperostosis of the Luschka joints and facet joint. In 2016, Oertel et al [9]. reported the use of endoscopic cervical foraminotomy for the treatment of intervertebral foramen stenosis. In 2017, Ye et al [10]. observed the clinical efficacy of percutaneous full-endoscopic cervical foraminotomy in the treatment of bony stenosis of the intervertebral foramen, indicating that it is a safe and feasible surgical approach [11]. This study aimed to evaluate and measure the effect of decompression, as well as evaluate the clinical efficacy of percutaneous full-endoscopic cervical foraminotomy in the treatment of bony stenosis of the cervical nerve root canal.

Materials And Methods

Inclusion criteria

Patients with bony stenosis of a single-segment cervical nerve root canal; patients who had no remission of pain and numbness after 3 months of conservative treatment; and patients with repeated episodes or worsening or intolerable pain.

Exclusion criteria

Patients with unstable lesions, severe malformations or spinal infections on imaging; patients with cervical spondylotic myelopathy or peripheral neuropathy; and patients with symptoms inconsistent with preoperative imaging.

General characteristics of the patient

In this study, 30 patients were enrolled, including 13 males and 17 females; the age ranged from 43 to 74 years, with an average of 54.3 years. Cervical lesions: C4-C5, 4 cases; C5-C6, 14 cases; C6-C7, 11 cases; C7-T1, 1 case. All patients had symptoms of radiculopathy, numbness, allergies and sensation caused by unilateral nerve root canal stenosis. Among the 30 patients, 26 were positive for the Eaten sign and 27 were positive for the Spurling sign. All patient imaging showed a significant narrowing of the corresponding nerve root canal.

Measurement of stenosis length

All patients underwent CT and MRI scans of the affected segments before surgery. The nerve root diameter “a” of the affected segment was obtained from the preoperative MRI images, and the diameter “a” of the nerve root measured in Fig 1a. 1was set as the reference. On the preoperative CT images, a rectangle with the width equal to the nerve root diameter was drawn to trace the nerve root. One side of the rectangle was set close to one side of the facet joint. The rectangular tracing intersected with the Luschka joints at two points: B and C. The distance between the two points was defined as the length “d” of the narrowing site, as shown in Fig 1b.

Surgical procedure

Under general anaesthesia with tracheal intubation, the patient was placed in the prone position with their head secured in the neutral position and their neck slightly tilted forward to maximize the cervical intervertebral space. The patient's arms were secured on the sides of their body and retracted properly towards the feet to avoid affecting the positioning of the cervical vertebrae during intraoperative C-arm radiography. The affected segment was identified and marked via the lateral view of the C-arm radiography. The operative field was routinely disinfected and draped. The Kirschner wire was placed based on the marked point into the junction of the upper and lower lamina medial to the facet joint of the diseased segment. After positioning in the C-arm radiography, a 0.7-cm-long skin incision was made, and the dilator and working trocar were placed over the Kirschner wire (Fig. 2). The Kirschner wire and the dilator were withdrawn. The endoscope system was placed. The electrical hook was used to slowly separate some attachments of the ligamentum flavum medial to the upper and lower lamina and the facet joint in Fig. 3a. Then, a high-speed grinding drill was used to remove the outer cortical bone and cancellous bone of the medial edge of the facet joint and part of the lamina of the upper and lower vertebral body. To avoid injury to the nerve root or spinal cord, the remaining contralateral cortical bone was gradually removed in steps by the hook and rongeur, thus establishing a safe operative field in Fig. 3b. Part of the ligamentum flavum and soft tissue in the interlaminar space were separated carefully and removed. At this time, the compression of the nerve root could be observed under endoscopy, and the tension of the nerve root could also be evaluated by probing with the hook. Next, the medial side of the facet joint as well as the upper and lower laminae could then be further grinded off until there was no significant tension in the nerve roots. Before grinding, the hook was used to explore the nerve root and surrounding tissue to identify the adhesion site in order to avoid injuring the nerve root. After grinding was complete, the hook was used to examine the nerve root again to confirm no compression on the nerve root (Fig. 3c-f). After complete decompression and confirmation of no active bleeding, the endoscope system was withdrawn, and the incision was closed.

Measurement of the length of the decompression zone

After surgery, CT imaging was repeated. The distance between the ends of the bone removal area on the medial edge of the facet joint was measured on CT; this distance is the length of decompression "e" (Fig. 4).

Statistical analysis

The sphericity test showed that the chi-squared approximation of the VAS score was 30.429 ($P \leq 0.05$). The Greenhouse-Geisser correction was used for the analysis, and the results were as follows: $F(2.564, 74.367) = 523.963$ and $P \leq 0.05$, indicating that the differences between the groups were statistically significant. The chi-squared approximation of the NDI score was 257.138 ($P \leq 0.05$). The Greenhouse-Geisser correction was used for the analysis, and the results were as follows: $F(1.050, 30.447) = 276.364$ and $P \leq 0.05$, indicating that the differences between the groups were statistically significant.

Results

All the 30 patients successfully completed the operation. The operation time ranged from 65 to 200 minutes, and the average operation time was 93.8 minutes. No obvious bleeding occurred during the operation. Two days after surgery, cervical CT showed enlargement of the cervical canal and reduction of nerve roots. Postoperative pain and numbness in the neck and upper extremities were significantly relieved. The average hospital stay in 30 patients was 4.4 days. Both VAS scores and NDI were significantly improved immediately after surgery and at the last follow-up. The mean value ± standard deviation of each group is shown in Table 1.

Table 1 VAS and NDI score values (n=30)

Indictors	Pro	2days	3 Months	6 Months	12 Months	*P* Value
VAS score	7.00±0.95	2.83±0.70	1.60±0.50	1.23±0.43	1.07±0.25	0.00
NDI score	45.13±13.66	11.13±3.14	6.27±1.80	3.53±1.14	2.47±0.86	0.00

Statistical changes in neck VAS and NDI scores were more pronounced than in preoperative scores, with statistically significant differences ($P < 0.05$) (Fig. 5). Improved Macnab score assessment: Of the 30 patients, 24 were excellent, 4 were good, 2 were acceptable, and the excellent and good rate was 93.3%. After 12 months of follow-up care, no cases were rated as invalid.

All patients had a complete decompression of the nerve root canal in the CT scan of the cervical spine. The average stenosis length d of the 30 patients before surgery was 5.46±1.82 mm, and the average decompression length e was 7.44±2.19 mm. The mean and standard deviation of the ratio of postoperative decompression length to preoperative stenosis length was 1.41 ± 0.2 (Table 2).

Table 2 Preoperative stenosis length, postoperative decompression length, and decompression range (mean ± SD)

Indicators	Narrow length(mm)	Decompression length(mm)	The ratio of decompression length to narrow length
Measured value	5.46±1.82	7.44±2.19	1.41±0.28

Discussion

CSR is a syndrome that includes various symptoms and signs of cervical nerve root compression caused by pathological changes such as cervical or intervertebral disc degeneration [12]. Cervical radiculopathy accounts for 60%-70% of this disease. Approximately 80-100% of patients have neck pain and radiating pain in the upper extremities, with or without muscle weakness and paraesthesia [13]. With the continuous improvement in surgical techniques, materials, and instruments, as well as auxiliary technologies such as imaging and endoscopy, the treatment of CSR has rapidly evolved to more convenient surgical treatments with better therapeutic effects [14]. However, traditional surgery has the disadvantages of significant trauma, slow recovery and many complications, limiting its clinical application. In recent years, minimally invasive techniques in spinal surgery have been introduced and are continuously developing [15]. The minimally invasive treatment of CSR has not only achieved good results in clinical practice but also improved the pain cycle of patients, thanks to the advantages of endoscopic techniques, which are associated with less trauma, less bleeding, shorter operation time and faster postoperative recovery.

Chang et al [16]. used an anterior cervical retractor system to treat 34 patients with cervical spondylotic myelopathy and removed some of the lamina and facet joints via a posterior approach. However, Kim et al [17]. found that the posterior approach and full-endoscopic treatment of cervical disc herniation are associated with better clinical results. Compared with those of the former, the VAS and NDI score for the endoscopic treatment of cervical disc herniation were relatively low. Recently, Oertel et al [9]. used endoscopic posterior cervical foraminotomy to treat osseous foraminal stenosis. The results showed that the approach is safe and can achieve satisfactory clinical efficacy. However, they did not report in detail the treatment of cervical foraminal stenosis with the simple endoscopic technique.

To further demonstrate the effectiveness of full-endoscopic cervical foraminotomy in the treatment of CSR caused by hyperostosis of the nerve root canal, we evaluated the results based on two aspects: the elimination of the cause and the improvement of symptoms and physical signs. In addition, we attempted to explore the effectiveness of this minimally invasive technique in treating patients with different lengths of stenosis. The feasibility of the measurement method was verified using the measured data of 30 patients, all of whom successfully underwent the surgery. Symptoms of pain and numbness in the neck and upper extremities were significantly relieved, and the VAS and NDI scores gradually decreased. The clinical outcomes were determined at the last follow-up visit and there were no complications associated with the surgery. The results showed that the measurement method could be effectively applied to percutaneous full-endoscopic cervical foraminotomy. According to the measurements from the new method, the length of the decompression was greater than that of the stenosis, indicating the elimination of the cause. The procedure used for the 30 patients has the following advantages: shorter operative time, less trauma, less bleeding, shorter length of hospital stay, faster recovery, and little impact on cervical spine movement.

In summary, percutaneous full-endoscopic treatment of osseous nerve root canal stenosis not only achieved good clinical results but also retained the stability of the neck segment to the utmost extent [18]. This study measured and compared the length of preoperative nerve root canal stenosis and the effective postoperative decompression length in 30 patients. It is proved that the technique can achieve complete decompression of the stenosis part by percutaneous total endoscopic posterior cervical intervertebral foramen in patients with different lengths of nerve root canal stenosis, so as to achieve better therapeutic effect. However, due to the limited number of cases selected in this study, there were limitations in assessing short-term follow-up during surgery. In order to more accurately assess the clinical efficacy of this minimally invasive technique, we can achieve this in the future by increasing the sample size and extending the follow-up period.

Conclusion

Percutaneous posterior total endoscopic nerve canal incision can successfully complete the decompression of osseous neck canal stenosis, and the minimally invasive method has a good clinical effect. Therefore, it can be used as a treatment option for patients with bony stenosis. Finally, we hope that the application of this technology can be further extended to patients with cervical spondylosis with two to three cervical stenosis.

Abbreviations

CSR: Cervical spondylotic radiculopathy; CT: computed tomography; MRI: Magnetic Resonance Imaging; VAS: Pain visual analogue scale; NDI: cervical dysfunction index; JOA: Japanese orthopedic association scores.

Declarations

Ethical approval l and consent to participate

The study is approved by The Ethical Committee of The Affiliated Hospital of Zunyi Medical College， which belongs to the China Association For Ethical Studies.And the Informed Consent(written)was obtained from all patients in this study.

Consent for publication

Informed Consent(written)was obtained from all participants included in this study

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests

Funding

No funding was obtained for this study

Authors’ contributions

ZZ designed the study and performed statistical analysis. QD, JA and JQ performed the drawings and pictures. drafted the manuscript; WL contributed to revise the manuscript. All authors read and approved the final manuscript.

Acknowledgements

We are grateful to all the staff of the Oncology Department of the Affiliated Hospital of Zunyi Medical University.

References

1. Kim MS, Lee DG, Chang MC. Outcome of transforaminal epidural steroid injection according to severity of cervical foraminal stenosis. World Neurosurg. 2018;110:398-403.
2. De Rooij JD, Gadjradj PS, Huygen FJ, et al. Management of Symptomatic Cervical Disk Herniation. Spine. 2017;42(5):311-317.
3. Terai H, Suzuki A, Toyoda H, et al. Tandem keyhole foraminotomy in the treatment of cervical radiculopathy: retrospective review of 35 cases. J Orthop Surg Res 2014;9:38.
4. Caglar YS, Bozkurt M, Kahilogullari G, et al. Keyhole approach for posterior cervical discectomy: experience on 84 patients. Minim Invasive Neurosurg. 2007;50:7-11.
5. Schroeder GD, Guyre CA, Vaccaro AR. The epidemiology and pathophysiology of lumbar disc herniations. Seminars in Spine Surgery. 2016;28(1):2-7.
6. Minamide A, Yoshida M, Simpson AK, et al. Minimally invasive spinal decompression for degenerative lumbar spondylolisthesis and stenosis maintains stability and may avoid the need for fusion. Bone & Joint Journal. 2018;100-B(4):499.
7. Nakamura JI, Yoshihara K. Initial Clinical Outcomes of Percutaneous Full-Endoscopic Lumbar Discectomy Using an Interlaminar Approach at the L4-L5. Pain Physician. 2017;20(4):507.
8. Ruetten S, Komp M, Merk H, et al. Full-endoscopic cervical posterior foraminotomy for the operation of lateral disc herniations using 5.9-mm endoscopes: a prospective, randomized, controlled study. Spine. 2008;33(9):940-948
9. Oertel JM, Philipps M, Burkhardt BW. Endoscopic posterior cervical foraminotomy as a treatment for osseous foraminal stenosis. World Neurosurg. 2016;91:50-57.
10. Ye ZY, Kong WJ, Xin ZJ, et al. Clinical Observation of Posterior Percutaneous Full-Endoscopic Cervical Foraminotomy as a Treatment for Osseous Foraminal Stenosis. World Neurosurg. 2017;106:945-952.
11. Lo Y L, Cheong P W T, George J M, et al. Pregabalin and Radicular Pain Study (PARPS) for Cervical Spondylosis in a Multiracial Asian Population. Journal of Clinical Medicine Research. 2014;6(1):66-71.
12. Dowdell J, Erwin M, Choma T, et al. Intervertebral Disk Degeneration and Repair. Neurosurgery. 2017;80(3S):S46-S54.
13. Xing L, Qu L, Chen H, et al. Clinical effect of traditional Chinese spinal orthopedic manipulation in treatment of Functional Abdominal Pain Syndrome. Complement Ther Med. 2017;32:19-24.
14. Rodrigues MA, Hanel RA, Prevedello DM, et al. Posterior approach for soft cervical disc herniation: a neglected technique. Surg Neurol. 2001;55(1):17-22.

15. Song Q, Tian W, He D, et al. Long-term clinical efficacy of cervical artificial disc replacement for cervical spondylotic radiculopathy. Zhong guo Xiu Fu Chong Jian Wai Ke Za Zhi. 2018;15:32(6):668-672.
16. Chang JC, Park HK, Choi SK. Posterior cervical inclinatory foraminotomy for spondylotic radiculopathy preliminary. J Korean Neurosurg Soc. 2011;49(5):308-313.
17. Kim CH, Kim KT, Chung CK, et al. Minimally invasive cervical foraminotomy and diskectomy for laterally located soft disk herniation. Eur Spine J. 2015;24(12):3005-3012.
18. Zhang C. Minimally Invasive Full-Endoscopic Posterior Cervical Foraminotomy Assisted by O-Arm-Based Navigation. Pain Physician. 2018;21(3):215.

Figures

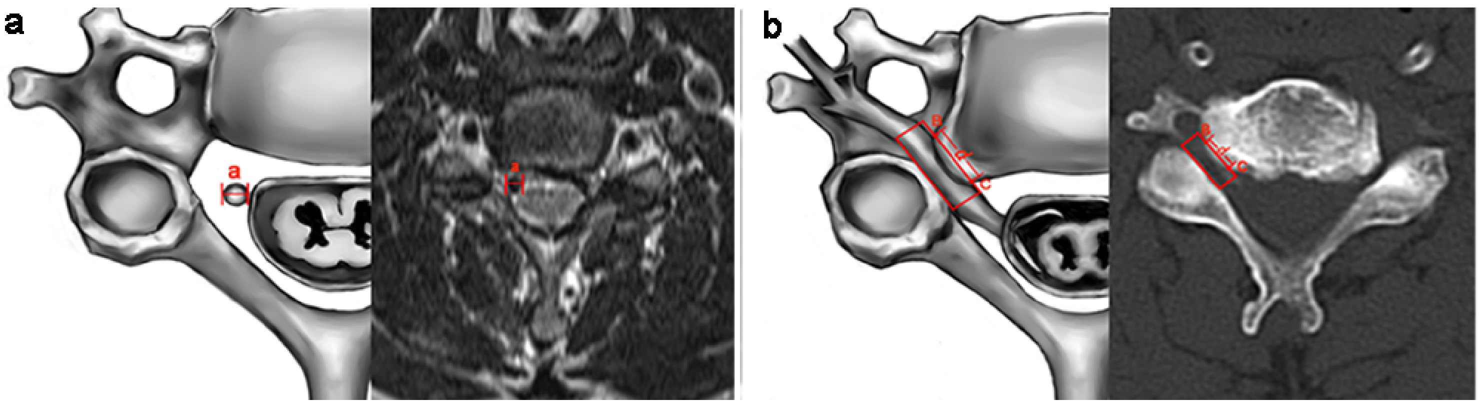

Figure 1

Narrow length measurement schematic. (a) Preoperative MRI measured the diameter of the affected nerve root a and schematic display. (b) Analog measurement method for narrow length d on MRI and schematic.

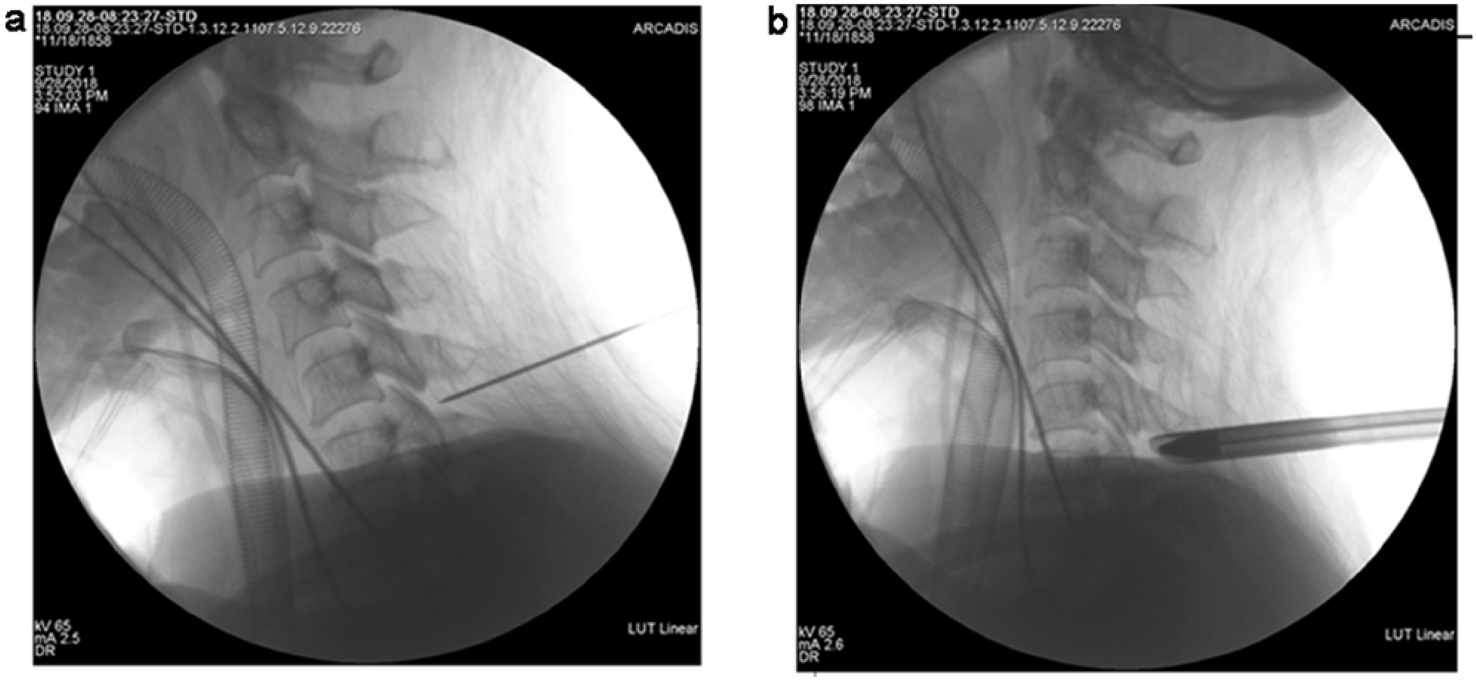

Figure 2

Preoperative lateral radiographs. (a) confirming the medial edge of the facet joint by needle punching of the side radiographic image; (b) Insert the expansion cannula and working channel along the K-wire under the X-ray.

Figure 3

Establishing a safe operating area under the endoscope system. (a) Black circles mark the upper and lower layers and the small joints; (b) The rongeur bites off the remaining contralateral cortical bone. Comparison of preoperative and postoperative decompression. (c-d) The black five-pointed star marks the nerve roots that are compressed before surgery. (e-f) Black five-pointed star marks the nerve roots after surgery.

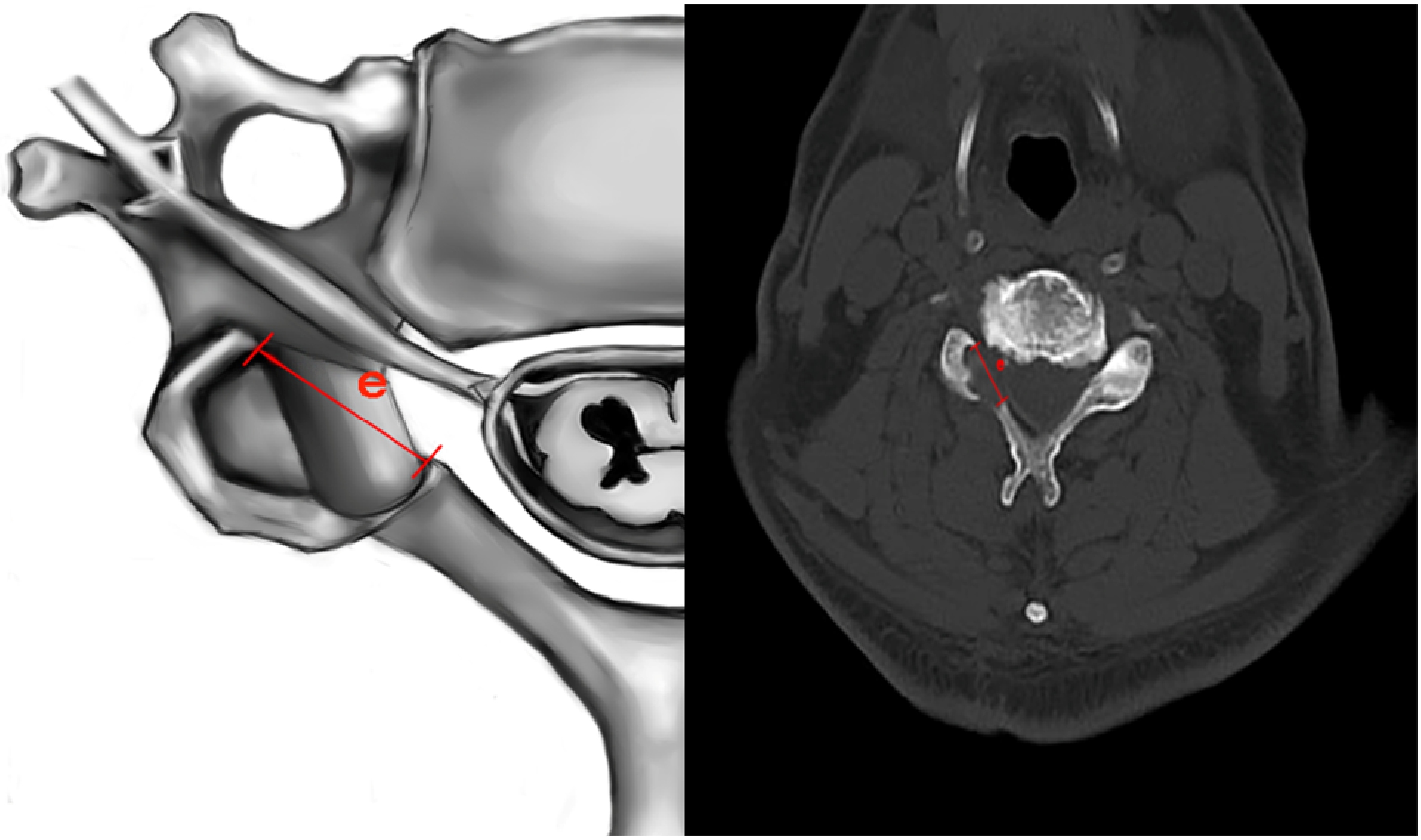

Figure 4

Postoperative decompression length measurement. The length “e” of the decompression zone refers to the distance between the ends of the bone removal zone on the medial edge of the facet joint; schematic representation (left), mark on CT (right).

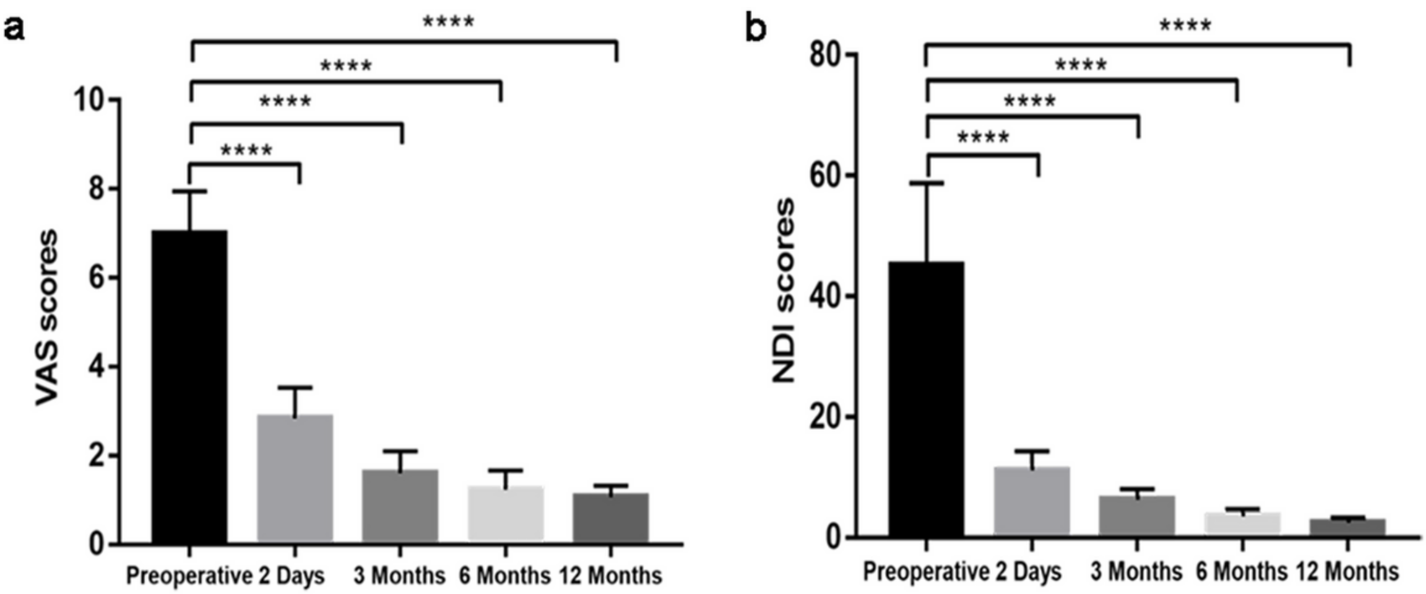

Figure 5

Statistical analysis of VAS and NDI scores after follow-up. A visual analogue scale (VAS); B neck disability index (NDI).