

# Efficiency of minimal oblique resection of the uncinete process during an anterior cervical discectomy and fusion

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## Abstract

Hypertrophy of the uncinete process (UP) can cause radiculopathy. Minimal UP resection is considered to remove the lesion while minimizing the risk of complications. This study aimed to elucidate the surgical results of minimal oblique resection of the UP. This study is a retrospective review of about sixty segments in 34 patients who underwent anterior cervical discectomy and fusion (ACDF) with minimal oblique uncinectomy between 2016 and 2018. The cross-sectional area of the UP was measured pre- and postoperatively. The interspinous distance, segmental Cobb angle, subsidence, fusion rate, surgical time, estimated blood loss, and postoperative complications were evaluated. The mean resected areas of the UP were  $17.4 \pm 8.7 \text{ mm}^2$  (25.9%) on the right and  $17.3 \pm 11.2 \text{ mm}^2$  (26.2%) on the left. The difference in interspinous distance in flexion-extension was  $7.1 \pm 3.2$  and  $1.6 \pm 0.6$  mm pre- and postoperatively, respectively ( $P = .000$ ). The fusion rate after ACDF was 91.7% when measured according to segment (55/60) and 91.2% when measured according to patients (31/34). The difference in the segmental Cobb angle in flexion-extension was  $8.3 \pm 6.2^\circ$  and  $1.9 \pm 0.3^\circ$  pre and postoperatively, respectively ( $P = .000$ ). Subsidence occurred in 4 (11.8%) patients and 5 (8.3%) segments. The average surgical time per segment was  $68.8 \pm 9.3$  minute, and the estimated blood loss was  $48.5 \pm 25.0$  mL. Postoperative complications comprised 1 case each of neck swelling, wound infection, pneumonia, and gastrointestinal bleeding. Our findings therefore revealed that minimal oblique uncinectomy during an ACDF can maintain the stability of the uncovertebral joint while sufficiently decompressing the neural foramen.

**Abbreviations:** ACDF = anterior cervical discectomy and fusion, CT = computed tomography, HNP = herniated nucleus pulposus, ISD = interspinous distance, OPLL = ossification of the posterior longitudinal ligament, UP = uncinete process, VAS = visual analog scale.

**Keywords:** anterior cervical discectomy and fusion, cross-sectional area, interspinous distance, uncinete process, uncinectomy

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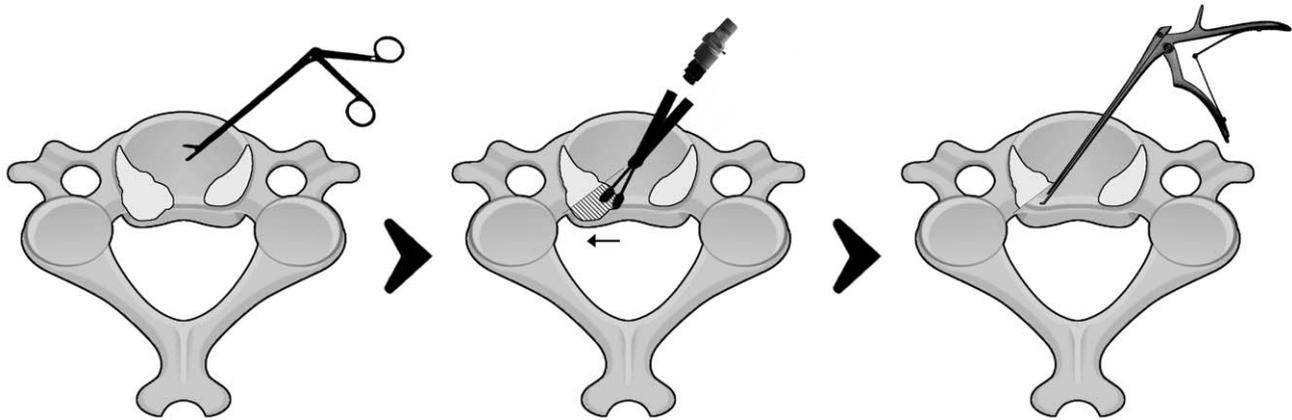
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## 1. Introduction

Anterior cervical discectomy and fusion (ACDF) is a widely accepted corrective procedure for a variety of cervical spinal diseases.<sup>[1]</sup> The uncinete process (UP) is a bony structure that extends from the posterolateral margin of an upper endplate of a cervical vertebral body.<sup>[2]</sup> UP hypertrophy can cause radiculopathy by compressing or irritating the exiting root at the neural foramen.<sup>[3]</sup> In these cases, conventional uncinectomy is widely performed to decompress the nerves of the intervertebral disc and remove osteophytes during an ACDF.<sup>[4]</sup> The uncovertebral joints limit the lateral flexion and posterior translation of the cervical spine. Thus, excessive uncinectomy can cause cervical spine instability.<sup>[5]</sup> The subsidence is reported to significantly increase if the total UP resection area is  $>38\%$ .<sup>[6]</sup> The UP is close to the radicular artery, vertebral artery, and spinal nerve roots. Vascular structure or nerve root injury rarely occurs but may occur during uncinectomy.<sup>[7]</sup> Therefore, excessive resection of the UP should be carefully performed. However, the fear of complications can lead to insufficient nerve decompression.<sup>[8]</sup> Therefore, a technique that can effectively decompress the relevant exiting nerve root by safely minimally removing the symptomatizing posterior part of the uncinete process while reducing the violation of the stabilizing function of the uncovertebral joint to its minimum should be identified. Minimal



**Figure 1.** Schematic illustration of minimal oblique uncinectomy. Left) Discectomy with pituitary forceps. Center) The microscope was tilted to secure an oblique trajectory. The posteromedial part of the uncinete process (UP) was removed using a high-speed drill. Right) Undercutting the UP with Kerrison punch to expose the foraminal epidural fat and exiting root.

resection of the UP has been considered to remove the lesion while minimizing the risk of complications. Therefore, this study aimed to elucidate the surgical results during a minimal oblique resection of the UP.

## 2. Materials and methods

### 2.1. Patients' demographic data

This study protocol was approved by the Institutional Review Board at Kangdong Sacred Heart Hospital (institutional review board number: 2020-04-004). All patients provided written informed consent about the surgical procedure.

This study is a retrospective review of the clinical and radiological results of 52 patients who underwent ACDF with minimal UP resection between 2016 and 2018 at a single institution. Patients who underwent 1- to 3-level ACDF (expressed according to cervical spine level counts) were included. The surgery was indicated for radiculopathy with herniated nucleus pulposus (HNP) or osseous foraminal stenosis, ossification of the posterior longitudinal ligament (OPLL) that extends to a foraminal area at the cervical spine, and trauma cases with degenerative UP hypertrophy causing radiculopathy.

Patients with spinal neoplasm, infection, central HNP without UP hypertrophy, trauma with fracture (UP, vertebral body, lamina, and pedicle), and trauma without foraminal symptom and those who underwent anterior and posterior combined surgery were excluded. Eighteen patients were excluded according to the above criteria. Thus, 34 patients were finally included and investigated. The total segments (a segment is the upper and lower vertebral body including the intervertebral disc) were sixty.

### 2.2. Surgical procedure

All patients underwent ACDF with cage (CORNERSTONE ASR; Medtronic, Memphis, TN, USA) and rigid anterior plate fixation (ATLANTIS VISION ELITE; Medtronic, Memphis, TN, USA) in the supine position under general anesthesia. The surgical procedure for ACDF was performed using the Smith-Robinson approach.<sup>[9,10]</sup> The longus colli muscle was laterally dissected until the UP was exposed. After the discectomy, the

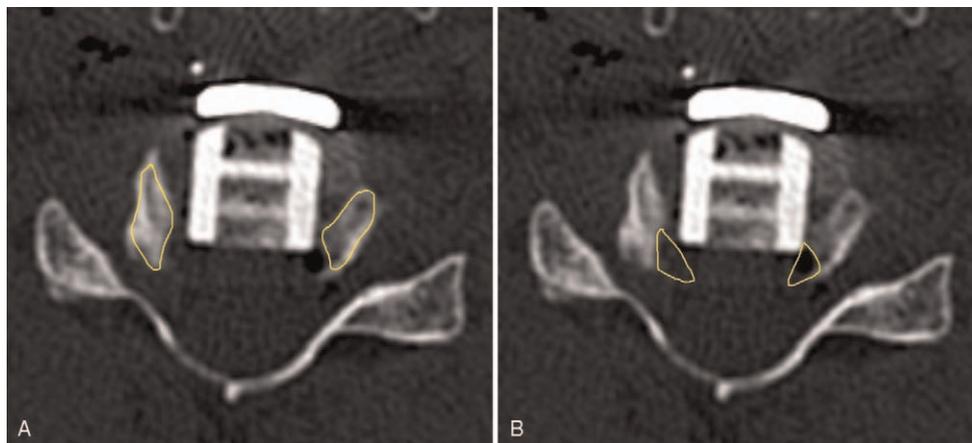
microscope was adjusted obliquely to face the opposite neural foramen. If this was not enough, we tilt the bed contralaterally or ipsilaterally. The posteromedial part of the hypertrophied UP was partially resected while the rest of the UP was saved (Fig. 1), and then the posterior longitudinal ligament was removed to expose the dura. Decompression of the exiting nerve root was performed by undercutting the UP using the Kerrison punch until the epidural fat of the neural foramen and the shoulder and an axillar portion of the exiting nerve root were visually confirmed. In addition, decompression of the invisible distal root was confirmed by blunt dissection using the micro-hook into the neural foramen along the exiting nerve root. After the decompression, the cage was inserted into the disc space with anterior plate fixation. In all patients, plates and screws were placed using a short plate according to an oblique screw trajectory.<sup>[11]</sup>

### 2.3. Radiologic evaluation

All patients underwent plain radiography, three-dimensional computed tomography (CT), and magnetic resonance imaging of the cervical spine preoperatively. Further, plain radiography and CT scan were performed immediately after the surgery. The cross-sectional area of the UP (mm<sup>2</sup>) was measured pre- and postoperatively on axial images obtained through the CT scan. The measurement was performed at the upper endplate of the lower vertebral body at the surgical level. The amount of area removed postoperatively was measured (Fig. 2). Plain radiographs, including dynamic (flexion/extension) studies, were reviewed to confirm segmental stability and fusion postoperatively. Using the dynamic plain radiographs, the difference in the interspinous distance (ISD) of  $\leq 2$  mm or the difference in the segmental angle of  $\leq 2^\circ$  was defined as fusion (Fig. 3).<sup>[12]</sup> The segmental Cobb angle was defined as the angle between the upper endplate of the upper vertebral body and the lower endplate of the lower vertebral body. Subsidence was defined as decreased intervertebral disc height by  $> 3$  mm.

### 2.4. Clinical evaluation

The clinical outcome was evaluated using the arm/neck visual analog scale (VAS) (pain evaluation), and the motor grade



**Figure 2.** The cross-sectional area on the axial image obtained through computed tomography. A) Residual uncinata process after a minimal oblique uncinctomy. B) Resected area of the UP (yellow draw area).

(British Medical Research Council grade) was measured at follow-up, and pre- and postoperative data were compared. Surgical time, estimated blood loss, and postoperative complications were also evaluated.

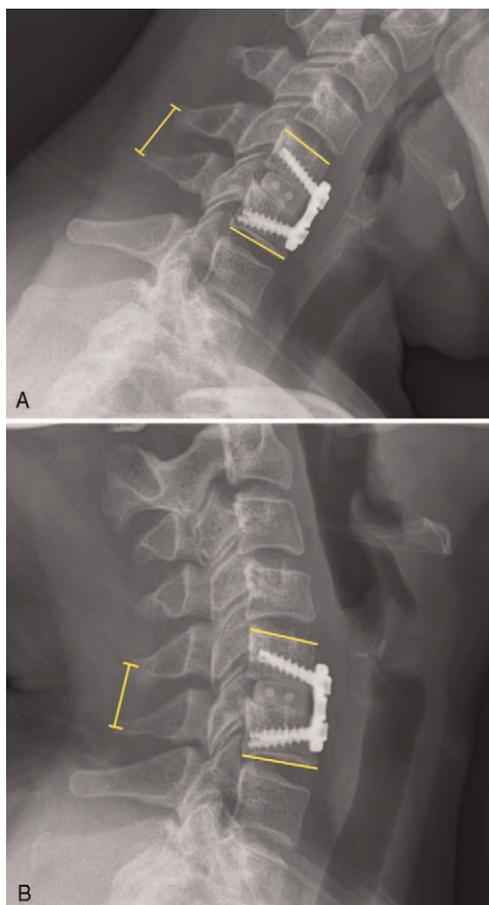
**2.5. Statistical analysis**

Data were collected and analyzed using SPSS (version 20.0; SPSS Inc., Chicago, Illinois). Student *t*-test was used for continuous variables. Mann–Whitney *U* test for nonparametric continuous variables was used to compare radiological and clinical outcomes. Pearson correlation analysis was performed to confirm the correlation of factors. A probability value of <0.05 was considered statistically significant.

**3. Results**

The patient population comprised 7 women and 27 men with a mean age of  $59.7 \pm 7.2$  (range, 37–79) years. The mean follow-up duration was  $25.1 \pm 6.9$  (range, 12–37) months. The diagnoses were stenosis (8 patients), HNP (7 patients), spinal cord injury (15 patients), and OPLL (4 patients). The total segments of ACDF were 60 (C3–4:5, C4–5:18, C5–6:23, and C6–7:14). Among 34 patients, 1-level ACDF was performed in 11 patients, 2-level ACDF in 19, and 3-level ACDF in 4. The mean height of the inserted cage was  $6.3 \pm 0.5$  (range, 5–7) mm. The mean body mass index was  $24.9 \pm 4.2$  kg/m<sup>2</sup>, and the age-adjusted Charlson comorbidity index was  $2.5 \pm 1.5$ . These parameters were not statistically significant (Table 1).

The area of the right UP was  $71.2 \pm 17.0$  mm<sup>2</sup> and  $54.6 \pm 17.2$  mm<sup>2</sup> pre- and postoperatively, respectively ( $P=0.000$ ). The area of the left UP was  $67.4 \pm 19.2$  mm<sup>2</sup> and  $49.5 \pm 18.7$  mm<sup>2</sup> pre- and postoperatively, respectively ( $P=.000$ ). The mean resected area of the UP was  $17.4 \pm 8.7$  mm<sup>2</sup> (25.9%) and  $17.3 \pm 11.2$  mm<sup>2</sup> on the right and left, respectively (26.2%). The pre- and postoperative ISD in flexion significantly decreased ( $24.6 \pm 6.2$  mm and  $19.0 \pm 5.4$  mm, respectively) ( $P=.000$ ). However, in extension, pre- and postoperative ISD showed no significant difference ( $P=0.944$ ). The difference in ISD in flexion-extension was  $7.1 \pm 3.2$  mm and  $1.6 \pm 0.6$  mm pre- and postoperatively, respectively ( $P=.000$ ). The fusion rate after an ACDF was 91.7% when measured according to segment (55/60) and 91.2% when measured according to patients (31/34). The pre- and postoperative segmental Cobb angle in flexion was  $-6.5 \pm 6.8^\circ$  and  $0.9 \pm 2.1^\circ$ , respectively ( $P=.000$ ), showing no significant different in extension ( $P=.151$ ). The difference in the segmental Cobb angle



**Figure 3.** The segmental Cobb angle and interspinous distance measurement. A) Flexion plain radiograph. B) Extension plain radiograph.

**Table 1**  
Demographic data of patients.

Type		P-value
Sex (F/M)	7/27	.843
Age (yr)	59.7±7.2 (range 37–79)	.789
Follow-up duration (months)	25.1±6.9 (range 12–37)	.707
Diagnosis		.305
Cervical stenosis	8	
Cervical HNP	7	
Cervical cord injury	15	
OPLL	4	
BMI (kg/m <sup>2</sup> )	24.9±4.2	.999
Age-adjusted CCI	2.5±1.5	.599
Levels		.664
C3–4	5	
C4–5	18	
C5–6	23	
C6–7	14	
Total	60	
Cage height(mm)	6.3±0.5 (range 5–7)	.059

BMI=Body mass index, BMI=body mass index, CCI=Charlson comorbidity index, HNP=herniation nucleus pulposus, OPLL=ossification of the posterior longitudinal ligament.

\*P-value < .05.

in flexion-extension was  $8.3\pm 6.2^\circ$  and  $1.9\pm 0.3^\circ$  pre- and postoperatively, respectively ( $P=.000$ ) (Table 2). The average decrease of the intervertebral disc height was  $1.4\pm 1.8$  mm. Subsidence occurred in 4 (11.8%) patients and 5 (8.3%) segments.

The pre- and postoperative mean arm VAS score was  $6.1\pm 2.4$  and  $1.9\pm 1.1$ , respectively ( $P=.001$ ). The neck VAS score was  $5.5\pm 1.1$  and  $2.1\pm 1.0$ , respectively ( $P=.001$ ). Motor grade also improved from  $3.5\pm 1.2$  to  $4.4\pm 0.9$  ( $P=.034$ ). The average surgical time per segment (from the skin incision to skin closure) was  $68.8\pm 9.3$  minute, and the estimated blood loss was  $48.5\pm 25.0$  mL. Postoperative complications were as follows: 1 case each of neck swelling, wound infection, pneumonia, and gastrointestinal bleeding (Table 3).

The correlation between the left/right resected UP areas and the difference in the segmental Cobb angle in flexion-extension, subsidence, and pre- and postoperative arm VAS difference were evaluated. No parameter showed a significant correlation (Table 4).

**Table 2**  
Radiologic outcomes.

	Preoperation	Postoperation	P-value
UP area (right) (mm <sup>2</sup> )	71.2±17.0	54.6±17.2	.000*
UP area (left) (mm <sup>2</sup> )	67.4±19.2	49.5±18.7	.000*
Resected UP area (right) (mm <sup>2</sup> )		17.4±8.7	
Resected UP area (left) (mm <sup>2</sup> )		17.3±11.2	
ISD in flexion (mm)	24.6±6.2	19.0±5.4	.000*
ISD in extension (mm)	17.4±5.8	17.4±5.3	.944
ISD difference (mm)	7.1±3.2	1.6±0.6	.000*
Cobb angle in flexion (°)	-6.5±6.8	0.9±2.1	.000*
Cobb angle in neutral (°)	0.5±5.4	1.6±1.9	.018*
Cobb angle in extension (°)	2.4±5.8	2.8±0.9	.151

ISD=interspinous distance, UP=uncinate process.

\*P-value < .05.

**Table 3**  
Clinical outcomes.

Clinical outcomes	Pre-operation	Post-operation	P-value
VAS arm	6.1±2.4	1.9±1.1	.001*
VAS Neck	5.5±1.1	2.1±1.0	.031*
Motor grade	3.5±1.2	4.4±0.9	.034*
Surgical time(min)/segment		68.8±9.3	
EBL (ml)/segment		48.5±25.0	
Post-complication			
Neck swelling		1	
Dysphagia		0	
Esophageal injury		0	
Hoarseness		0	
Neural/vascular injury		0	
Wound infection		1	
Pneumonia		1	
Gastrointestinal bleeding		1	

EBL=estimated blood loss, VAS=visual analog scale.

\*P-value < .05.

#### 4. Discussion

The UP is located close to the spinal nerve root. The development of osteophytes in the UP due to some degenerative diseases may increase the pressure on the adjacent neurovascular structures.<sup>[13]</sup> Therefore, it should be removed to decompress the neurovascular structures in order to improve the conditions that may develop. We should pay attention to the potential risk of damage of a nerve root or vertebral artery during UP resection.<sup>[14]</sup> The UP affects the movement of the cervical spine, such as flexion, extension, lateral flexion, and rotation.<sup>[15]</sup> Kotani et al. reported that even with fusion, increasing the resection area of the UP reduced the functional vertebral unit stability.<sup>[5]</sup> Lee et al described that the possibility of subsidence significantly increases with the total resected UP area.<sup>[6]</sup> Subsidence is a complication of ACDF, which can lead to neural foramen narrowing, nerve root compression, and pseudarthrosis.<sup>[16]</sup> By bearing the load of the vertebra above, the UP stabilizes on the vertebra.<sup>[5,17]</sup> Considering these various problems, we performed a minimal but sufficient resection of the UP. No instability occurred after minimally removing the UP in our technique. In the flexion-extension plain radiograph, the mean segmental Cobb angle difference was  $< 2^\circ$  and the mean ISD difference was  $\leq 2$  mm during the postoperative follow-up. This is due to the high fusion rate of 91%. The UP resection resulted in an increased range of motion in flexion-extension, that is, approximately twice as that in the lateral bending/axial rotation.<sup>[18]</sup> The mean degree of subsidence was  $1.4\pm 1.8$  mm during follow-up. The subsidence rate is reportedly 9.6% to 30% with anterior plate fixation.<sup>[19–21]</sup> The subsidence significantly increases when the total amount of the UP resection area is

**Table 4**  
Pearson correlation analysis.

Parameters	Resected UP area (left)	P-value	Resected UP area (right)	P-value
ΔCobb angle	-0.143	.347	0.066	.669
Subsidence	-0.106	.459	-0.142	.321
ΔVAS	-0.141	.324	-0.165	.247

ΔCobb angle=difference in the segmental Cobb angle in flexion-extension, ΔVAS=pre- and postoperative arm VAS difference, UP=uncinate process, VAS=visual analog scale.

>38%.<sup>[6]</sup> In this study, a subsidence rate of 11.8% was observed, which was not high compared to that in previous results. This is the result of maintaining the stability of the uncovertebral joint due to partial resection of the UP, with a mean value of  $25.8\% \pm 10.1\%$ . The most posterior one-third of the UP has been reported to be the main part of the limitation mechanism.<sup>[5]</sup> Minimal uncinectomy was performed by undercutting the posterior part of the UP, thus preserving the anterior and apex parts of the UP that are in contact with the joint.<sup>[18,22,23]</sup> Our results suggest that the relationships between the amount of UP resection and the difference in the segmental Cobb angle in flexion-extension and the subsidence are not statistically significant. It is thought that the removal amount was small and did not affect the results. Several authors reported that micro-motion causes subsidence.<sup>[24,25]</sup> We restricted micro-motion by using cages and anterior plate fixation.<sup>[6,18,26]</sup> We also believe that the short plate and oblique screw fixation technique could help maintain the stability and reduce the subsidence.<sup>[11]</sup> The stability was also maintained due to the remaining anterior and apex parts of the UP that are in contact with the joint.<sup>[18,22,23]</sup> Symptoms were improved by removing the posterior part of the UP that was in contact with the nerve. Some authors believe that symptoms can also be relieved through an indirect decompression by disc space distraction and resorption of the osteophyte after fusion.<sup>[27–29]</sup> In addition, considering the risk of neurovascular complications that may occur during uncinectomy, whether uncinectomy is still necessary remains controversial. However, a residual osteophyte at the neural foramen may contribute to symptom recurrence if the foramen was narrowed by subsidence.<sup>[16]</sup> Furthermore, symptoms might persist after an ACDF without uncinectomy that is expectedly associated with indirect decompression. Revision surgery is a disinclined option in both patients and surgeons. In our patients, no neurovascular complications occurred, which is thought to be due to the minimal uncinectomy via an oblique trajectory.

Performing minimal uncinectomy does not require a longer operation time. The mean total surgical time per segment, including exposure, discectomy, PLL removal, foraminal decompression by minimal uncinectomy, cage insertion, and plate fixation, was about 69 minute.

Abundant epidural plexus or venous engorgement due to neural foraminal stenosis may cause profuse bleeding. Hemostasis with thrombin-soaked gelfoam packing was more effective for coagulation than epidural vein cauterization with bipolar cautery.

In our study, a small sample size with a retrospective research design is one of the several limitations. There is no comparative analysis with conventional surgical methods. It would also be helpful to conduct a study using stand-alone surgical cases, excluding the effects of the anterior plate. This study did not describe other factors that could affect the subsidence. Although we have excluded cases that may affect outcomes, there may be bias in trauma and OPLL cases. There may be a bias in reflecting the total removed volume by using the axial image of CT scan in this study. However, it is meaningful that satisfactory results were obtained by minimal oblique resection of the UP. Based on the above results, it was possible to operate safely and rapidly. Besides, using the obliquely undercutting approach, a useful decompression effect can be expected even if the UP was less resected. Subsidence and fusion rates were also not inferior to those observed in the conventional method.

## 5. Conclusion

Minimal oblique uncinectomy during an ACDF showed good clinical and radiological outcomes. This approach can be one of the methods that maintain the stability of the uncovertebral joint while sufficiently decompressing the neural foramen.

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## Author contributions

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**Funding acquisition:** Byoung Hun Lee.

**Investigation:** Byoung Hun Lee, Jong Hwa Park.

**Methodology:** Byoung Hun Lee, Jong Hwa Park.

**Project administration:** Byoung Hun Lee.

**Resources:** Jong Hwa Park, Jong Young Lee.

**Software:** Byoung Hun Lee.

**Supervision:** Jong Hwa Park, Jong Young Lee, Hong Jun Jeon, Seung-Woo Park.

**Validation:** Jong Hwa Park.

**Visualization:** Byoung Hun Lee, Jong Hwa Park.

**Writing – original draft:** Byoung Hun Lee.

**Writing – review & editing:** Jong Hwa Park.

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