Research Square

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# Hyoid Bone Partial Resection to Reduce Superior Laryngeal Nerve Injury in Upper Cervical Anterior Cervical Discectomy and Fusion: technical note

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# Abstract

**Purpose:** To describe a partial hyoid resection (PHR)-assisted anterior approach for upper cervical Anterior Cervical Discectomy and Fusion (ACDF) and evaluate its feasibility and early outcomes compared to the conventional approach without hyoid resection.

**Methods:** This retrospective case series included eight patients who underwent single-level ACDF at C3–4 using an anterior retropharyngeal approach by a single surgeon. Four patients received a partial hyoid resection (PHR group) to enhance cephalad exposure, while four underwent the standard approach without resection (non-PHR group). Outcome measures included operative time, radiologic outcomes (prevertebral soft tissue swelling, cage position and rotation, plate position and rotation), and perioperative complications.

**Results:**The PHR group had a longer mean operative time compared to the non-PHR group (126.3 vs. 98.7 minutes). Radiologic analysis showed slightly increased prevertebral soft tissue swelling in the PHR group (35.5 mm vs. 24.0 mm). However, implant positioning was more accurate in the PHR group, evidenced by reduced cage offset (0.83 mm vs. 1.30 mm), cage rotation (5.6° vs. 11.2°), and plate rotation (4.5° vs. 7.8°). Clinically, the PHR group experienced only one minor complication (distal screw loosening), whereas the non-PHR group had more significant complications including one pharyngeal tear and one superior laryngeal nerve injury.

**Conclusion:**Partial hyoid resection appears feasible and safe for enhancing exposure in high cervical ACDF. In this series, it was associated with more favorable implant alignment and fewer traction-related events, suggesting potential advantages in select cases.


# 1. Introduction

Anterior cervical discectomy and fusion (ACDF) at the C2–3, C3-4 level remains technically demanding because the hyoid bone and attached infrahyoid musculature restrict cephalad visualization, while the superior laryngeal nerve (SLN) and recurrent laryngeal nerve (RLN) are vulnerable to traction injury [1, 2]. Reported RLN palsy rates after anterior cervical surgery range from 2.3–24.2%. Although under-recognized, SLN injury may impair high-pitched phonation and airway protection, especially in high cervical approaches [3–6].

Most surgeons are familiar with the anterior retropharyngeal approach due to its reproducibility and relatively safe dissection plane. Current strategies to enlarge the upper-cervical operative corridor rely on cranial skin extension, aggressive soft-tissue retraction, or detachment of the infrahyoid musculature [7]. These maneuvers often prolong operative time, increase postoperative dysphagia, and still provide only modest cephalad visualization [8]. To address these challenges, various modifications to the standard approach have been proposed. One such technique involves the temporary detachment of the infrahyoid muscles from the hyoid bone to improve laryngeal mobility and access to C2. Their study reported successful internal branch of SLN (iSLN) preservation in all 12 cases and a relatively low rate of transient

dysphagia (16.7%) [9, 10]. However, this procedure can be considered overly aggressive and may not be familiar to spine surgeons.

In contrast, the transoral approach, although it provides direct midline access to the upper cervical spine, is less commonly performed because of its higher risk for postoperative infection, soft palate or pharyngeal wall injury, and the need for specialized instrumentation and postoperative airway management [11].

We therefore developed a partial hyoid resection (PHR)-assisted anterior retropharyngeal approach (PHR-ARPA) technique that removes about 15 mm segment of the hyoid body, thereby expanding the cephalad window without excessive soft-tissue traction. This technical note aims to describe a step-by-step PHR-assisted upper-cervical ACDF, and to compare operative exposure, time, and early complication profiles with the conventional (non PHR) approach.

## 2. Materials and methods

This retrospective study was approved by the institutional review board (IRB), which waived the requirement for individual patient consent. We reviewed all patients who underwent single-level ACDF at the C2–3 and C3–4 levels, performed by a single spine surgeon at a single institution between March 1, 2022, and May 31, 2025. All cases involving PHR were performed only when collaboration with an otorhinolaryngologist specializing in head & neck surgery was available. In cases where coordinated surgical collaboration was not feasible, the conventional approach without hyoid resection (non-PHR) was selected.

## 2.1 Patient population

Initially, we reviewed all patients who underwent single-level ACDF at the C2–3 and C3–4 levels, performed by a single spine surgeon at a single institution between March 1, 2022, and May 31, 2025. The final cohort comprised eight consecutive patients who underwent single-level ACDF at the C3–4 level. Patients were assigned to the PHR group if collaboration with an otorhinolaryngologist specializing in head and neck surgery was available; otherwise, they were assigned to the non-PHR group. Ultimately, four patients were included in each group for comparative analysis. One patient who underwent ACDF at C2–3 was excluded from the study due to severe osteopetrosis, deemed unsuitable for accurate evaluation of the new technique (Table 1).

**Tables 1. Patient demographics and Partial Hyoid Resection status**

| No. | Sex | Age | Diagnosis | Operation | PHR |
|---|---|---|---|---|---|
| 1 | F | 85 | Herniated cervical disc | ACDF C3-4 | Yes |
| 2 | M | 54 | Herniated cervical disc with myelopathy | ACDF C3-4 | Yes |
| 3 | F | 70 | Adjacent Segment Disease | ACDF C3-4 | Yes |
| 4 | M | 72 | Adjacent Segment Disease | ACDF C3-4 | Yes |
| 5 | M | 39 | Herniated cervical disc with myelopathy | ACDF C3-4 | No |
| 6 | M | 71 | Herniated cervical disc | ACDF C3-4 | No |
| 7 | M | 67 | Herniated cervical disc with myelopathy | ACDF C3-4 | No |
| 8 | M | 74 | Retrolisthesis with myelopathy | ACDF C3-4 | No |

## 2.2 Outcome Measures and Radiologic Analysis

Surgical outcomes were evaluated, including operative time, radiographic prevertebral soft-tissue swelling, cage and plate placement accuracy, and postoperative complications such as nerve or visceral injuries

### 2.2.1 Radiographic Soft tissue Swelling

Soft tissue swelling was quantified by summing the prevertebral soft tissue thickness measurements from vertebral levels C2 through C6 on lateral cervical radiographs. Preoperative values were compared with those on postoperative day 2 (POD 2), known for peak swelling on previous literature (Fig. 1) [12, 13].

### 2.2.2 Cage Position and Rotation

On axial Computed Tomography (CT) images, cage rotation was defined by the angle between the vertebral anterior-posterior (AP) axis and the cage's AP axis. Cage position was assessed by measuring the lateral offset from the center of the vertebral AP axis to the center of the cage. The CT scans were obtained at postoperative 2 weeks during an outpatient follow-up visit to evaluate implant positioning and overall surgical outcome (Fig. 2).

### 2.2.3 Plate Position and Coronal Rotation

On AP radiographs, the plate’s coronal rotation was defined by the angle between the central axis of the cervical spine and the axis of the implanted cervical plate. Plate position deviation was assessed by measuring the lateral offset from the cervical midline to the center of the plate (Fig. 3).

## 3. Surgical Technique

## 3.1 Patient Positioning

Place the patient supine on the operating table. Insert a shoulder roll beneath the shoulders to gently extend the neck and elevate the chin. Maintain the head in slight extension with minimal rotation to prevent misalignment of cervical anatomy.

## 3.2 Skin Incision and Dissection

Mark a transverse skin incision approximately 5–6 cm in length, two fingerbreadths below the mandibular angle, correlating with the hyoid bone (C3 level). An incision is made slightly off midline, either left or right, according to the surgeon's preference. Incise and elevate platysma horizontally and identify the submandibular gland (SMG). Gently mobilize and retract SMG superiorly out of the operative field. The facial vein inferior to the SMG should be identified and carefully managed. After elevating the submandibular gland superiorly, the posterior belly of the digastric muscle serves as an important anatomical landmark superiorly during this exposure. Medially, identify the strap muscles. The hypoglossal nerve (CN XII) typically runs superior to the operative level; it is often identified in the field but not directly exposed through dissection. The iSLN beneath digastric muscle is identified and preserved (Fig. 4).

## 3.3 Partial Hyoid Bone Resection

Palpate and clearly identify the greater cornu of the hyoid bone just deep inferior to the posterior belly of the digastric muscle, which serves as a reliable anatomical landmark. Securely grasp the exposed lateral hyoid using an Allis clamp. Perform careful periosteal dissection around the targeted segment with a Bovie electrocautery to release the surrounding soft tissue attachments. Resect approximately 1.5 cm of the lateral hyoid bone using heavy scissors, ensuring preservation of the underlying oropharyngeal mucosa (Fig. 5).

## 3.4 Exposure and Retraction

After the partial hyoid resection, gently retract the hyoid-laryngeal complex medially, significantly increasing the pliability and ease of exposure. Identify and retract the carotid sheath laterally, clearly defining the operative corridor. Define the anatomical window bounded superiorly by the hypoglossal nerve and lingual artery, and inferiorly by the internal branch of the superior laryngeal nerve (iSLN).

## 3.5 Dissection Toward the Prevertebral Fascia and Final Exposure

Meticulously dissect along the lateral edge of the thyrohyoid membrane, maintaining proximity to the pharynx and larynx. If encountered, cautiously ligate, or cauterize the superior thyroid artery and vein, carefully preserving the external branch of the SLN (Fig. 6-a). Clearly identify the bilateral longus colli muscles and elevate these muscles subperiosteally. Confirm clear visualization of the operative disc

space and adjacent vertebral bodies. At this stage, the operative field is fully prepared for subsequent cervical decompression and fusion procedures (Fig. 6-b, Fig. 7).

# 4. Result

A retrospective comparative analysis was performed on eight patients who underwent ACDF at the C3–4 level; four patients had PHR, and four received the conventional procedure without PHR. Surgical outcomes were then compared between these two techniques (Table 2).

Table 2
Partial Hyoid Resection status and Surgical result

| No. | PHR | Surgery Time (min) | ΔSoft Tissue Swelling (mm) | Cage Rotation (°) | Cage Position (mm) | Plate Coronal Rotation (°) | Plate Position (mm) | Major Complications |
|---|---|---|---|---|---|---|---|---|
| 1 | Yes | 122 | + 26 | + 0.9 | + 0.8 | -1.0 | + 4.0 | - |
| 2 | Yes | 111 | + 31 | -9.7 | + 0.6 | + 6.7 | -0.7 | - |
| 3 | Yes | 116 | + 44 | + 7.6 | + 0.5 | + 5.8 | + 2.0 | Distal screw loosening |
| 4 | Yes | 156 | + 41 | -4.3 | + 1.4 | *- | *- | - |
| 5 | No | 101 | + 24 | -5.1 | + 2.1 | + 10.6 | -2.0 | - |
| 6 | No | 90 | + 23 | -10.4 | -0.9 | + 1.6 | -2.2 | - |
| 7 | No | 187 | + 29 | -3.9 | + 1.5 | + 10.6 | -1.5 | Intraoperative pharyngeal tear |
| 8 | No | 105 | + 20 | -15.4 | -0.7 | -2.1 | + 3.3 | Impair high-pitched phonation, Dysphagia |
| *Cage & Plate rotation: (+) rotation toward contralateral side or clockwise, (-) rotation toward ipsilateral side or counterclockwise* | | | | | | | | |
| *Cage & Plate position: (+) deviation toward contralateral side, (-) deviation toward ipsilateral side* | | | | | | | | |
| ** Stand-alone cage is used* | | | | | | | | |

Operative time was notably longer in the PHR group (mean, 126.3 min) compared with the non-PHR group (mean, 98.7 min), excluding an outlier case complicated by an intraoperative pharyngeal tear. Radiographic evaluation on postoperative day 2 demonstrated greater prevertebral soft tissue swelling in the PHR group (mean increase, 35.5 mm) than in the non-PHR group (mean increase, 24.0 mm). However, this difference was not associated with clinically significant complications such as airway obstruction in either group (Table 3).

Implant positioning analysis demonstrated improved alignment accuracy in the PHR group across multiple parameters. The mean cage offset was slightly greater in the PHR group (+ 0.83 mm) compared to the non-PHR group (+ 0.25 mm); however, the mean absolute cage offset was smaller in the PHR group (0.83 vs. 1.30 mm), indicating more centered cage placement. Similarly, cage rotation was less pronounced in the PHR group, with a mean absolute rotation angle of 5.6°, compared to 11.2° in the non-PHR group. For the plate, the mean offset was toward the contralateral side in the PHR group (+ 1.5 mm), whereas the non-PHR group showed a slight ipsilateral deviation (–0.6 mm); however, the mean absolute plate offset was nearly equivalent between groups (2.2 mm vs. 2.3 mm). Importantly, the mean absolute plate rotation was lower in the PHR group (4.5°) compared to the non-PHR group (7.8°), further supporting the observation that partial hyoid resection facilitated more accurate and stable implant alignment (Table 3).

Complication analysis revealed one instance of distal screw loosening in the PHR group. Conversely, the non-PHR group experienced one intraoperative pharyngeal tear and one SLN injury presenting as impaired high-pitched phonation and dysphagia (Table 3).

Table 3
Summary of Mean Clinical Outcomes in PHR and non-PHR Groups

| Parameter | PHR group (n = 4) | Non-PHR group (n = 4) |
|---|---|---|
| Operative Time (min) | 126.3 | *98.7 |
| ΔSoft Tissue Swelling (mm) | 35.5 | 24.0 |
| Absolute Cage Offset (mm) | 0.83 | 1.30 |
| Cage Offset (mm) | + 0.83 | + 0.25 |
| Absolute Cage Rotation (°) | 5.6 | 11.2 |
| Absolute Plate Offset (mm) | 2.2 | 2.3 |
| Plate Offset (mm) | + 1.5 | –0.6 |
| Absolute Plate Rotation (°) | 4.5 | 7.8 |

# 5. Discussion

This study demonstrates that PHR-ARPA is a feasible and safe adjunct to the anterior retropharyngeal approach in upper cervical ACDF, particularly at the C3–4 level. By removing a lateral segment of the hyoid bone, the technique provided an expanded cephalad operative corridor without excessive soft tissue retraction. This allowed for improved visualization, more precise implant placement, and potentially reduced traction-related complications.

Radiographically, the PHR group demonstrated significantly improved cage alignment, showing smaller cage offset (0.83 mm vs. 1.30 mm) and rotation (5.6° vs. 11.2°). Plate alignment also showed lower

mean rotational deviation (4.5° vs. 7.8°) in the PHR group, despite a slight tendency toward contralateral lateral offset. This may paradoxically reflect the expanded surgical corridor provided by the PHR technique, enabling more freedom in instrumentation and visualization. Such deviation may indirectly reflect enhanced surgical exposure achieved by PHR-ARPA. Nonetheless, meticulous attention to midline orientation remains essential to ensure symmetrical implant placement. The improved alignment accuracy in cage and plate positioning observed in the PHR group is anticipated to reduce biomechanical complications, potentially enhancing long-term surgical outcomes

Although operative time and prevertebral soft tissue swelling were modestly higher in the PHR group—an expected consequence of the additional dissection and bone removal required—these differences did not result in clinically significant airway compromise or prolonged dysphagia. Furthermore, the absence of SLN or pharyngeal injuries in the PHR group, compared to the non-PHR group where such complications occurred, supports the protective value of the PHR technique in reducing traction-related morbidity. This stands in contrast to the non-PHR group, which encountered complications including an intraoperative pharyngeal tear and a superior laryngeal nerve injury [5, 14]. Collectively, these findings support the utility of PHR-ARPA in enhancing surgical access while potentially reducing traction-related complications.

Traditional solutions—cranial skin extension, aggressive soft tissue retraction—achieve similar or poor visual corridors at the cost of prolonged traction, greater postoperative odynophagia, and potential voice alteration [15–18]. In contrast, PHR-ARPA preserves strap-muscle continuity, avoids the higher postoperative infection risk associated with the transoral approach, and eliminates the need for rigid retraction against the pharyngeal system. The operative gains observed with PHR (increased exposure, reduced retraction, and acceptable operative time) derive from geometric enlargement of the working space rather than forceful soft-tissue displacement.

PHR is likely to be most advantageous in cases of C2–3 or high C3–4 pathology, in patients with short muscular necks, prior extensive cervical fusions, or ossified posterior longitudinal ligament [19]—situations where the cephalad working space is intrinsically narrow. Reducing retraction requirements may decrease the incidence and severity of early postoperative dysphagia. Additionally, the PHR approach described here is a modified technique derived from the well-established lateral pharyngotomy approach [20]. Given its familiarity among head and neck surgeons, this method is highly reproducible and easily adoptable by multidisciplinary teams.

The limitation of this report is its small, uncontrolled case series from a single surgeon. SLN function and swallowing were evaluated only by clinical observation rather than validated instruments such as fiberoptic endoscopic evaluation or high-resolution manometry, so subtle deficits could have been missed [21–24]. Prospective, multicenter studies that incorporate objective dysphagia and voice metrics, compare PHR-ARPA with conventional method, and correlate radiographic corridor gain with cage position and fusion integrity are warranted.

In conclusion, PHR may serve as a useful adjunct to improve exposure in select high cervical ACDF cases. Within the limited scope of this series, its use was associated with more favorable implant positioning and a reduced incidence of traction-related events, warranting further validation.

# Declarations


### Funding:

This research received no external funding.


### Ethics approval and consent to participate

This study was approved by the Institutional Review Board (IRB blinded). All procedures involving human participants were performed in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments. Due to the retrospective nature of the study and use of de-identified data, the requirement for informed consent was waived.

### Data availability statement

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

### Competing interests

The authors declare that they have no competing interests.

### Consent for publication

Not Applicable.

### Clinical registration number

Not Applicable.

### Author's Contributions

All authors read and approved the final manuscript.

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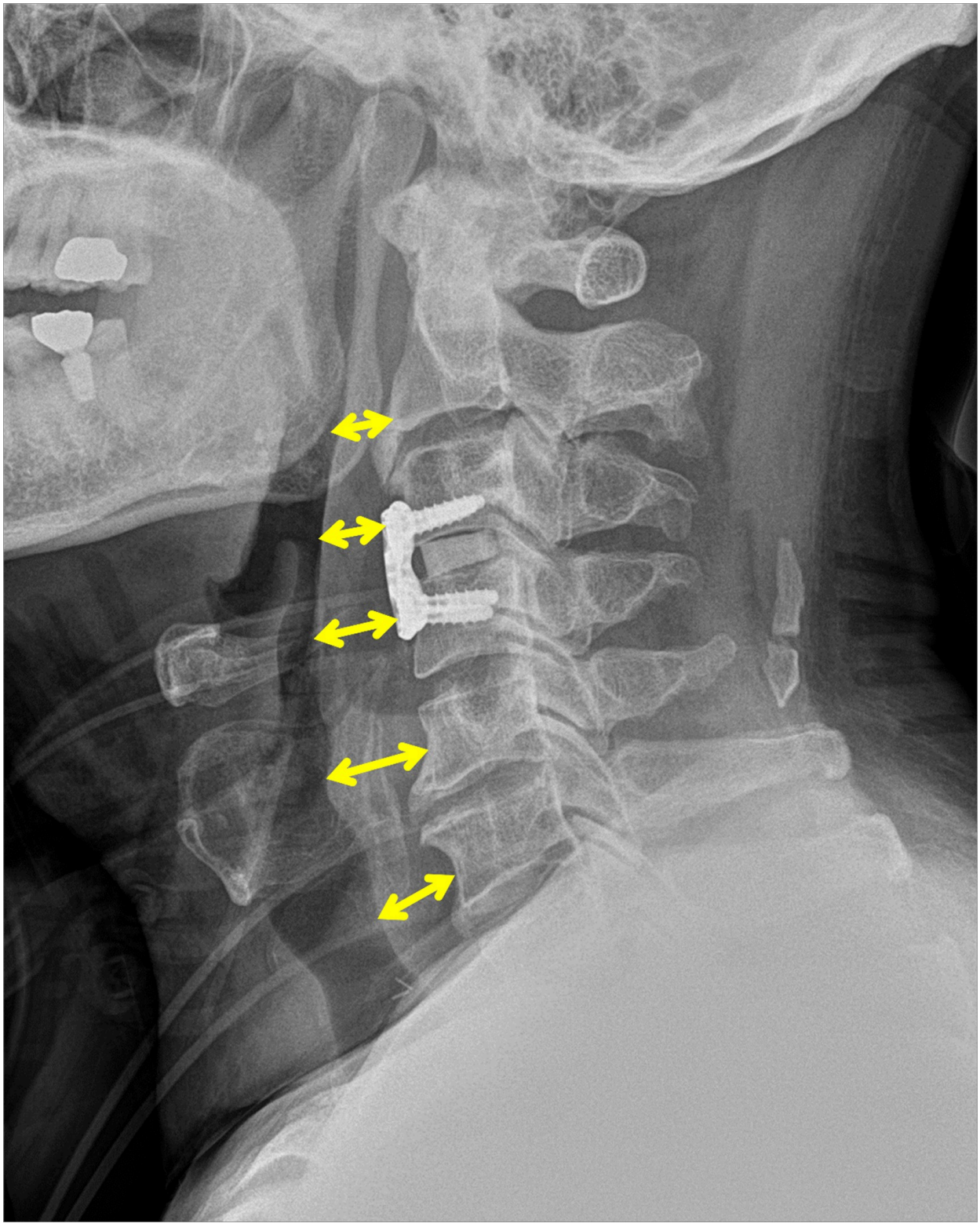

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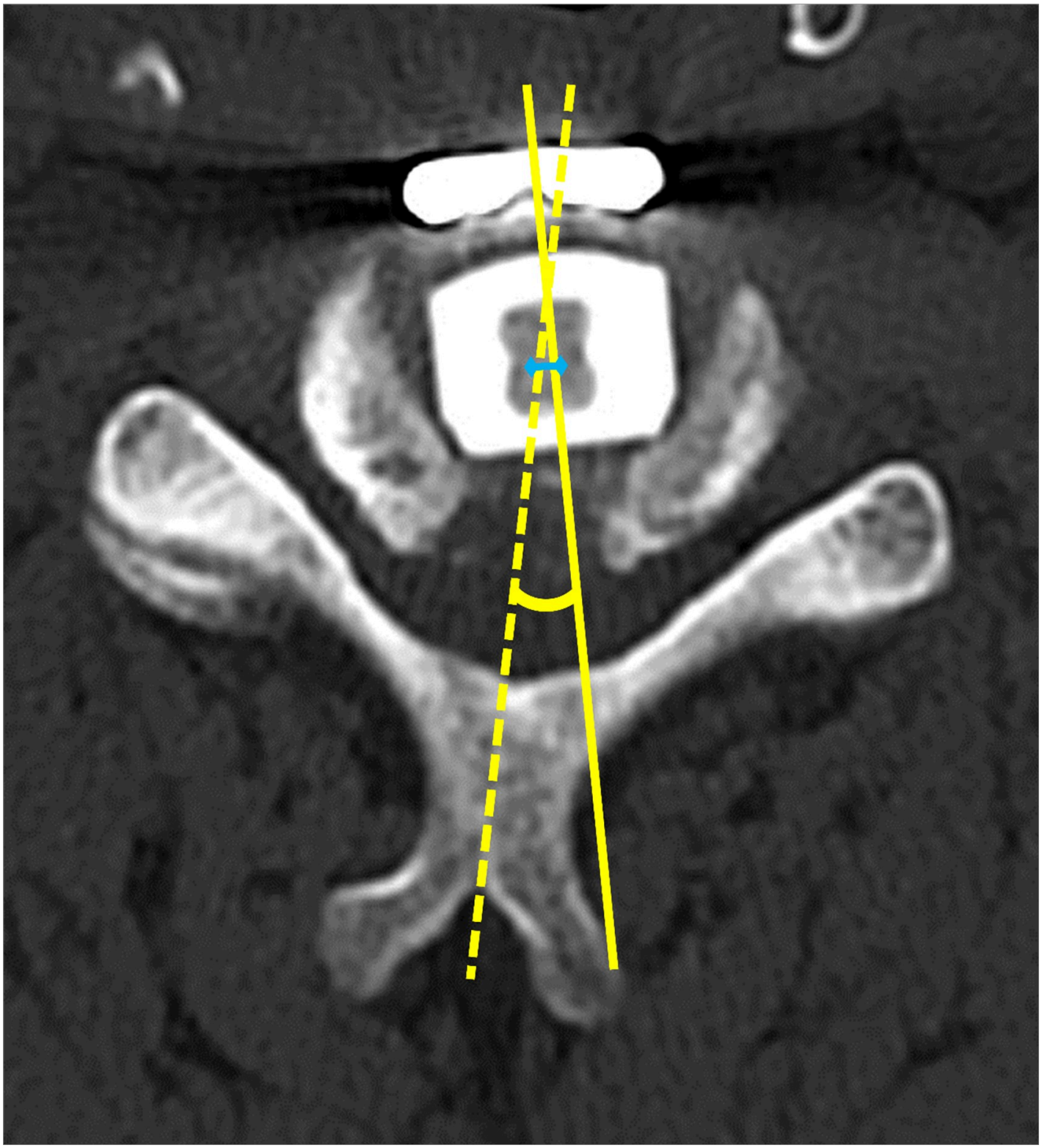
# Figures



## Figure 1

### Measurement of Prevertebral Soft Tissue Thickness

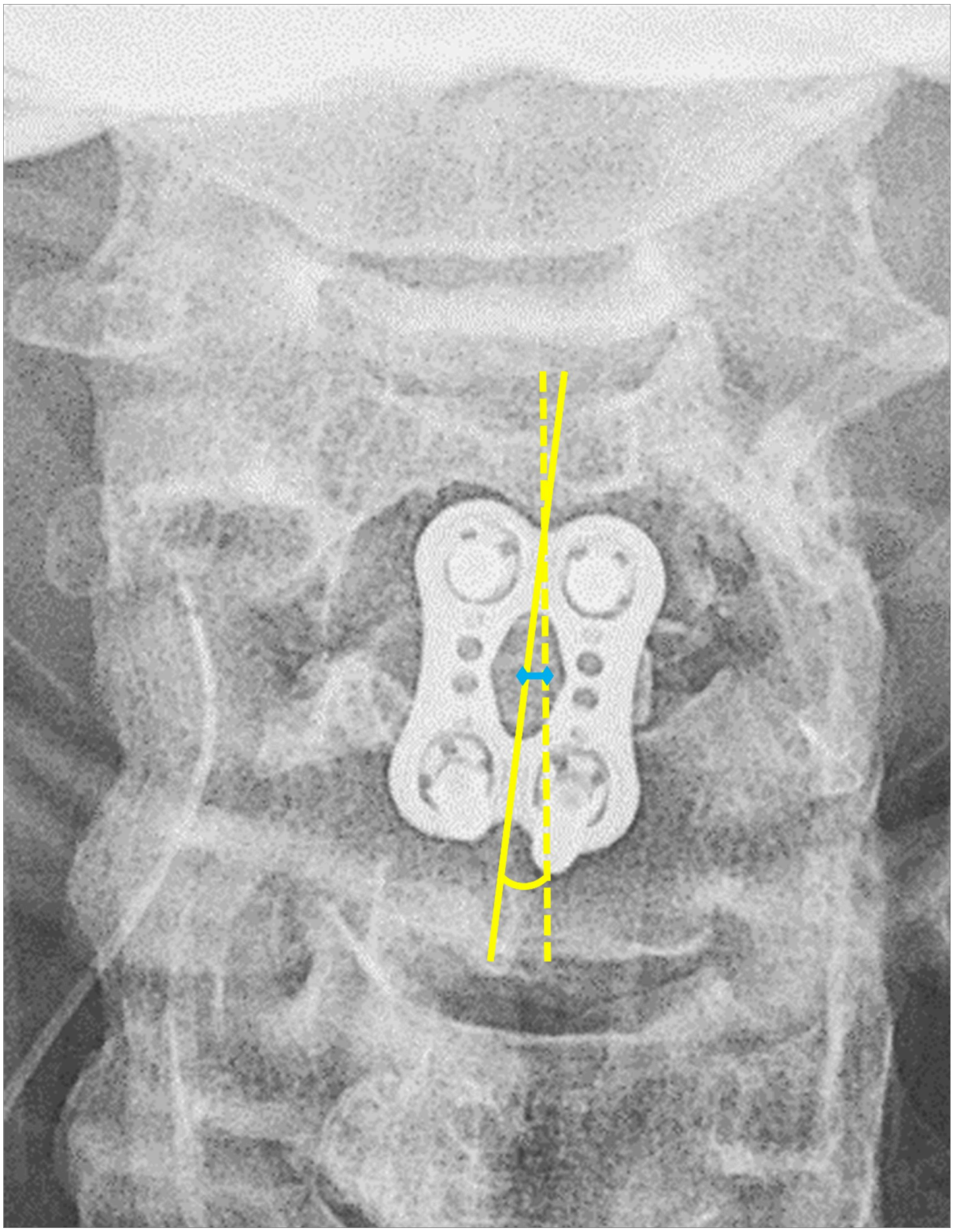
Lateral cervical radiograph on postoperative day 2 showing measurements of prevertebral soft tissue thickness from C2 to C6 (arrows), which were summed to quantify overall swelling.



## Figure 2

### Assessment of Cage Rotation on Postoperative Axial CT

The yellow dashed line represents the vertebral anterior-posterior (AP) axis, while the solid yellow line indicates the cage AP axis. The angle between the two lines defines cage rotation.



## Figure 3

### Assessment of cervical plate positioning.

The yellow dashed line represents the central axis of the cervical spine, drawn between the midpoints of adjacent disc spaces. The solid yellow line indicates the axis of the implanted cervical plate. The angle between the two lines defines plate rotation.

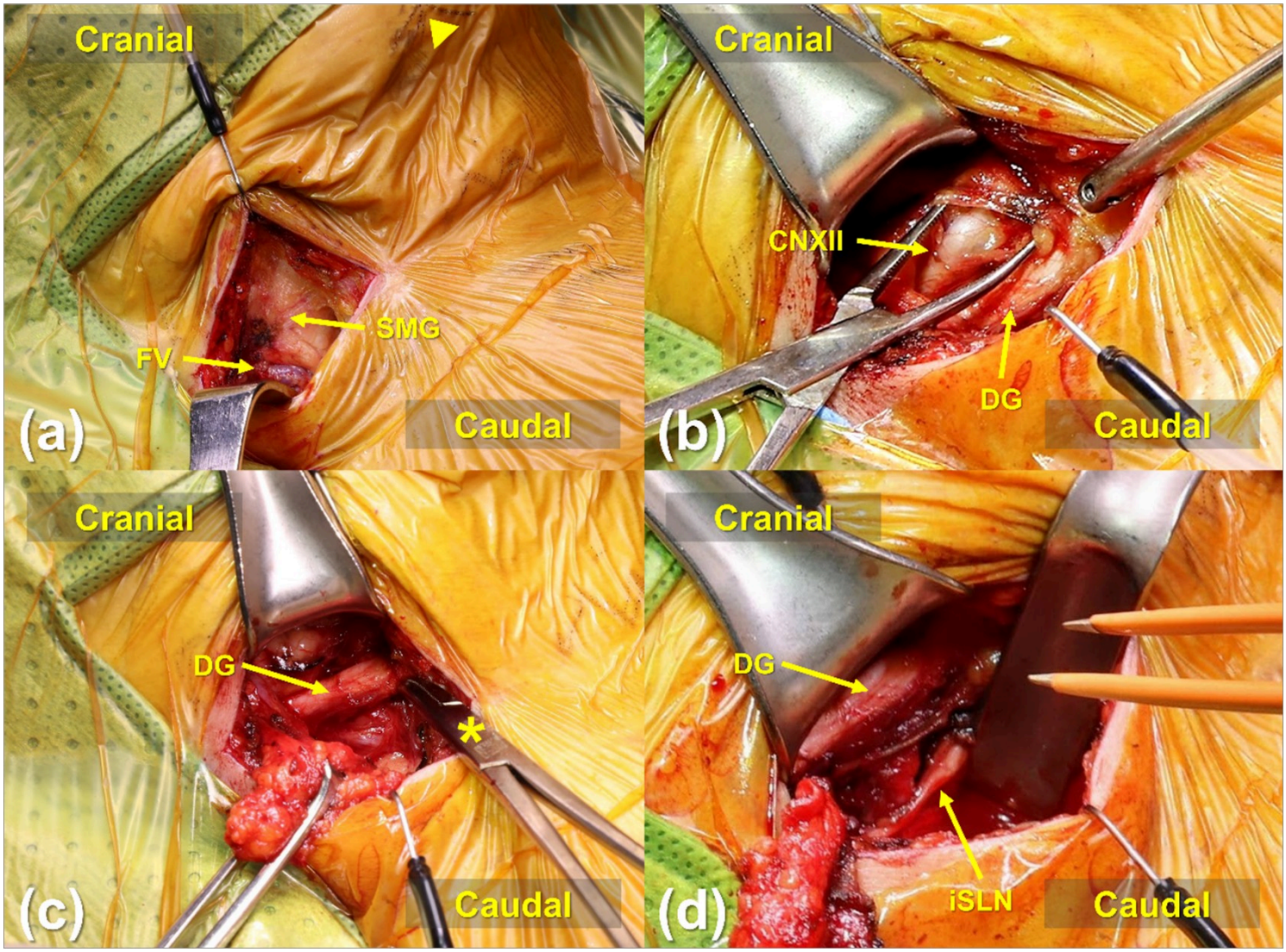



**Figure 4**

**Stepwise exposure of PHR-assisted anterior cervical approach.**

(a) A transverse skin incision is made just below the mandibular angle, at the level of the hyoid bone (C3). The triangle marks the mandibular midline. After elevating the platysma, the submandibular gland (SMG) and facial vein (FV) are visualized.

(b) The posterior belly of the digastric muscle (DG) serves as a key anatomical landmark for cephalad orientation. The hypoglossal nerve (CN XII) is identified along its expected course but is not routinely dissected for full exposure.

(c) The asterisk marks the tip of a mosquito forceps inserted into the deep and inferior plane beneath the DG, approaching the level of the hyoid bone.

(d) Internal branch of superior laryngeal nerve (iSLN) is encountered in the deep inferior plane beneath the DG.

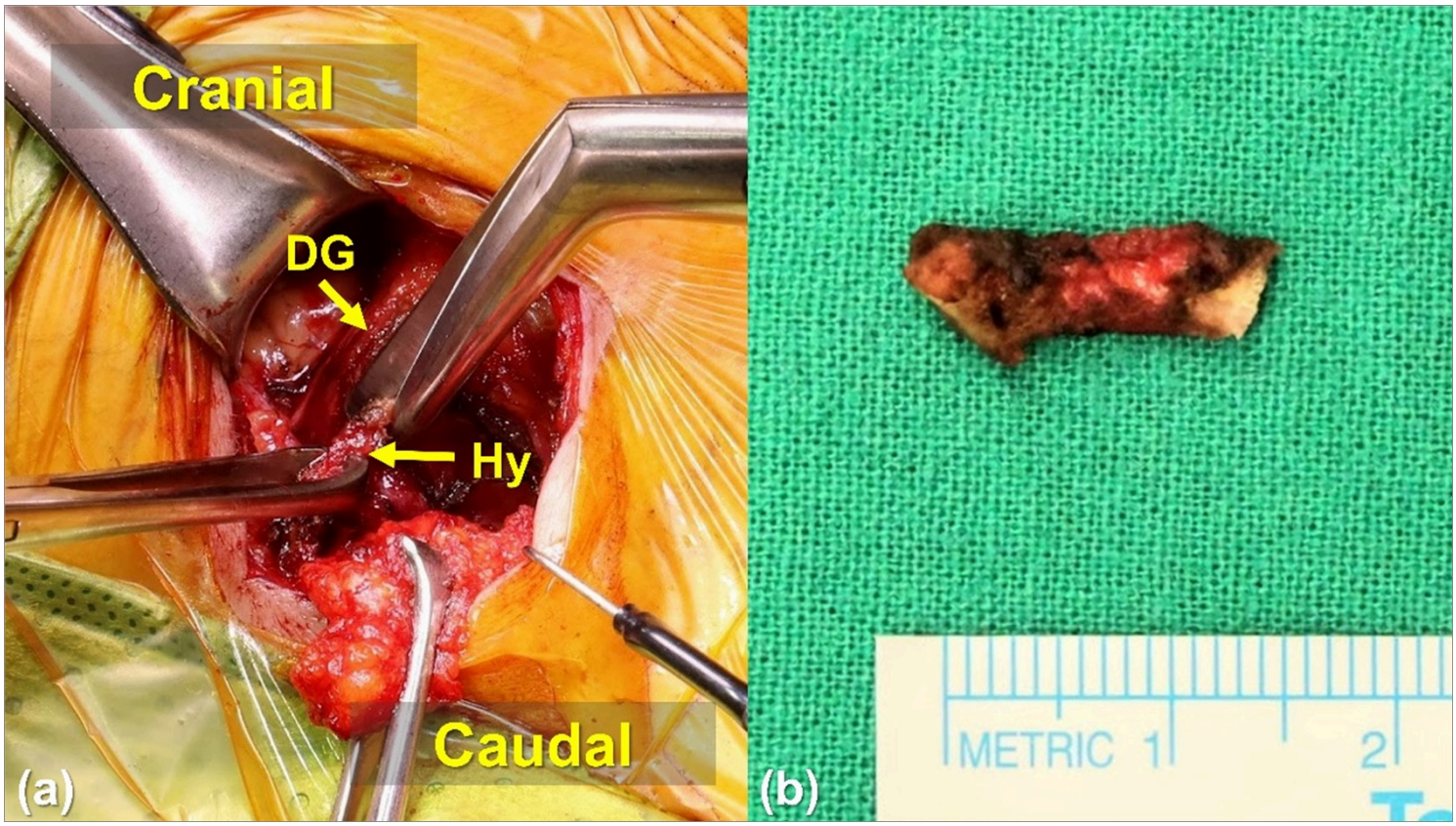



**Figure 5**

**Partial hyoid resection**

(a) Following subperiosteal dissection, the lateral margin of the hyoid bone—the greater cornu (Hy)—is partially resected. The posterior belly of the digastric muscle (DG) is shown for anatomical reference.

(b) Gross photograph of the resected lateral segment of the hyoid bone, measuring approximately 1.5 cm in length.

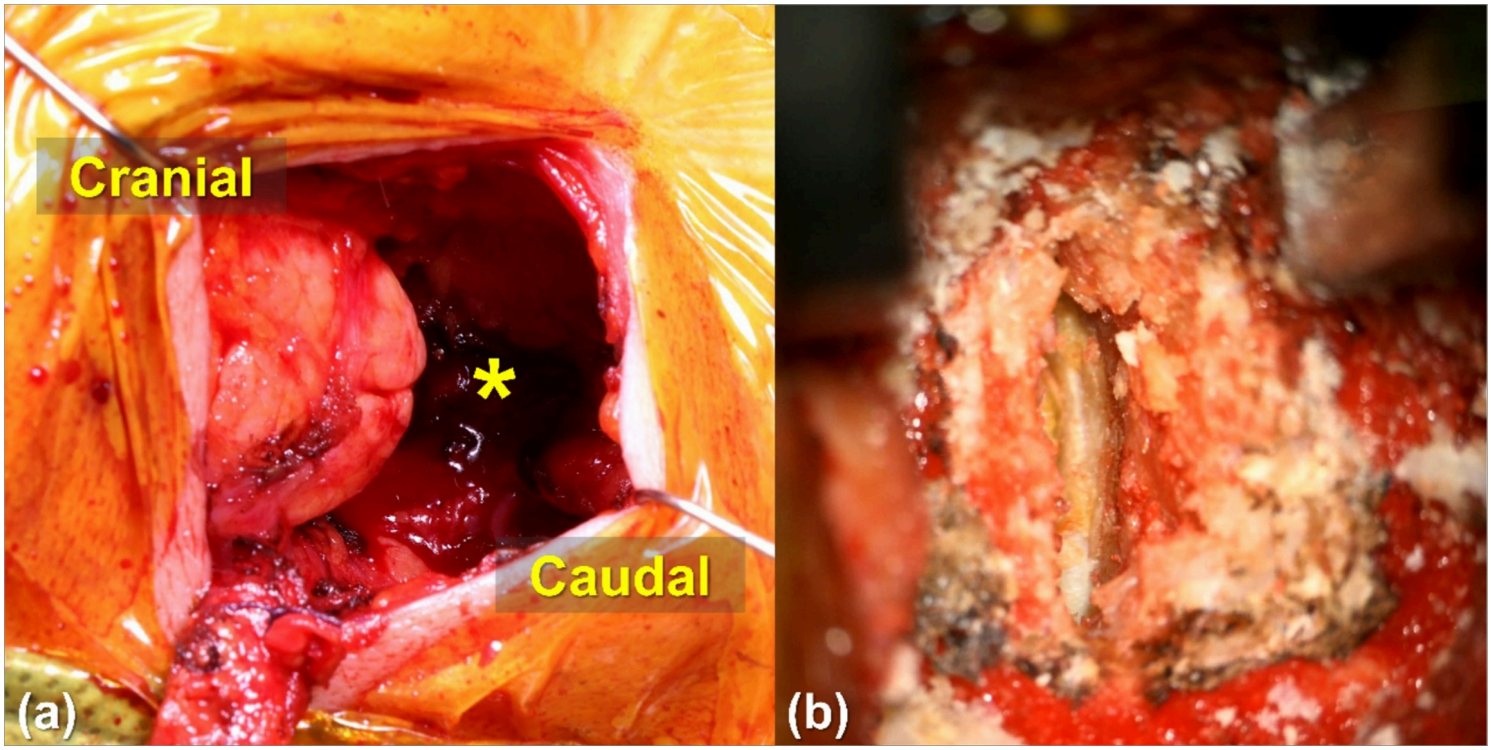
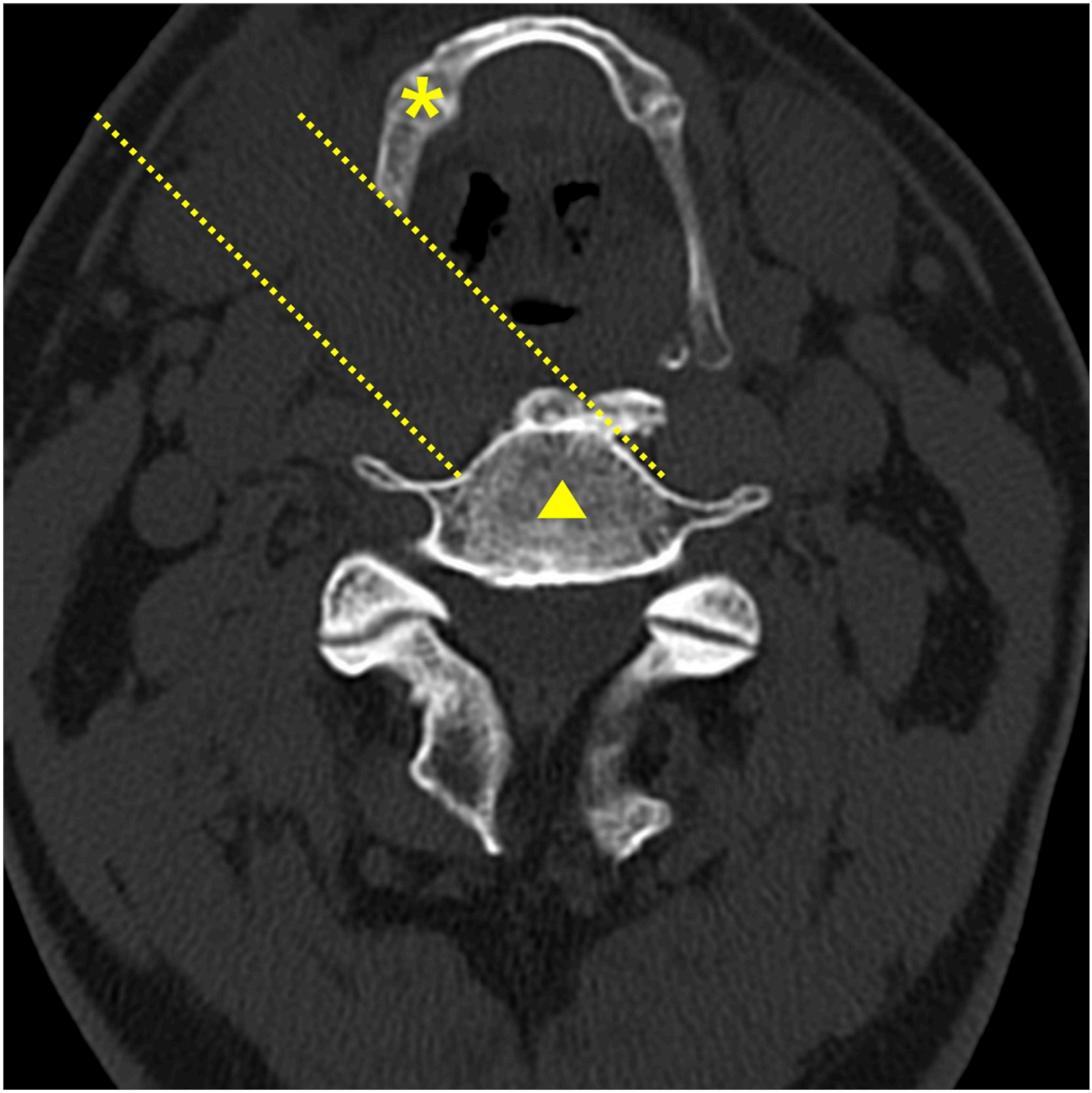



**Figure 6**

**Intraoperative visualization after PHR, demonstrating surgical corridor and discectomy field.**

(a) After lateral hyoid resection, the expanded surgical window (asterisk) provides excellent cephalad exposure.

(b) Intraoperative microscopic view after discectomy, showing clearly visualized bilateral uncovertebral joints.



## Figure 7

### Postoperative axial Computed Tomography image.

The asterisk indicates the resected segment of the hyoid bone, and the triangle marks the C3 vertebral body. The two dotted lines represent the expanded surgical window to the prevertebral space created by PHR