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Computer tomography navigation for the transoral anterior release of a complex craniovertebral junction deformity: A report of two cases

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ABSTRACT

INTRODUCTION: The surgical correction of deformities of the craniovertebral junction (CVJ) remains a challenge due to its complex anatomy. Despite the well-known usefulness of computed tomography (CT) navigation in posterior spinal surgery, it is applied far less frequently in anterior spinal surgery, mainly due to registration difficulties.

PRESENTATION OF THE CASE: Case 1 was a 68-year-old female with rheumatoid arthritis, with a complaint of neck pain, motor weakness, and dysesthesia in the upper extremities. Case 2 was a 61-year-old male with Chiari malformation, with a complaint of neck pain and gait disturbance after a fall. Magnetic resonance imaging (MRI) showed severe atlantoaxial dislocation and multilevel cervical spinal cord compression in both patients. Continuous halo traction failed to reduce atlantoaxial dislocation, even under general anesthesia, and they were treated with combined anterior release and posterior decompression and fixation using CT navigation. Occipitocervical assimilation, which was present in both patients, enabled precise registration for navigation.

DISCUSSION: The lack of anatomically characteristic landmarks on the vertebral surface makes obtaining accurate registration difficult in anterior CVJ surgery using CT navigation. The remaining mobility in the occipitocervical joint precludes the use of facial or cranial landmarks. However, occipitocervical assimilation, which is not uncommon in patients with CVJ deformities, enables accurate navigation during transoral surgery.

CONCLUSION: Transoral anterior release using CT navigation is an effective treatment option for rigid complex CVJ deformities. The accurate identification of the patients' anatomical features such as occipitoatlantal assimilation, is crucial for the conducting accurate preoperative CT-based navigation during transoral surgery.

1. Introduction

The craniovertebral junction (CVJ) deformities that occur in association with spinal cord compression constitute a potentially devastating condition that may lead to quadriparesis and even death. The surgical correction of CVJ deformities remains challenging due to the complex anatomy of the CVJ and its proximity to major vessels. Although the majority of CVJ deformities can be successfully managed with a posterior-only approach [1–3], a combined anterior-posterior approach is sometimes required in patients with rigid CVJ deformities. Transoral anterior release is reportedly effective in achieving anatomical reduction in cases of rigid atlantoaxial subluxation, in which the attachment of the longus colli muscle and the bilateral atlantoaxial joints is released to provide mobility [4]. Achieving a sufficient release of the musculoligamentous tissues via the transoral approach is technically demanding due to the narrow surgical field and the presence of adjacent neurovascular structures, especially in patients with severe deformities. We herein present our experience of treating a patient with a rigid complex CVJ deformity using transoral anterior release assisted by preoperative computed tomography (CT)-based navigation.

2. Case reports

2.1. Case 1

A 68-year-old female presented to our hospital with a three-month history of severe neck pain that was exacerbated by an upright posture. She had suffered from rheumatoid arthritis for 45 years. On admission, she had extreme difficulty in maintaining an upright posture due to intractable neck pain. A neurological examination showed motor weakness and dysesthesia in the upper extremities. In addition, her deep tendon reflexes were exaggerated

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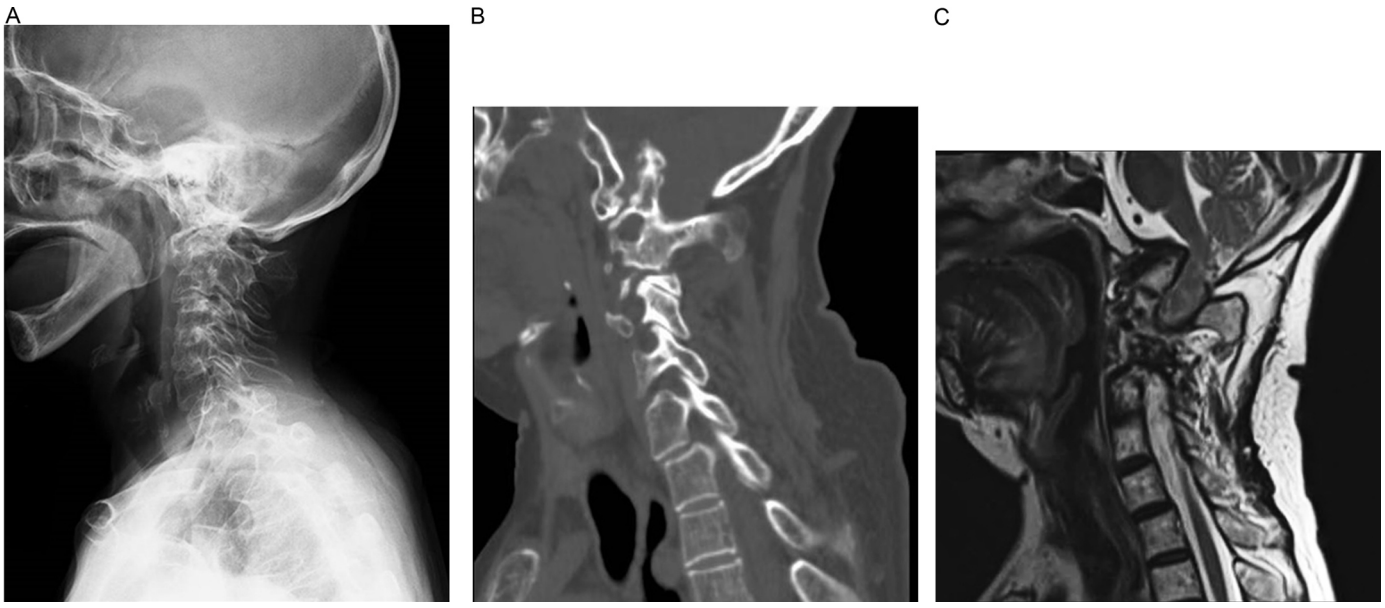

Fig. 1. (A) A lateral cervical radiograph showing severe vertical subluxation. (B) A sagittal CT image demonstrating the upper migration of the odontoid process. The fusion of the clivus and C1 is also noted. (C) A T2-weighted sagittal MR image showing compression of the spinal cord with high-intensity signal changes at clivus level.

in both the upper and lower extremities, and Babinski's sign was present bilaterally. Plain lateral radiography showed severe vertical subluxation (Fig. 1A). Subaxial instability was also noted on flexion-extension radiographs. CT demonstrated basilar invagination, occipitocervical assimilation and kyphoscoliosis of the upper cervical spine (Fig. 1B). The anterior ring of the atlas was fused with the clivus and displaced downward at the level of C2/3. Enhanced CT revealed tortuous vertebral arteries, and magnetic resonance imaging (MRI) showed compression of the spinal cord by the odontoid process, with high-intensity signal changes within the pinched spinal cord (Fig. 1C). Multilevel subaxial spinal cord compression was also noted.

The patient first underwent halo traction with increasing weight (up to 11 kg; patient's body weight: 51 kg) over three days; however, the traction failed to achieve an anatomical reduction. After preoperative halo traction (10 kg) under general anesthesia also failed to obtain an anatomical reduction (Fig. 2A), we decided to perform a transoral anterior release of the CVJ with subsequent posterior fusion and decompression. The patient was placed in the supine position with continuous halo traction (8 kg), and the reference arc of the navigation system (Stealth Station; Medtronic Sofamor Danek, Memphis, TN) was attached to the halo ring via a metal connector (Fig. 2B). Registration was conducted by touching the surface of the patient's head and face, and navigation was used to confirm the orientation of the surgical field (Fig. 2C). After confirming the anatomical structures of the CVJ with the aid of preoperative CT-based navigation, a 2 cm longitudinal incision was made on the posterior pharyngeal wall. The mucosa and prevertebral muscles were subsequently elevated and retracted laterally, and the longus colli and longus capitis muscles were dissected. The lower portion of the anterior C1 arch was removed to reach the base of the odontoid process. The paradental scar tissue was released until sufficient reduction was achieved. The wound was closed with 3–0 vicryl sutures. C2–C5 laminectomy combined with occipitothoracic (O-T3) fusion was subsequently performed. Multilevel spinal cord compression, subaxial instability and suboptimal bone quality necessitated such long posterior fusion. The patient was maintained in a halo vest for four weeks after surgery.

Her neck pain was relieved shortly after the procedure, and the dysesthesia of the upper extremities was substantially improved. Postoperative CT demonstrated an improvement in the basilar invagination, a reduction of the kyphosis at the CVJ, and that the clivoaxial angle had improved from 131° to 151° (Fig. 3A, B). At 36 months of follow-up, the patient remained neurologically intact and was able to walk without assistance.

2.2. Case 2

A 61-year-old male presented to our hospital with a four-month history of neck pain and gait disturbance after a fall. He was diagnosed with Chiari malformation and basilar invagination, and underwent foramen magnum decompression at the age of 16. On admission, he showed spastic gait. A neurologic examination showed motor weakness and dysesthesia in the upper and lower extremities.

CT demonstrated severe vertical subluxation, basilar invagination, occipitocervical assimilation and kyphoscoliosis of the upper cervical spine. The anterior ring of the atlas was fused with the clivus and displaced downward at the level of the C2/3. MRI showed compression of the spinal cord by the odontoid process. Multilevel subaxial spinal cord compression was also noted.

Preoperative continuous halo traction (10 kg; the patient's body weight; 46 kg), also under general anesthesia, failed to achieve an anatomical reduction. We therefore performed a transoral anterior release of the CVJ (Fig. 4), with subsequent posterior fusion (O-C4) and C1 posterior arch laminectomy. The patient's motor weakness and gait disturbance improved after surgery. Postoperative CT demonstrated an improvement in the basilar invagination, a reduction of the kyphosis at the CVJ, and that clivoaxial angle had improved from 82° to 128°. The patient remained ambulatory without some neurological deterioration until 18 months after surgery when he died of gastric cancer.

3. Discussion

With the recent advancements in spinal instrumentation, a majority of CVJ deformities can be effectively managed by a posterior-only approach. In very few cases, however, a circumferential approach is required to achieve anatomical reduction particularly cases with a longstanding deformity or bony fusion. In

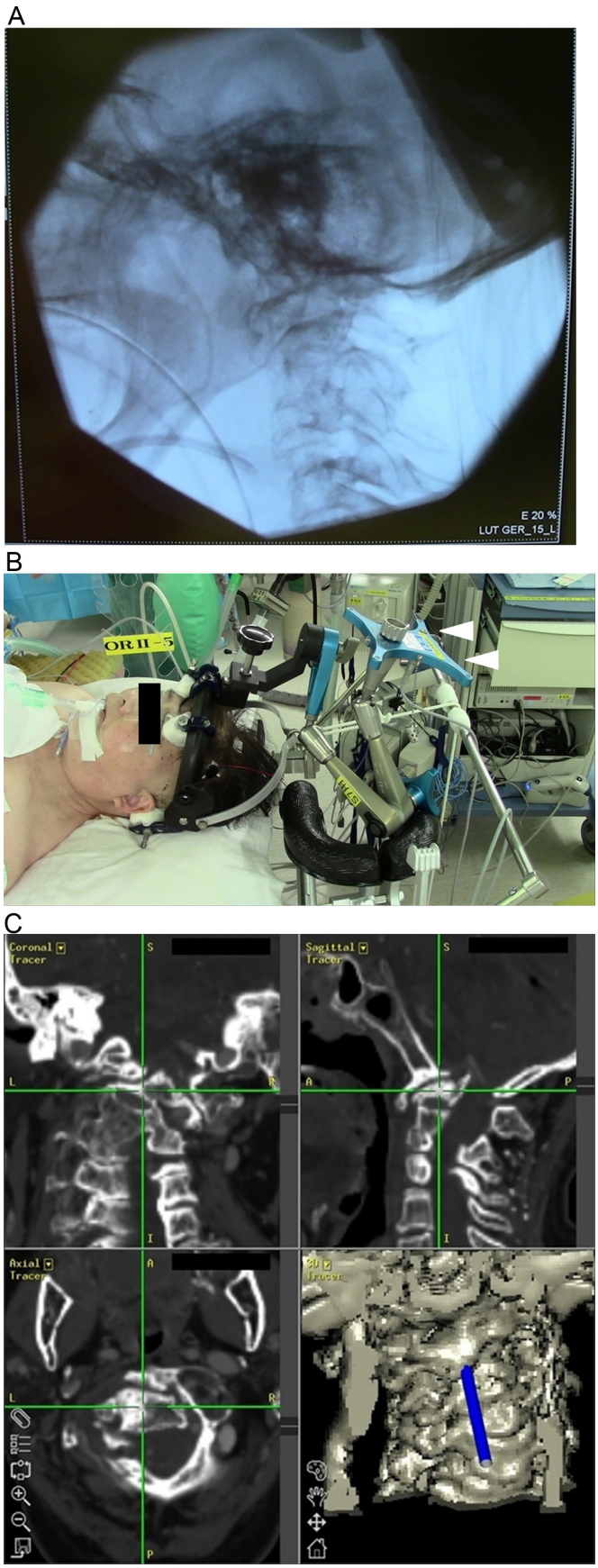

Fig. 2. (A) Preoperative traction under general anesthesia failed to reduce the basilar invagination. (B) The preoperative setting of the patient. The reference arc of the navigation system (the arrow head) was attached to the halo ring via a metal connector. (C) The intraoperative CT navigation images. The tip of the probe was visualized on the CT navigation images.

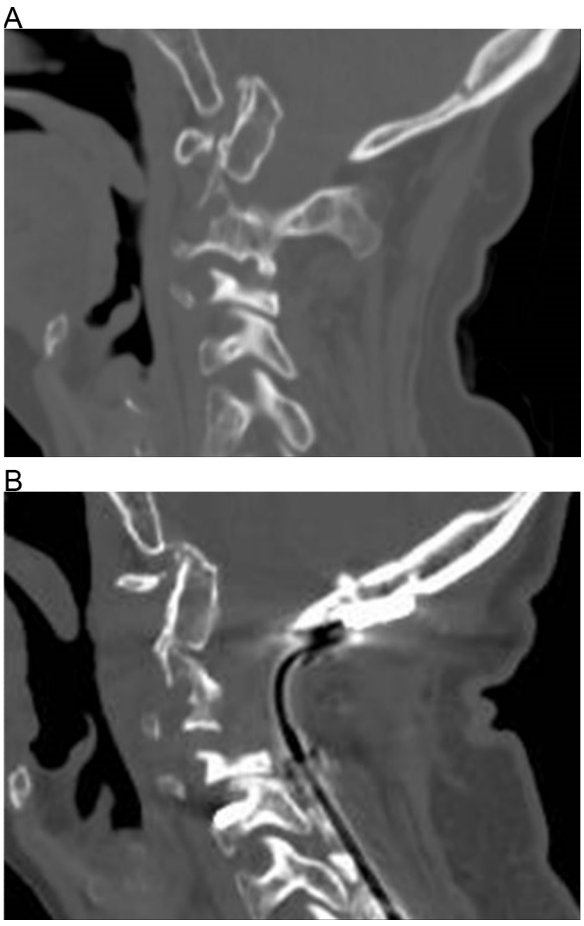

Fig. 3. (A) Preoperative sagittal cervical CT shows basilar invagination and CVJ kyphosis. The clivoaxial angle was 131°. (B) Postoperative sagittal cervical CT shows the improvement of the basilar invagination and CVJ kyphosis. The clivoaxial angle was 151°.

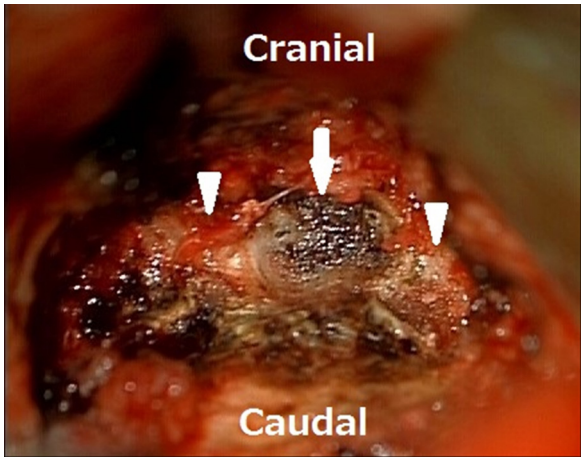

Fig. 4. A microscopic view of the partially resected C1 anterior arch (the arrow head) and the odontoid process (the arrow) after transoral anterior release.

unequivocal cases, we determine the need for an anterior approach based on the findings from the preoperative CT images under halo traction. A combined approach is adopted only when no mobility is noted at the CVJ, even under maximum halo traction.

CT navigation systems have been widely used in the field of spinal surgery and are considered useful for avoiding neurovascular injury and performing accurate resection [5]. However, despite

the widespread use of CT navigation for posterior spinal surgery, it has rarely been utilized for anterior spinal surgery for patients with CVJ anomalies [6–8]. To our knowledge, the use of CT navigation has not been previously reported in transoral anterior release surgery.

The application of CT navigation in anterior spinal surgery is known to be associated with technical difficulties [5]. Firstly the lack of anatomically characteristic landmarks on the vertebral surface makes it difficult to obtain accurate registration. In addition, the remaining mobility in the occipitocervical joint precludes the use of facial or cranial landmarks. In the present case, however, the assimilation of the clivus and atlas allowed us to perform registration by touching facial and cranial landmarks, and accurate navigation was maintained throughout the procedure, as the positional relationship between the occipital bone and atlas remained unchanged. Occipitocervical assimilation is not uncommon in patients in CVJ deformities. Goel et al. reported that occipitoatlantal assimilation was observed in 153 of 190 surgically-treated patients with basilar invagination [9]. Zandonadi Ferrreira and Botelho reported that 37 of 78 patients with CVJ malformation showed occipitocervical assimilation and, most notably, that all of the 27 patients with basilar invagination showed occipitocervical assimilation [10]. We believe that a thorough preoperative evaluation for potential occipitoatlantal assimilation is important for being able to achieve a navigation-assisted transoral anterior release.

4. Conclusion

CT navigation-assisted transoral anterior release can be an effective treatment option for rigid complex CVJ deformities. The accurate identification of the patients' anatomical features such as occipitoatlantal assimilation, is crucial for the conducting accurate preoperative CT-based navigation during transoral surgery.

This case report was written in accordance with the CARE guidelines [11].

Conflict of interests

The authors declare no conflict of interest in association with this study.

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Ethical approval

Written informed consent was obtained from the patient for the publication of this case report and accompanying images.

Patient consent

Written informed consent was obtained from the patient for publication of this case report and the accompanying images. A copy of the written consent is available for review by the Editor-in-chief of this journal on request.

Author contributions

Junya Miyahara: contributed to data collection and writing the manuscript.

Yujiro Hirao: contributed to discussion and data collection.

Yoshitaka Matsubayashi: contributed to discussion and data collection.

Hirotaka Chikuda: was the supervisor, and contributed to discussion and manuscript preparation.

Guarantor

The Guarantor of the paper is Hirotaka Chikuda who is the corresponding author of the paper.

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