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Surgical Stabilization of a Craniocervical Junction Abnormality with Atlantoaxial Subluxation in a Dog

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Abstract : A 7-month-old female Bichon Frise, displaying neck pain and ataxia, was diagnosed with craniocervical junction abnormality (CJA), along with atlantoaxial subluxation. Surgical fixation of the atlantoaxial subluxation was performed, using cortical screws and bone cement, along with an odontoidectomy. After surgery, nonsteroidal anti-inflammatory medication was prescribed for pain control, and a loose bandage was applied to the neck. Mild ambulatory tetraparesis remained 1 week after surgery. Three weeks after surgery, the range of neck motion was near normal, and clinical signs had improved. CJA should be considered as a differential diagnosis in dogs with cervical myelopathy. Surgical stabilization using cortical screws and bone cement through a ventral approach can be successful in dogs with CJA and atlantoaxial subluxation.

***Key words*:** atlantoaxial subluxation, craniocervical junction abnormality, dog.

Introduction

Craniocervical junction abnormalities (CJAs) occur most frequently in small and toy breed dogs (2,7). The term CJA is comprehensive term for variety of malformation in craniocervical regions (7). The most commonly diagnosed form of CJA is Chiari-like malformation (CLM) and other forms of CJAs, including atlantooccipital overlapping (AOO), atlantoaxial instability (AAI), occipitoatlantoaxial malformation (OAAM) have been also reported in dogs (7). There have been many reports describing malformations in the caudal occipital region, and congenital disorders of atlantoaxial region also have been reported in dogs. However, only a few reports have been reported describing concurrent malformations in both caudal occipital region and first two cervical vertebra (3).

Atlas malformation has anatomically various forms depending on the area of the defect. The atlas contains three ossification centers, the body and the left and right sides of the dorsal lamina. Complete fusion of the dorsal mid-line and ventral arch of the atlas in dogs is expected to occur by 120 days of age (8,14,15). If the bone is not completely ossified, malformation develops, accompanied by neurological signs (14).

In a report on incomplete fusion of the atlas, five dogs exhibiting neurological signs were treated with surgical or conservative procedures (14). Three dogs underwent surgical stabilization of C1 and C2, while the other two dogs were treated conservatively. All the dogs improved clinically. In another report, a 3-year-old Border Collie with an acute onset of neurological signs was diagnosed with a bipartite atlas (incomplete fusion of the dorsal and ventral parts of the atlas) (15). The dog was treated with conservative management and showed clinical improvement within 1 week. These cases show that malformation of the atlas has a good prognosis when it occurs alone or with mild neurological signs. However, if the atlas malformation occurs in association with other congenital deformities in craniocervical region, the treatment becomes more complex, and the prognosis will be poor.

CLM, the most common type of CJA, is a congenital disorder of craniocervical junction in which caudal part of cerebellum is indented by abnormal occipital structure, often along with cerebellar herniation into foramen magnum. Neurologic pain and other neurologic signs as abnormal sensations represent common clinical signs of CLM. Syringomyelia (SM) is often developed secondary to CLM and causes additional neurological symptoms. The preferred diagnostic technique to confirm CLM with SM is MRI, which can visualize syrinx formation (4).

Atlantoaxial instability (AAI) is another type of CJA; however occurs with a relatively high frequency. AAI typically occurs in young, toy breed dogs, especially Yorkshire Terriers, Pomeranians, Miniature Poodles, Chihuahuas, and Pekingese (1,10). Similar to other CJAs, AAI may cause ataxia, neck pain, and other neurological signs in dogs (10,11). Morphological features of AAI include aplasia, hypoplasia, dorsal angulation, or degeneration of the dens, along with failure of ligamentous support and increased distance between the arch of C1 and the spinous process of C2 (10). Due to these diverse causes, the clinical signs also vary. The severity of the signs with AAI varies from neck pain to tetraparesis, which may be caused by compression or concussion of the spinal cord. There are two surgical approaches to correct

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AAI, the dorsal and the ventral procedures. The ventral procedure is considered to be a more favorable method for arthrodesis, with a good long-term outcome (5).

In the following case, we report the successful surgical stabilization of CJA with atlantoaxial subluxation in a dog.

Case

A 7-month-old female Bichon Frise dog, weighing 3.2 kg, was referred for evaluation after an acute onset of right-sided ataxia and neck pain; however, the signs were not prominent. After the onset of ataxia, the dog was anorectic and reluctant to move.

On physical examination, the dog exhibited right-sided hemiparesis. In addition, spinal reflexes and muscle tone were increased in all four limbs. A pain response was also elicited on palpation of the cervical region, especially with the neck in flexion. From the physical examination findings, the lesion was localized to the area between C1 and C5. No abnormalities were found on other diagnostics, including blood testing. On survey radiographs, no abnormalities were found in the chest or abdomen. In the craniocervical region, the dens appeared to be shortened on the dorso-ventral view. However, no other anatomical abnormalities were clearly identified.

The CT scan showed dorsal angulation of the dens and malformation of the atlas in the sagittal image (Fig 1). The dorsal lamina of the atlas was defective, and its length was shortened compared to that of the dens. In addition, the articular surfaces of the dens and the atlas were not in contact. On the 3D reconstruction, these anomalies were clearly confirmed, and the foramen magnum was also found to be expanded.

On MRI, a dorsal displacement of the dens toward the spi-

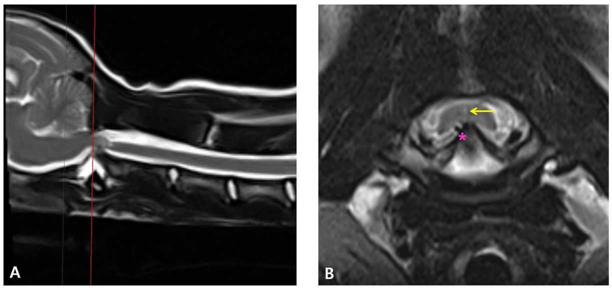

Fig 2. T2-weighted sagittal MRI image (A) and transverse MRI image (B) at the point of red line of (A). The yellow arrow is indicating compression of spinal cord and the purple asterisk mark is pointing to dorsal angulation of dens.

nal cord was observed (Fig 2), and the spinal cord exhibited a high intensity due to compression. Furthermore, there was an indentation of the caudal part of the cerebellum by malformation of the supra-occipital bone. Mild extrusion of the vertebral discs was also confirmed at the C2 to C3 and C5 to C6 intervertebral disc spaces.

Ultimately, the dog was diagnosed with atlantoaxial subluxation and atlas malformation, along with CLM. After the diagnosis, gabapentin (10 mg/kg, Kuhnil pharm, Hwaseong, Republic of Korea) was prescribed q8h for pain relief, and the dog's condition improved. However, the signs recurred 1 month later and were more severe than those observed initially. The dog displayed non-ambulatory tetraparesis and severe cervical pain; therefore, surgical treatment was elected.

The dog was anesthetized and positioned in dorsal recumbency for a ventral arthrodesis of C1 and C2. After a median skin incision, the muscles were separated to expose the C1 to C2 junction. The joint capsule and articular cartilage were removed using a high--speed bur. In addition, an odontoidec-

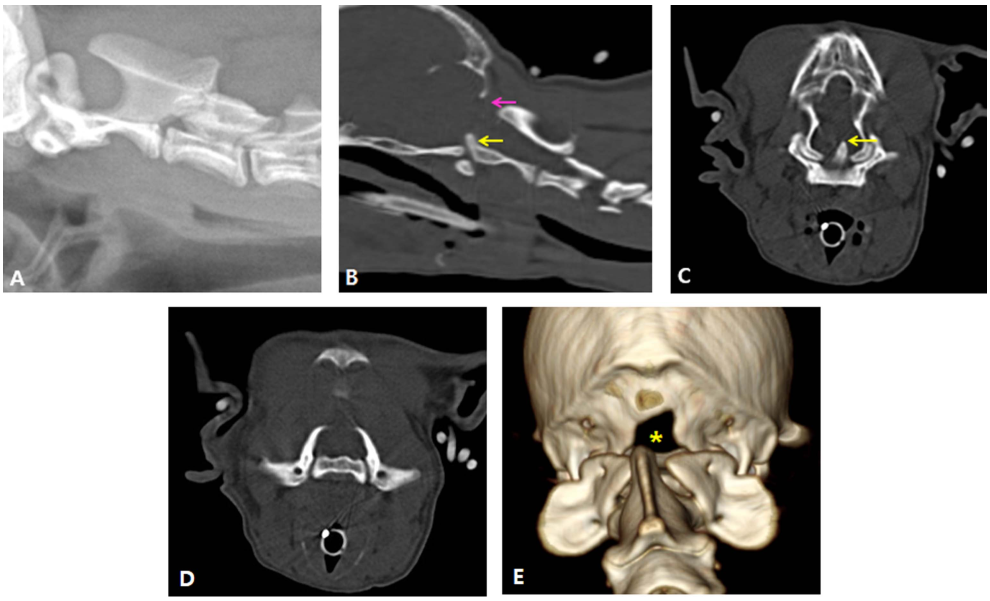

Fig 1. Diagnostic images. Cervical radiograph (A) and sagittal CT image (B). The *yellow arrow* is pointing to the dorsal angulation of the dens. The *purple arrow* is pointing to the defect in the dorsal lamina of atlas. The image (C) and (D) is transverse CT view, showing dens dorsal angulation and incomplete ossification of atlas bone each other. The figure (E) is 3D reconstruction image of the CT image. The *yellow asterisk* is indicating expansion of the foramen magnum.

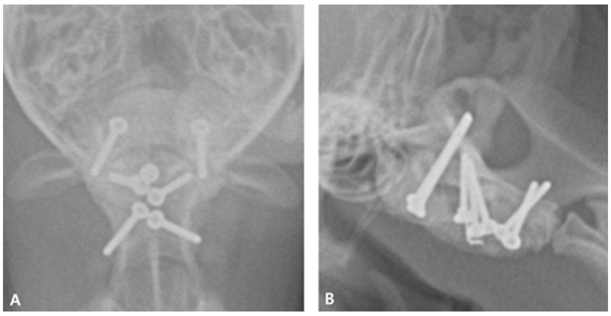

Fig 3. Postoperative ventrodorsal (A) and lateral (B) radiographs.

tomy was performed to correct the alignment of C1 and C2 before arthrodesis. After the odontoidectomy, ventral stabilization was performed using 1.5 mm cortical screws and polymethylmethacrylate (PMMA) bone cement (EUROFIX G, Synimde, Chamberet, France). C2 was fixed in alignment, and then one screw was inserted into C2 to use for leveraging. Two screws were inserted into C1 and four screws were inserted into C2 for the articular fixation as follows. First, two 1.5 mm cortical screws were inserted in a cranio-lateral direction from the posterior aspect of the transverse foramen and medial direction of the atlas wing. Two screws were then inserted from the attachment point of the longus colli muscle in a cranio-lateral direction into the ventral body of C2. Finally, two screws were inserted in a caudal direction from the body of the transverse process. After insertion of the screws, a cortico-cancellous bone graft from the proximal humerus and PMMA bone cement were applied to strengthen the stabilization. Finally, the muscles were sutured, followed by the subcutaneous tissue and skin. Because it was confirmed that the occipitoatlantal joint was not unstable during the operation, an additional joint arthrodesis could be cause the movement of the neck joint to become stiffer, and finally, there was concern about additional instability in the adjacent joints, so no further fixation of the occipitoatlantal joint was performed during this surgery procedure.

Postoperative radiographs were performed to verify the position of the screws in C1 and C2 (Fig 3). The radiographs confirmed that the screws were placed as intended, and C1 and C2 were also positioned correctly on the lateral view.

Immediately after surgery, the dog had mild pain and weak ambulation. Gabapentin (10 mg/kg, q8h) and firocoxib (5 mg/kg, q24h, Previcox®, Merial, Toulouse, France) were prescribed for pain control after surgery. In addition, a loose bandage was applied for one week, and exercise was strictly restricted for 4 weeks.

On the first recheck 1 week after surgery, the dog had ambulatory tetraparesis with ataxia. However, the overall condition had improved, and postural reactions were nearly normal. After the recheck examination, a cervical splint was applied to protect the cervical site. Three weeks post-surgery, the dog still displayed ambulatory tetraparesis; however, the gait was nearly normal, with normal postural reactions. In addition, the range of motion in the neck was significantly improved compared to that before surgery. At this point, the exercise restriction was lifted, and controlled walks were recommended. Five months later, the dog was in good condition and walked well without any major problems, although the neck movements and gait seemed slightly stiff.

Discussion

The multiple deformities in craniocervical region are an unusual situation and it is necessary to plan the treatment procedure through careful physical examination and advanced diagnostic testing, including CT or MRI to correct the central cause of clinical problem. The presence of spinal cord compression, the severity of neurological signs, and the degree of instability are important factors that should be considered when formulating a treatment plan (14). When neurological symptoms are severe, surgical correction may be considered; however, medical treatment can be effective if there are no clinical signs or only mild neurological signs.

The incomplete ossification of the atlas may cause various degrees of neurological signs (15). These signs are usually associated with a meningocele or meningomyelocele, which are caused by a defect of the dorsal lamina (8). In addition, the absence of the dorsal lamina can allow severe spinal cord injury, with even minor trauma to the neck. The defect in the posterior arch also weakens the apical ligament between C1 and C2 and can lead to AAI. In the present case, the diagnosed atlas malformation did not cause clinical problems in the patient, so the therapeutic procedures chosen involved only stabilization of the AAI. However, the arthrodesis performed in our case not only stabilized the atlantoaxial joint, but also corrected the instability caused by the defect of the posterior arch. For this reason, C1-C2 arthrodesis was chosen in this patient, with atlantoaxial subluxation concurrent with atlas malformation.

Other malformations, including CLM and expansion of the foramen magnum, were also diagnosed in this case; however, they were not clinically significant. These deformities can cause similar neurological signs and are likely to occur together. Therefore, it is crucial to identify the main cause of the clinical signs by carefully performing diagnostics, in order to accurately treat the patient.

There are numerous reports of AAI in toy and small breed dogs and also various treatment procedures used for correcting this disorder. The surgical procedures include ventral and dorsal approaches, of which both are currently used. Ventral procedures are most common; however, the techniques are challenging, due to the narrow bone corridors present in small breed dogs (6,9). In addition, there are various approaches to the ventral procedure, depending on the surgical instruments and method used (1,12). In one report on the ventral procedure, the surgical model was divided into a fixation plate model, a multiple metallic implants and PMMA fixation model, and a transarticular fixation model (12). Out of the several strength tests, the multiple metallic implants with PMMA fixation model was the most preferred method. Therefore, we chose this technique, and when possible, it would be advantageous to use metallic instruments and PMMA bone cement for a strong stabilization.

The prognosis of CJA can be determined by accurate diagnosis and evaluation for central cause of clinical problem. In addition, when there are multiple deformities in craniocervical region, sequential therapeutic steps may be necessary. In this case, different anatomical deformities were found in diagnostic imaging, however we tried to correct the major cause of neurological symptom first. Because of the serious spinal cord injury on MRI, we have treated it first. If neurological symptoms persists after surgery, we intend to make another treatment step by step. After approximately 5 months of post-surgical monitoring, the neurological symptoms gradually alleviated, and the dog's condition improved. However, careful monitoring is still necessary, because neurological signs can develop due to other congenital deformities in dogs, including CLM, expansion of the foramen magnum, and the atlas malformation.

In conclusion, congenital malformations, such as CJA, should be considered in dogs with clinical signs of a cervical myelopathy. Surgical stabilization of CJA with atlantoaxial subluxation can be accomplished by performing a C1-C2 arthrodesis using cortical bone screws and bone cement.

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