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Stabilisation of atlantoaxial subluxation in the dog through ventral arthrodesis

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SUMMARY

Ten miniature breed dogs with atlantoaxial subluxation underwent ventral lag screw stabilisation. The procedure did not include bone graft packing into the atlantoaxial articulation. Four dogs showed continuous improvement after surgery. Three dogs developed complications due to external trauma and postoperative implant failure but improved with conservative therapy. Three patients died or euthanasia was performed in early perioperative or postoperative period. The long-term outcome was good or favourable in all surviving patients. Suspected fibrous tissue proliferation and stabilisation without permanent bone fusion was found to be clinically satisfactory when the atlantoaxial joint has been subjected to limited stress during a long-term monitoring period.

Keywords: Yorkshire terrier, atlantoaxial subluxation, ventral lag screw, bone graft

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Introduction

Atlantoaxial subluxation (AAS) is an inherited or acquired disease, mostly described in toy breed dogs [Lorenz and Kornegay, 2004]. Impairment of atlantoaxial articulation is caused by excessive flexion of the head resulting in injury to ligaments and/or dens axis fractures. Several inherited malformations of atlantoaxial articulations have been described in toy breeds [Johnson and Hulse, 1989; Wheeler, 1992; Lorenz and Kornegay, 2004]. Dens axis hypoplasia, aplasia or absence of ligamentous support predispose to failure with minimal trauma, resulting in pain and upper motor neuron tetraparesis. Pain during head flexion is the most common sign of the disease.

The treatment of AAS can be either conservative or surgical [Lorenz and Kornegay, 2004; Sharp and Wheeler, 2005; Havig *et al.*, 2005]. Conservative treatment is reserved for patients with mild clinical signs [Gilmore, 1984; Havig *et al.*, 2005]. The goal of surgery is to decompress the spinal cord and stabilise the atlantoaxial joint [Sorjonen and Shires, 1981; Lorenz and Kornegay, 2004; Sharp and Wheeler, 2005]. Dorsal and ventral surgical techniques have been described as effective in the stabilisation of AAS. Dorsal techniques include stabilisation of the atlas arch and dorsal process of the axis using orthopaedic wire, non-metallic surgical suture or nuchal ligament as well as cross pin fixation [Chambers *et al.*, 1977; LeCouteur *et al.*, 1980; Jeffery, 1996]. Ventral techniques include transarticular cortical screw placement [Denny *et al.*, 1988; Rochat and Shores, 1999; Wheeler, 1992], transarticular cortical screws and pins with polymethylmethacrylate reinforcement [Blass *et al.*, 1988; Schulz *et al.*, 1997; Platt *et al.*, 2004; Sanders *et al.*, 2004], transarticular pinning of atlantoaxial articulations [Beaver *et al.*, 2000; Johnson and Hulse, 1989; Thomas *et al.*, 1991] and bone plating [Stead *et al.*, 1993]. Veterinary surgeons tend to favour ventral stabilisation techniques recently, as they seem to

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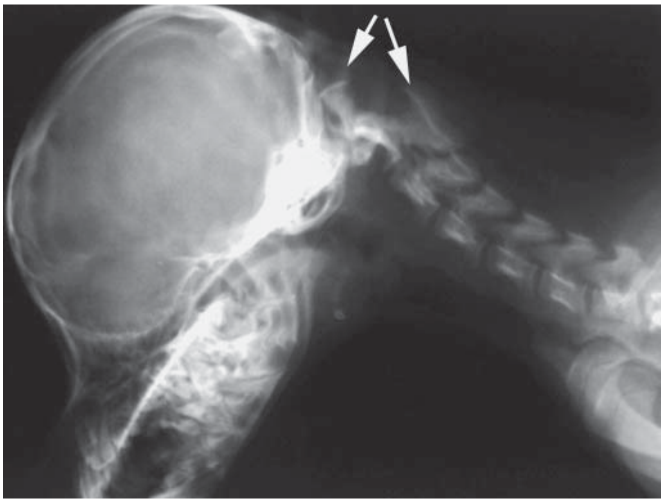


Figure 1: Preoperative lateral radiograph of a Yorkshire terrier with AAS. The distance between the dorsal arch of the atlas and the dorsal spine of the axis is enlarged (arrows). The cranial aspect of the body of the axis is dislocated to dorsal. Dens axis is hypoplastic.

provide easier anaesthetic monitoring, lower surgical risk and permanent fusion of atlas and axis. It has been proposed that bone grafting should be used to enhance fusion between two vertebral bodies [Lorenz and Kornegay, 2004]. All the above operating techniques produced good long-term results for patients [Denny *et al.*, 1988; Thomas *et al.*, 1991; Beaver *et al.*, 2000; Platt *et al.*, 2004; Sanders *et al.*, 2004]. The purpose of this study was to show long-term results and complications of ventral lag screws without cancellous bone graft packing in the joint in 10 cases of AAS stabilisation.

Animals, Material and Methods

The medical records of confirmed AAS cases from 2000 to 2005 were reviewed retrospectively. The inclusion criteria included complete results of physical and neurological examination, radiological conformation of AAS, surgical treatment with ventral lag screw stabilisation, postoperative radiographs and long-term follow-up data. Data collected included breed, sex, age, body weight and the course and duration of neurological dysfunction. The neurological status was graded before and after surgery according to the following scale: 1) without neurological deficits, 2) mild tetraparesis, mild generalised ataxia and episodic pain, 3) moderate to severe ambulatory tetraparesis, generalised ataxia and pain, 4) nonambulatory tetraparesis or tetraplegia and pain.

Diagnosis

The diagnosis was confirmed on plain lateral radiographs. Later, properly positioned plain lateral and ventrodorsal radiographs of the head and upper cervical region were taken under general anaesthesia before and after surgery, avoiding excessive head and neck flexion. The distance between the dorsal arch of the atlas and the spinal process of the axis were evaluated on lateral radiographs. Possible dens axis fracture, malformation or aplasia was checked on the ventrodorsal projection.

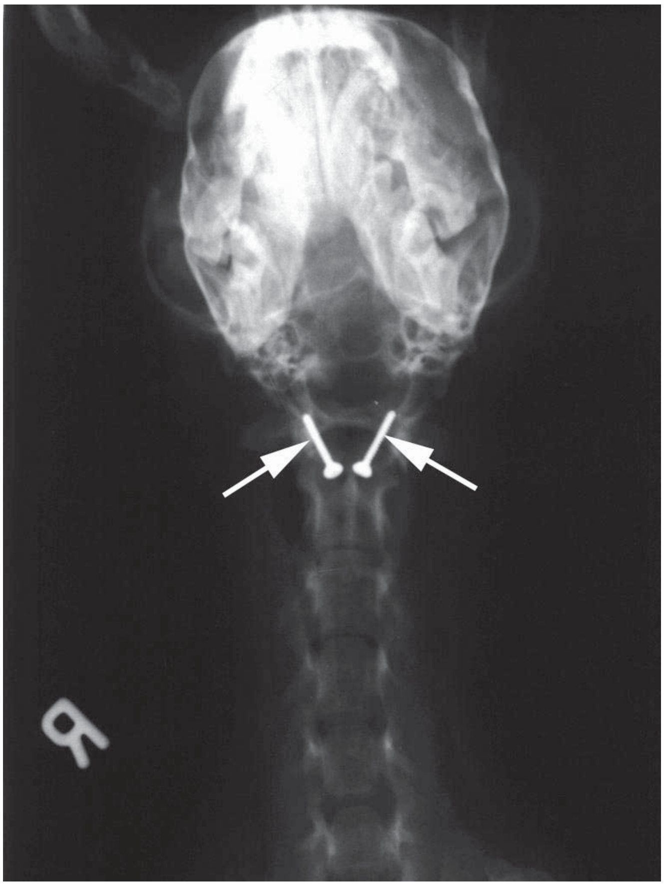
Anaesthesia

Anaesthesia protocol included premedication with i.v. diazepam [Apaurin, KRKA] and buprenorphine [Temgesic, Schering-Plough], induction of anaesthesia with i.v. bolus of propofol [Propofolum, Abbott Laboratories] and maintained by inhalation of a halothane [Narcotan, Slovakofarm], nitric oxide and oxygen mixture. Continuous fentanyl infusion was administered during surgery. Monitoring during anaesthesia included recording of pulse rate, SpO_2, respiratory rate, and end tidal CO_2. Manipulation during general anaesthesia was careful and patients were transported taped to firm cardboard.

Surgery

The surgical method in all cases was through a standard ventral approach to the atlantoaxial articulation [Sharp and Wheeler, 2005]. Patients where placed in dorsal recumbency with the neck slightly extended and the front legs pulled back. The patient was fixed into position with tapes over the mandible and cranial thorax. The skin incision extended from the larynx to C4–C6 vertebras. Care was taken to preserve the thyroid gland and its blood supply. The sternohyoid muscles were separated and retracted to expose the trachea. The sternothyroid muscle was mobilised and divided close to the larynx. The larynx and cranial section of the trachea were retracted laterally using Gelpi self-retaining retractors. The tendons of the longus colli muscles were elevated and separated from the ventral process of C2.

Figure 2a: Postoperative ventrodorsal radiograph of a Yorkshire terrier with AAS (case No. 6). 1.5 mm cortical screws are inserted through the atlantoaxial articulation (arrows).



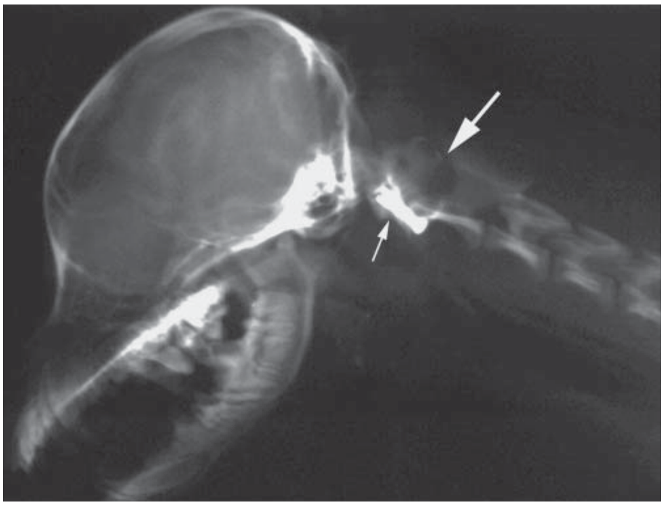


Figure 2b: Postoperative lateral radiograph of a Yorkshire terrier with AAS (case No. 6) showing normal distance between the dorsal arch of the atlas and the dorsal spine of the axis (big arrow). Transarticular implants are placed between C1 and C2 (small arrow).

Soft tissue remnants were removed from the ventral section of both vertebral bodies. The joint space was opened to identify the ventral border and position of each vertebra. Part of the joint capsule obscuring the view was removed. The vertebral body of the axis was grashed with micro Halsted forceps, positioned medially on the lateral section of the body. Forceps were used to establish and hold the optimal position of both vertebrae. 1.5 mm cortical screws were used to stabilise the atlantoaxial joints. A 1.5 mm hole for the lag screw was first drilled in the cranial section of C2 beginning on one side of the vertebral body just behind the bony cranial wall. Then, the opening to C1 was drilled using a 1.1 mm drill and tapped. The drill bit was covered with the sleeve to prevent soft tissue damage and ensure positioning as close as possible to the ventral musculature of C2/C3. The drill was directed craniolaterally approximately 30 degrees from the midline to reach the largest portion of the bony lateral part of the atlas. No bone graft was packed into the articulation. The screw was inserted in the predrilled and tapped hole, and tightened like a lag screw. Care was taken to ensure a firm grip into the bone. The procedure was repeated on the opposite side. The wound was closed in a routine manner. The position of the screws was evaluated on postoperative radiographs in lateral and ventrodorsal projections.

Postoperative care

Hospitalisation of patients was maintained until they were ambulatory and pain-free. Repeated injections of morphine (Morphin Biotica 1%, Hoechst-Biotica) every 6 hours were used for postoperative analgesia in all dogs during the first 24–48 hours. Soft padded neck bandages were applied postoperatively to young and small dogs with large heads in proportion to their bodies. Neck bandages were maintained during the first 4–6 weeks after surgery. The intensity and duration of postoperative physiotherapy was prescribed according to the postoperative neurological status of the patient. All owners were instructed to restrict their pet's physical activity for 6–8 weeks after surgery, allowing just short 5-minute walks three times daily.

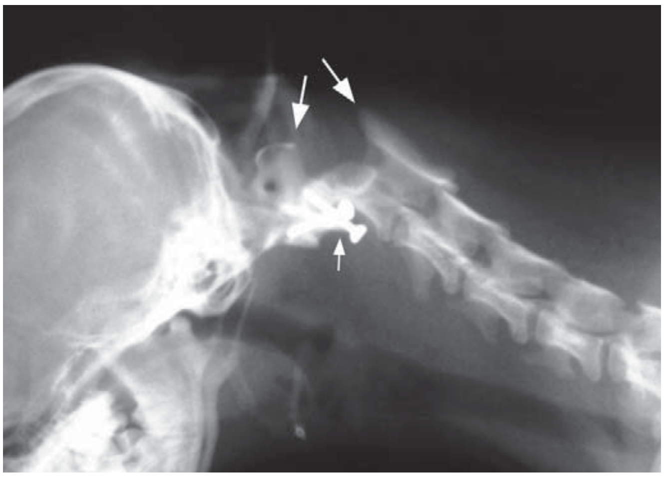
All dogs were evaluated daily during the postoperative hospitalisation period and at various intervals after discharge by the postgraduate or resident surgeon of the ECVN. Additionally, all owners were repeatedly interviewed by phone. Owners were asked to score their pet's condition using the following scheme: "good" – without any visible abnormalities, "favourable" – better than before surgery with only mild deficits in gait and/or rare episodes of rigidity/pain, and "poor" – status similar or worse than before surgery.

Results

From a total of 13 dogs, 10 met the inclusion criteria and 3 dogs were excluded because conservative treatment was applied. 8 dogs included in the study were Yorkshire Terriers, 1 was a Japanese Chin and 1 was a Chihuahua. 5 dogs were scored to have a neurological status grade 2, three dogs grade 3 and two dogs grade 4 before surgery. An increased distance between the dorsal arch of the atlas and the spinal process of the axis was noted in preoperative radiographs in all dogs (Fig. 1). The dens of the axis was fractured in 1 case, hypoplastic in 2 cases and normal in 7 dogs. The postoperative radiographs confirmed good implant positioning and the dorsal arch of the atlas was overlapped by the spinal process of the axis in all dogs (Fig. 2a and 2b). Neurological scoring after surgery was better in 4 patients, similar in 4 patients and worse in 2 patients than before surgery. Soft padded neck bandages were used for 3-6 weeks after surgery in 4 cases. The mean hospitalisation time was 7.2 days. Mean long-term results were collected after 28 months. Pertinent clinical data are summarised in Table 1.

4 dogs (40%) had no postoperative or long-term complications and a gradual improvement in their neurological condition was observed. The long-term results were rated as good (3 cases, 30%) or favourable (1 case, 10%). Perioperative complications occurred in one patient (10%), early postoperative in three (30%), and late postoperative complications in two cases (20%).

Figure 2c: Lateral radiograph of a Yorkshire terrier following an accident 5 days after surgery (case No. 6). Both implants are displaced caudally and dorsally (small arrow). The distance between the dorsal arch of the atlas and the dorsal spine of the axis is enlarged (big arrows).



	#1	#2	#3	#4	#5	#6	#7	#8	#9	#10
Breed	Yorkshire terrier	Yorkshire terrier	Yorkshire terrier	Yorkshire terrier	Yorkshire terrier	Yorkshire terrier	Yorkshire terrier	Japanese Chin	Chihuahua	Yorkshire terrier
Sex	Male	Female	Male	Female	Male	Female	Male	Male	Male	Male
Weight (kg)	1.2	1.3	1.5	2.9	2.8	1.6	1.5	2	1.4	1.6
Age at presentation (months)	5	12	12	24	9	7	8	9	16	8
Neurological grade before surgery	2	2	2	2	3	3	3	4	4	2
Neurological grade 24 hours after surgery	CPA*	3	2	2	2	2	3	3	4	1
Neurological grade on discharge	-	2	1	1	1	2	5	2	2	1
Hospitalisation period (days)	-	3	6	6	8	2	3	17	12	8
Neck bandage after surgery	-	+	+	+	-	-	-	+	-	-
Follow-up period (months)	-	32	46	14	35	-	-	28	25	16
Perioperative complication (hours)	5	-	-	-	-	-	-	-	-	-
Early postoperative complication (days)	-	2	-	-	-	5	3	-	-	-
Late postoperative complication (days)	-	-	-	-	20	-	-	-	53	-
Neurological grade at the end of the study	dead	2	1	1	1	euthanasia performed	euthanasia performed	2	2	1
Final outcome, owners grading		Favorable	Good	Good	Good			Favorable	Favorable	Good

Table 1: Pertinent clinical data in 10 dogs with AAS. * cardiopulmonary arrest

One patient (case no.1) suffered a cardiopulmonary arrest and died 5 hours after surgery. Case no.6 improved from grade 3 to grade 2 during postoperative hospitalisation but three days after discharge the dog jumped off a sofa and became ataxic (grade 3). Radiological examination after the accident revealed fractures of the cranial articular surface of C2 and the caudal articular surface of C1 at the operation site (Fig. 2c and 2d). Both implants were displaced. The owners elected for euthanasia. The condition of case no. 7 did not improve during three days after the surgery. Repeated radiological examination revealed implant migration and fracture of the wing of the atlas. The owner elected euthanasia.

A worsening clinical status and ventrolateral migration of one of the implants was observed in one dog (case no. 2) within 36 hours after surgery. A soft padded neck bandage was applied for 3 weeks and the condition of the dog improved gradually. The long term outcome (32 months) was considered to be favourable in this patient after developing complications in the postoperative period. One patient (case no. 5) improved continuously during the first 20 days after surgery but became tetraparetic after running in a forest. Ventral migration of one of the screws was diagnosed on radiographs (Fig. 3). Strict cage rest in the hospital for 5 days improved the patient's condition. Another dog (case no. 9) had been discharged from the hospital after reaching grade 2, but 53 days after surgery he was attacked by a large dog and became ataxic (grade 3). The radiographs taken after the accident showed breaking of both implants but no significant dislocation in the atlantoaxial joint compared with postoperative radiographs. Patient status improved gradually after cage rest. Ultimately, long-term results were rated good or favourable in 7 cases.

Discussion

Ventral surgical techniques are widely used for stabilisation of AAS [Denny *et al.*, 1988; Thomas *et al.*, 1991; Schulz *et al.*, 1997; Beaver *et al.*, 2000; Platt *et al.*, 2004; Sanders *et al.*, 2004]. The general principle of stabilisation is to reach permanent stability of two unstable vertebrae. Bone graft harvested from the proximal humerus, together with surgical stabilisation achieves final bony union of the atlas and axis and implants provide the stabilisation until firm union occurs [Sorjonen and Shires, 1981]. In this study, the intervertebral space was not packed with bone graft. The joint space was opened just to confirm the correct position of the two vertebral bodies before implant introduction. Avoiding graft collection reduces surgical time and surgical trauma (humerus is not involved). Postoperative physiotherapy is thus easier. Fibrous connective tissue proliferates from the ventral part of the vertebral body, overlapping the joint space. Fibrous proliferation is independent of bone graft packed into the joint space and provides additional stability to surgical implants [Sorjonen and Shires, 1981]. According to the results of this study, lag screw stabilisation together with fibrous tissue formation connecting two vertebrae could be satisfactory for a longer period of time. Seventy per cent of patients in this study showed good or favourable long-term outcomes after having been treated with ventral lag screw stabilisation without bone grafting.

A major perioperative complication in AAS surgery is cardiopulmonary arrest. The usual cause is suspected to be iatrogenic trauma to the medulla oblongata and/or the spinal cord during surgery due to excessive manipulation or improper implant placement [Thomas *et al.*, 1991; Beaver *et al.*, 2000]. Suboptimal implant placement, implant failure, and excessive patient movement are the common causes for such complications as did occur in dog no. 1. Other fatal complications (major implant failure, vertebra fracture, exacerbations of motability) in this study occurred postoperatively in 2 immature partients (age at presentation 7 and 8 months, Tab. 1). Lag screw failure was probably the consequence of improper implant positioning, vertebral immaturity or both. Immature patients might benefit from a different surgical stabilisation technique, using pins and/or screws reinforced with polymethylmethacrylate, or even from conservative treatment with a soft padded neck bandage or neck splint until the bone matures [Platt *et al.*, 2004; Sanders *et al.*, 2004; Havig *et al.*, 2005].

Late postoperative complications in 2 patients were associated with traumatic accidents during the convalescence period. Radiological examination revealed unilateral lag screw failure, but did not show exacerbation of AAS. These cases responded well to conservative treatment. Obviously, this study was limited by the small number of patients and the lack of objective histological findings to support the clinical results. Long-term results should therefore be collected in a larger group of patients.

Figure 2d: Ventrodorsal radiograph of a Yorkshire terrier following an accident 5 days after surgery. The left screw is still in the left caudal articular facet of the atlas but has moved out of the axis; the right screw is displaced from the atlas but still in the right cranial articular facet of the axis (arrows).

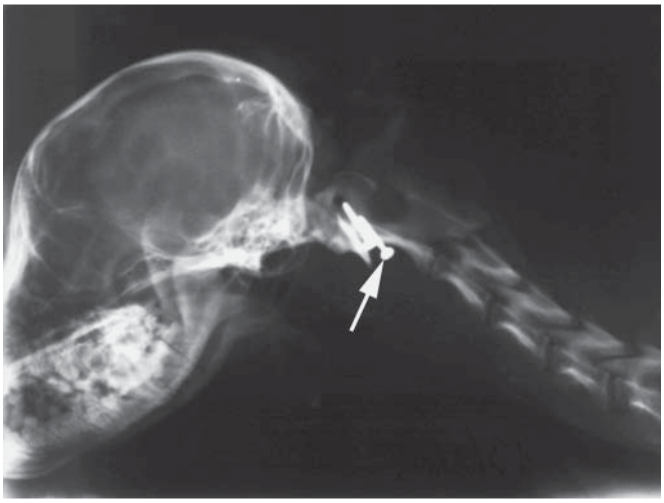


Figure 3: Lateral radiograph of a Yorkshire terrier (case No. 5) following an accident 20 days after surgery. One screw is displaced caudally (arrow). The distance between the dorsal arch of the atlas and the dorsal spine of the axis is normal.

There is probably no one single optimal procedure for the surgical stabilisation of AAS. The choice of treatment is dependent on many factors and is subjective. The ventral lag screw fixation technique seems to be effective in the cases in this study. Nevertheless, the surgical procedure might be complicated if vertebrae are too immature to withstand loads on implants. Stabilised patients can become healthy without permanent bone fusion associated with a bone graft applied to the joint space. Healing, after ventral stabilisation with fibrous tissue proliferation only, provides satisfactory long-term results in patients with AAS. Avoiding bone grafting shortens surgical time and makes postoperative physiotherapy easier.

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