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## The Use of Computed Tomography in the Diagnosis and Treatment Planning of Temporomandibular Joint Ankylosis in Two Cats

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**ABSTRACT:** The use of computed tomography (CT) in the diagnosis and treatment of two cats with a history of inability to open the lower jaw was evaluated. The CT scan of Case 1 revealed extensive callus formation and osseous fusion in the left temporomandibular joint (TMJ) and subluxation in the right TMJ. The CT scan of Case 2 revealed irregular bone proliferations in bilateral intra-articular and periarticular structures. Excision arthroplasty was performed unilaterally in Case 1 and bilaterally in Case 2, and a temporal myofascial flap was applied. At one-year follow-up, both cases maintained painless range of motion of the lower jaw with no signs of re-ankylosis. The CT scanning with three-dimensional (3D) reconstruction is an indispensable imaging method for the diagnosis and preoperative planning of TMJ ankylosis in cats.

**Keywords:** ankylosis; cat; computed tomography; temporomandibular joint.

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## INTRODUCTION

TMJ lesions were observed in more than 50% of maxillofacial injuries in cats (Çetinkaya, 2012; Knight and Meeson, 2019). These injuries can cause fractures, ankylosis and luxations in the joint (Çetinkaya, 2012; Arzi and Lantz, 2020). Ankylosis is defined as pathological stiffening or immobilization of a joint. Intra-articular (true ankylosis) or extra-articular (false ankylosis) lesions that affect the TMJ, such as trauma, various developmental, infectious, inflammatory, and neoplastic changes, cause ankylosis in the TMJ. The most common cause of both true ankylosis and false ankylosis is shown as falling and vehicular trauma (Gatineau et al., 2008; Çetinkaya, 2012; Zavodovskaya et al., 2019). It accounts for approximately 11% of TMJ injuries in cats (Çetinkaya, 2012). TMJ ankylosis, also known as open mouth jaw locking, causes inability to open the mouth, severe masticatory dysfunction and feeding disorders (Gatineau et al., 2008; Nutt et al., 2018). In the diagnosis of TMJ disorders, other diseases with open mouth jaw locking findings such as luxation, dysplasia or fractures of the TMJ, mandibular or facial trauma including zygomatic arch fracture, osteoarthritis, masticator muscle myositis, neoplasia, retrobulbar abscess, and severe ear diseases should be differentiated (Beam et al., 2007; Gatineau et al., 2008; Larguier and Jamet, 2015). Due to the complex bone structure of the skull and the superimposition of important structures, the diagnostic value of conventional skull radiography is quite limited. CT is valuable in evaluating the spatial position of TMJ bones as well as osseous lesions in the cat skull and understanding the pathogenesis of TMJ lesions. Clear and detailed diagnostic imaging is essential for a definitive diagnosis and correct treatment plan for TMJ disorders, as inadequate imaging can harm an animal's health, quality of life, and functionality (Beam et al., 2007; Arzi et al., 2013; Larguier and Jamet, 2015).

The aim of this study is to evaluate the diagnostic yield of CT and its contribution to surgical planning with correct treatment in rare cases of TMJ ankylosis in cats.

## CASE HISTORY

In the procedures performed for both case reports, signed informed consent forms were obtained from cat owners.

### CASE 1

A 7-month-old, 4.1 kg female Ankara crossbred

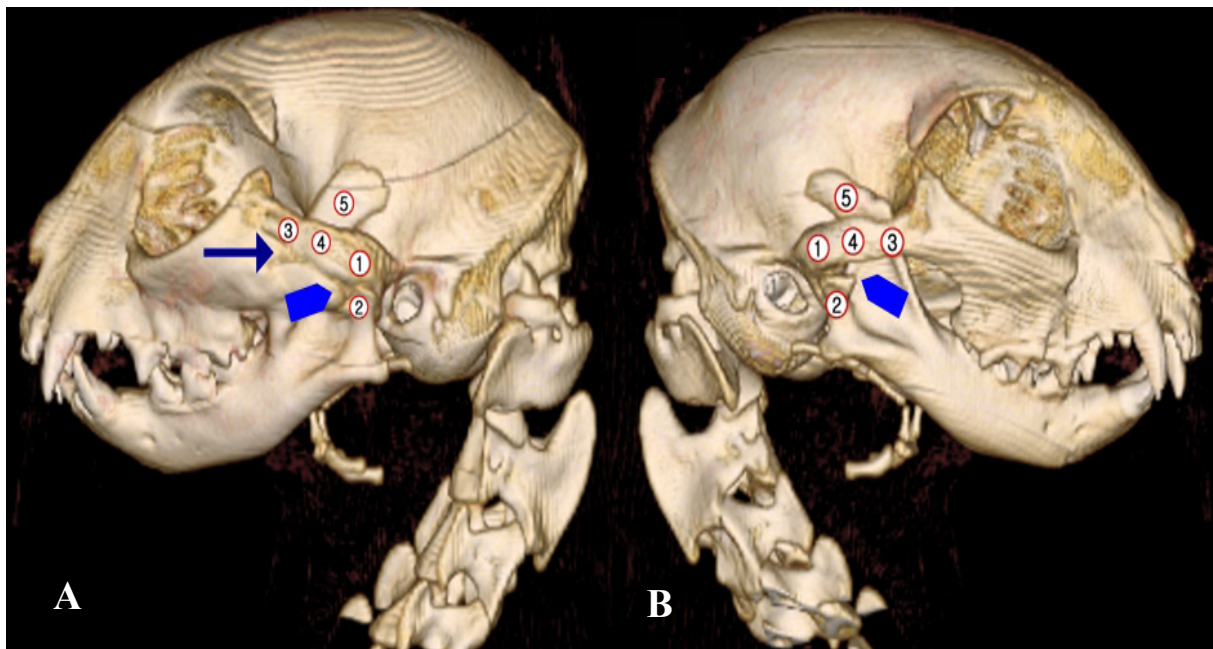
cat was brought to our clinic with complaints of difficulty in eating and inability to open the mouth. No observations of open mouth jaw locking were reported in the anamnesis. It was informed that the lower jaw opening gradually decreased.

On clinical examination, heart rate was 112 beats/min, respiratory rate was 27 breaths/min, and rectal temperature was 38.9°C. Asymmetry in the form of partial swelling of the craniomaxillar muscles on the left side was observed. The lower jaw was intact but with very slight malocclusion. Despite vigorous opening and closing manipulations, the lower jaw was in a partially open position. The visually assessed maximum jaw opening from the cutting edges of the lower incisors to the cutting edges of the upper incisors was 7 mm. No signs of pain were observed on palpation of the skull, craniomaxillar muscles, and TMJ. The body condition score was low due to malnutrition (3/9). As far as can be seen, no other lesion was noticed in the examination of the oral cavity and its surroundings. Ventrodorsal skull radiography showed that possible involvement of the left TMJ caused ankylosis.

Before the CT scan, the cat was sedated with IV injection of dexmedetomidine (5 µg/kg) (Dekstomid® 200 mcg/2 mL, Polifarma İlaç, Tekirdağ Turkey) and butorphanol (0.3 mg/kg) (Butomidor® 10 mg/mL, Richter Pharma AG, Wels, Austria). The patient was positioned in the dorsal recumbency position on the CT gantry. In the noncontrast transverse CT scan (256-slice CT-scanner with at 0.625 mm) (GE Revolution Waukesha, USA), moderate ankylotic changes were observed in the left TMJ as a result of a vertical fracture extending to the middle region of the mandibular fossa of the left temporal bone and the lateral region of the condyloid process of the mandible. It was noted that the left TMJ space was closed with callus formation and widespread sclerotic density increases around the joint (Figure 1). In the three-dimensional (3D) reconstruction of the skull, osseous fusion was determined between the ventral border of the mandibular fossa of the temporal bone in the left TMJ and the condyloid process, and in the zygomatic arch and coronoid process (Figure 2-A). In the right TMJ, subluxation between the mandibular fossa of the temporal bone and the condyloid process of the mandible and a flattened condyloid process were observed (Figure 2-B). After the diagnosis, it was informed that the cat owner's child had accidentally stepped on the head of the cat 3 months ago and that the lesion might have occurred at that time.



**Figure 1.** Case 1, non-contrast transverse CT scan showing loss of joint space with diffuse bone proliferation associated with moderate ankylosis in the left TMJ. Periarticular callus formation is also seen in the medial and lateral angles of the mandibular fossa of the temporal bone and the condyloid process of the mandible (arrow) (L: left).



**Figure 2 (A)** Case 1, 3D reconstruction of the left TMJ showing osseous fusion between the zygomatic arch and the coronoid process (arrow), and between the mandibular fossa of the temporal bone and the condyloid process of the mandible (arrowhead). **(B)** 3D reconstruction of subluxation of the right TMJ at the same level and flattening on the dorsal surface of the condyloid process (arrowhead) (1: mandibular fossa of temporal bone, 2: condyloid process, 3: Zygomatic arch, 4: Zygomatic process of temporal bone, 5: coronoid process)

The cat was premedicated with dexmedetomidine (4 mcg/kg, IM) (Dekstomid® 200 mcg/2 mL, Polifarma İlaç, Tekirdağ Turkey), ketamine (3 mg/kg, IM) (Alfamine® %10, Alfasan International B.V., Woerden, Holland) and butorphanol (0.3 mg/kg, IV) (Butomidor® 10 mg/mL, Richter Pharma AG, Wels, Austria) one week later for surgery. Propofol 1% (2 mg/kg, IV) (Propofol-PF® %1, 200 mg/20 mL IV, Polifarma İlaç, Tekirdağ, Turkey) was injected for anesthesia induction. A temporary tracheostomy was performed by positioning in dorsal recumbency and general anesthesia with sevoflurane was maintained.

Before surgery, cephalexin (20 mg/kg) (Cefatek® %15, Teknovet İlaç, Tekirdağ, Turkey) was injected intramuscularly. The left TMJ surgical area of the head was routinely prepared in the right lateral recumbency position. In order to expose the condyloid process, a diagonal skin incision was made about 3 cm towards the caudal of the TMJ, following the ventral border of the arcus zygomaticus. A partial periosteal incision was made in the origin of the masseter muscle at the ventral caudal border of the zygomatic arch, and the masseter muscle was retracted in the rostroventral direction. Condyloid process and joint structure were exposed by incision made in the joint capsule. First, small perforations were made on the caudoventral border of the zygomatic arch, the ventral area of the coronoid process, and the condyloid process using a low speed hand piece. A partial ostectomy of approximately 1.5 cm of the zygomatic bone was performed at the caudoventral border of the zygomatic arch. Then, the condyloid process was removed from the base of the neck using bone chisels and rongeurs. The subcutaneous tissue was dissected dorsally in the direction of the temporal muscle. The deep temporal fascia covering the temporalis muscle was exposed by incising the superficial temporal fascia. The temporal myofascial flap, which was lifted with a periosteal elevator, was rotated over the zygomatic arch and sutured to the newly created joint space with 3/0 polyglactin. Mouth opening was evaluated intraoperatively by moving the lower jaw with up and down manipulations. The surgical site was routinely closed.

Recovery from anesthesia was uncomplicated. Postoperatively, cephalexin (20 mg/kg, IM) (Cefatek® %15, Teknovet İlaç, Tekirdağ, Turkey) was administered for 7 days and meloxicam (Metacam® 0.5 mg/mL, BI Promeco, Mexico) for 5 days (0.2 mg/kg for the first 24 h, 0.1 mg/kg orally once a day for the next four days). The patient was alert and re-

sponsive the next morning, and could also eat a small amount of soft food.

In order to prevent the recurrence of ankylosis and to ensure adequate opening of the lower jaw, the owner was recommended to perform daily physical therapy for three weeks. Physical therapy consisted of manually opening the mouth gently to the maximum extent in the morning and evening. It was also recommended that soft food be given every 2 h for a week, followed by a gradually return to hard food, to promote food grip and natural range of motion of the lower jaw. A continued increase in range of motion was seen at the 3rd week postoperative follow-up. It was observed that the cat closed its lower jaw with voluntary masticatory movements and functional occlusion findings. There was no sign of friction or pain when the mouth was fully opened manually. The maximum jaw opening was measured as 26 mm. It was recommended to continue physical therapy with the same movements twice a day and to continue feeding with more than one meal frequency.

In the 3rd month follow-up, the cat was able to eat normally without showing any signs of pain and reached normal body condition (5/9). No deviation was detected in the lower jaw. It was decided to terminate physical therapy. During the one-year follow-up period, it was determined that the range of motion of lower jaw was preserved without any signs of recurrence of open mouth jaw locking.

## CASE 2

A 3 years old, 4.4 kg, male neutral, domestic short-hair cat was brought to our clinic with the complaint of open mouth and jaw locking. In the anamnesis, it was informed that the cat was adopted with the finding of open mouth jaw locking, and there was no known trauma that the cat may have had in the past or recently.

The clinical examination of the cat, which looked mildly anxious, found a heart rate of 119 beats/min, a respiratory rate of 22 breaths/min, and a rectal temperature of 39.1°C. It was noted that the craniomaxillary muscles were more swollen on the right side. The lower jaw was symmetrical and robust. Despite the manipulative forces in opposite directions, the lower jaw was in a permanently partially open position. Maximum jaw opening was 5 mm. No signs of pain on palpation of the skull and craniomaxillary muscles, and no crepitation was detected on palpation of the

TMJ. The body condition score was low due to malnutrition (2/9). No other lesion was observed in the examination of the oral cavity and its surroundings.

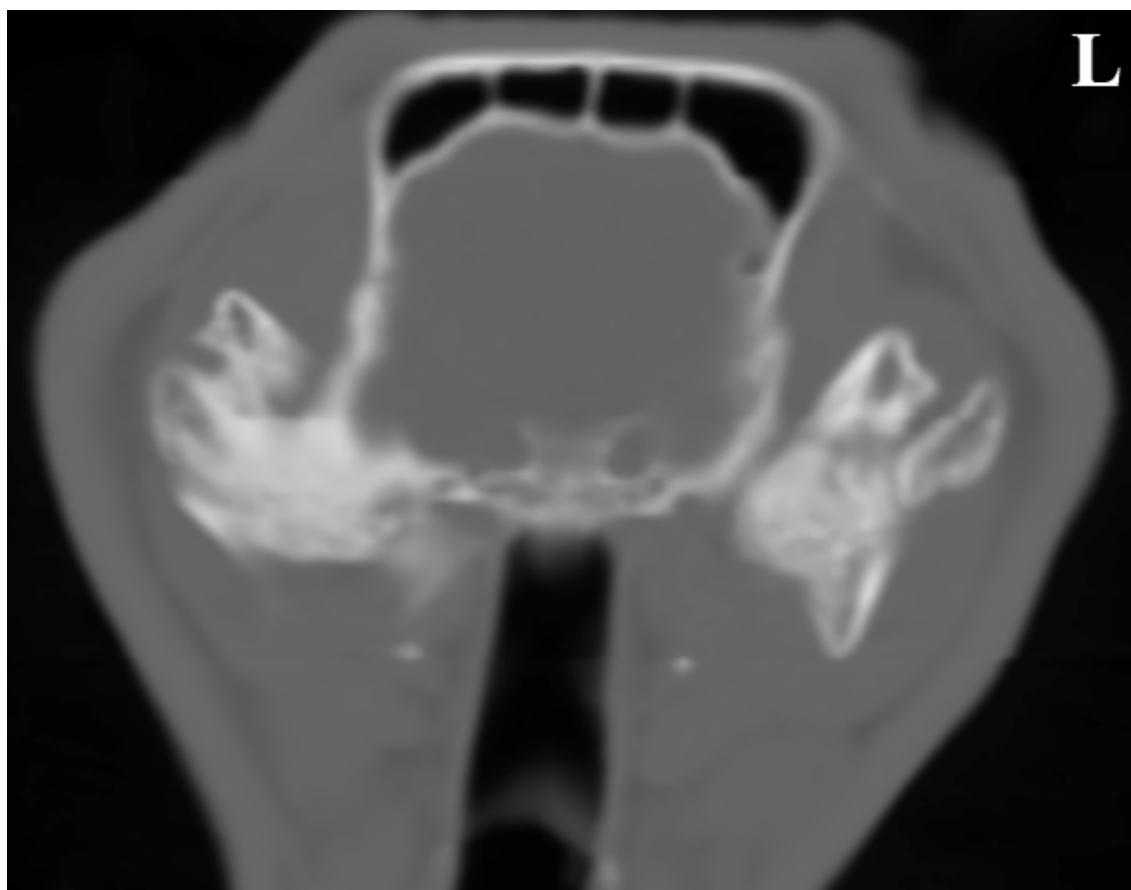
On radiographic examination without sedation, lateral oblique skull radiograph showed possible involvement of both TMJs causing ankylosis. Then, in the CT scan, the patient was positioned in the dorsal recumbency position in the gantry. Non-contrast transverse CT scan (256-slice CT-scanner with at 0.625 mm) (GE Revolution Waukesha, USA) showed complete loss of joint space in bilateral TMJ. Widespread sclerotic density increases were observed in TMJs, more prominently in the right TMJ. Linear hypodense line of an old fracture was observed in the bones forming the joint in the left TMJ. Severe bilateral ankylosis was determined in both TMJ due to deformational abnormalities (Figure 3).

The cat underwent the same sedation and general anesthesia protocol used in Case 1 and was taken into surgery for first right TMJ and then left TMJ. A tem-

poral myofascial flap was performed using the same surgical approach and technique described in Case 1. However, zygomatic arch partial ostectomy was performed in a larger area in both TMJs. Recovery from anesthesia was uncomplicated, and the same antibiotic and NSAID protocol as in Case 1 was used postoperatively.

The patient was alert the next morning but less concerned with the environment than in Case 1. First of all, physical therapy and a special feeding program were created for 3 weeks postoperatively. The cat owner was recommended a daily physical therapy practice, which consisted of manually opening the mouth in the morning and evening to the maximum extent. The feeding diet consisted of giving soft food to make it easier to mastication and then gradually switching to hard food every 2 h.

In the 3rd week follow-up, it was observed that the cat had a 28 mm jaw opening and closed its lower jaw with functional occlusion finding. There was no



**Figure 3.** Case 2, non-contrast transverse CT scan showing deformational abnormalities in both TMJs. In both TMJs, it was observed that there was no dark line representing the normal joint space and osseous fusion was formed in the joint spaces. The mandibular fossa of the temporal bones and the condyloid processes of the mandible were extremely misshapen and thickened with irregular bone proliferation (L: left).

evidence of friction on manual opening of the lower jaw. It was recommended to reduce the feeding diet and continue physical therapy.

Although a deviation of approximately 3 mm to the left of the lower jaw was observed in the 3rd month follow-up, the patient was able to eat normally without pain. It was observed that the quality of life increased and reached normal body condition (5/9). It was decided to discontinue feeding diet and physical therapy. In the six-month and 1-year follow-up, it was observed that the deviation to the left continued at the same distance, but the mandibular range of motion was maintained without any signs of re-ankylosis with a high quality of life.

## DISCUSSION

True and false ankylosis of the TMJ are not common in cats. True ankylosis is mainly caused by trauma, while false ankylosis is caused by trauma, luxation, neoplasms, and masseter muscle myositis (Okumura et al., 1999; Bar-Am et al., 2008; Gatineau et al., 2008; Nutt et al., 2018; Knight and Meeson, 2019). TMJ ankylosis due to fracture has been shown to be the most common cause of open mouth locking of the jaw (54%) (Gatineau et al., 2008). In TMJ, subluxation cases may not be malocclusion, but luxation cases necessarily progress with malocclusion (Arzi and Lantz, 2020). In our study, the subluxation in Case 1 did not progress with malocclusion. Since this case did not complete its skeletal development, it was thought that ankylosing in the left TMJ affected bone development and caused subluxation in the right TMJ. The formation of callus due to a bilateral fracture in the TMJ of the cat in Case 2 suggested that it may have been exposed to a severe trauma affecting the skull from both sides, such as a traffic accident. Trauma, the major etiologic factor of TMJ ankylosis, was similar to previous studies (Okumura et al., 1999; Bar-Am et al., 2008; Gatineau et al., 2008; Çetinkaya, 2012; Knight and Meeson, 2019). Diagnosis of lesions in TMJ ankylosis, differential diagnosis and determination of the most appropriate treatment plan for the problem is difficult. If surgery is to be performed with the correct diagnosis and treatment, determining the surgical field boundaries with the most appropriate surgical option also complicates the management of ankylosis cases. For this purpose, the use of CT together with anamnesis, clinical findings, physical examination and radiography is extremely important for the application of the correct surgical technique and optimal results in the management of ankylosis

cases (Bar-Am et al., 2008; Larguier and Jamet, 2015; Knight and Meeson, 2019).

Radiography was used for diagnosis in cases of TMJ ankylosis before the use of CT was introduced. For this purpose, radiographic images of TMJ in oblique lateral position are required. However, radiographic findings cannot provide sufficient data for detailed evaluation of TMJ, failure to detect other possible underlying causes, and determination of suspicious conditions such as TMJ dysplasia. Due to such limitations of radiography, difficulties in determining the triggering cause and definitive diagnosis have brought the use of CT to the fore (Maas and Theyse, 2007; Bar-Am et al., 2008). CT is a imaging diagnostic method that provides rapid and detailed examination with the feature of evaluating bone structures in different planes (sagittal, transverse and dorsal) and creating 3D reconstructions (Maas and Theyse, 2007). CT scans may not identify all soft tissue lesions despite high quality and high definition images, but it is still superior to radiography in providing soft tissue information and has proven invaluable in these cases (Okumura et al., 1999; Beam et al., 2007). It has a critical importance in the evaluation of etiology and pathology mechanisms of all lesions that require detail such as cranial trauma, symphyseal laxity, TMJ dysplasia. In addition to providing a definitive diagnosis and prognosis, the importance of CT increases as it also allows resection of ankylosing tissue in false ankylosis and surgical planning in gap arthroplasty in true ankylosis (Okumura et al., 1999; Beam et al., 2007; Maas and Theyse, 2007). Although the size of the lesion was defined in the transverse plane in the current study, the imaging of the osseous fusion between the zygomatic arc and coronoid process in 3D reconstruction shed light on preoperative planning along with the diagnosis. In both cases, the anamnesis was insufficient and the etiology was unknown. Although possible involvement of the TMJ was recognized on radiography, the etiology and correct diagnosis were determined only on CT. This case report provides useful information for veterinarians who encounter similar cases in determining the etiology and differential diagnosis of TMJ cases with insufficient anamnesis.

In the treatment of TMJ ankylosis, it is aimed to identify the primary cause and to alleviate/eliminate this cause. Surgical intervention with the least invasive technique is recommended to restore the normal range of motion of the lower jaw and prevent its re-

currence (Gatineau et al., 2008; Larguier and Jamet, 2015). Surgical osteoplasty of the TMJ is based on the removal of dense fibrous or bone tissue (Maas and Theyse, 2007; Gatineau et al., 2008; Nutt et al., 2018). Excisional arthroplasty describes condylar processus, caudal part of the zygomatic arch, and extensive resection of the mandible (Bar-Am et al., 2008; Gatineau et al., 2008; Nutt et al., 2018; Mittal et al., 2019). It has also been reported that condylectomy can be performed only in pathologies affecting the condylar process (Çetinkaya, 2012). These surgical techniques can also be performed bilaterally. Successful results are obtained by providing an acceptable range of motion of the lower jaw and improving the appearance of the lower jaw. However, it has not been determined how much tissue should be resected around the TMJ to provide acceptable range of motion in the TMJ ankylosis (Maas and Theyse, 2007; Bar-Am et al., 2008; Gatineau et al., 2008; Mittal et al., 2019). In the study, sufficient range of motion of lower jaw was achieved with excisional arthroplasty technique in three TMJs. Therefore, the excisional arthroplasty technique can be considered as less invasive despite the large resection area.

Alloplastic and autogenic materials have been used for a long time in human medicine to protect the gap formed in TMJ ankylosis surgery, isolate the cut edges and prevent the recurrence of ankylosis (interpositional gap arthroplasty). It has been reported that autogenous materials for interpositioning have a much lower rate of re-ankylosis than alloplastic materials (Mestrinho et al., 2015). Autogenous materials such as temporal myofascial flap and fat graft were used for interpositioning in cats and successful results were obtained (Heo et al., 2008; Larguier and Jamet, 2015; Nutt et al., 2018; Mittal et al., 2019). In the current study, the temporal myofascial muscle was easily

transposed in both cases and provided solid support to the TMJ. As stated by the researchers, temporal myofascial flap is a useful and valuable autogenous material for interpositional gap arthroplasty in TMJ surgery in cats (Heo et al., 2008; Mittal et al., 2019). In order to prevent re-ankylosis, a new callus or fibrosis after condylectomy or excisional arthroplasty in TMJ ankylosis, physical therapy based on manual opening of the lower jaw, and a special diet programme is required for about 4 weeks (Okumura et al., 1999; Bar-Am et al., 2008; Gatineau et al., 2008; Çetinkaya, 2012; Nutt et al., 2018). In the postoperative 3 and 12 months follow-up, it was observed that the maximal opening of the lower jaw did not change in both cases, with a mild malocclusion that did not affect the feeding in Case 2. The physical therapy and diet program are a part of the whole treatment postoperatively. Therefore, the importance of following this program completely and patiently should be informed to the cat owner in preoperative planning.

In conclusion, TMJ should be evaluated comprehensively in terms of intra-articular positional and periarticular structural abnormalities in cats with suspected TMJ disorders. CT scan with 3D reconstruction allows to determine the underlying cause and severity of the lesion in TMJ ankylosis with insufficient anamnesis and unknown etiology. At the same time, it is a imaging diagnostic method that is of indispensable importance for determining the surgical technique and surgical limit in preoperative planning.

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#### CONFLICT OF INTEREST

None declared.

## REFERENCES

- Arzi B, Cissell DD, Verstraete FJ, Kass PH, DuRaine GD, Athanasiou KA (2013) Computed tomographic findings in dogs and cats with temporomandibular joint disorders: 58 cases (2006-2011). *J Am Vet Med Assoc* 242 (1):69-75.
- Arzi B, Lantz GC (2020) Fractures and luxations involving the temporomandibular joint. In: *Oral and maxillofacial surgery in dogs and cats*. 2nd ed, Elsevier, St Louis, MO: pp368-376.
- Bar-Am Y, Pollard RE, Kass PH, Verstraete FJM (2008) The diagnostic yield of conventional radiographs and computed tomography in dogs and cats with maxillofacial trauma. *Vet Surg* 37 (3):294-299.
- Beam RC, Kunz DA, Cook CR, Carson RL, Briscoe P, Cook JL (2007) Use of three-dimensional computed tomography for diagnosis and treatment planning for open-mouth jaw locking in a cat. *J Am Vet Med Assoc* 230 (1):59-63.
- Çetinkaya MA (2012) Temporomandibular joint injuries and ankylosis in the cat. *Vet Comp Orthop Traumatol*, 25 (5):366-374.
- Gatineau M, El-Warrak AO, Marretta SM, Kamiya D, Moreau M (2008) Locked jaw syndrome in dogs and cats: 37 cases (1998-2005). *J Vet Dent* 25 (1):16-22.
- Heo SY, Lee HB, Lee KC, Kim NS (2008) Reconstruction of temporomandibular joint ankylosis with temporalis myofascial flap in a cat: A case report. *Vet Med (Praha)* 53 (5):277-281.
- Knight R, Meeson RL (2019) Feline head trauma: A CT analysis of skull fractures and their management in 75 cats. *J Feline Med Surg* 21

- (12):1120-1126.
- Larguier L, Jamet N (2015) False ankylosis of the temporomandibular joint in a cat. *Vet Comp Orthop Traumatol* 28 (6):455-458.
- Maas CPHJ, Theyse LFH (2007) Temporomandibular joint ankylosis in cats and dogs. A report of 10 cases. *Vet Comp Orthop Traumatol*, 20 (3):192-197.
- Mestrinho LA, Gawor JP, Serrano AM, Niza MM (2015) Superficial temporal myofascial flap application in temporomandibular joint arthroplasty in a cat. *J Feline Med Surg Open Rep* 1 (2):1-5.
- Mittal N, Goyal M, Sardana D, Dua JS (2019) Outcomes of surgical management of TMJ ankylosis: A systematic review and meta-analysis. *J Craniomaxillofac Surg* 47 (7):1120-1133.
- Nutt AE, Anderson T, Gracis M, Doran I, Warren-Smith C, Langley-Hobbs SJ (2018) Open-mouth jaw locking in cats: A literature review and use of CT in three cases. *J Feline Med Surg*, 20 (12):1180-1191.
- Okumura M, Kadosawa T, Fujinaga T (1999) Surgical correction of temporomandibular joint ankylosis in two cats. *Aust Vet J*, 77 (1):24-27.
- Zavodovskaya R, Vapniarsky N, Garcia T, Verstraete FJM, Hatcher DC, Arzi, B (2020.) Intra-and extra-articular features of temporomandibular joint ankylosis in the cat (*Felis catus*). *J Comp Pathol* 175:39-48.