Computed tomographic findings in dogs and cats with temporomandibular joint disorders: 58 cases (2006–2011)

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Objective—To describe CT findings in dogs and cats with temporomandibular joint (TMJ) disorders.

Design—Retrospective case series.

Animals—41 dogs and 17 cats.

Procedures—Medical records and CT images of the skull were reviewed for dogs and cats that were examined at a dentistry and oral surgery specialty practice between 2006 and 2011.

Results—Of 142 dogs and 42 cats evaluated, 41 dogs and 17 cats had CT findings consistent with a TMJ disorder. In dogs, the most common TMJ disorder was osteoarthritis; however, in most cases, there were other TMJ disorders present in addition to osteoarthritis. Osteoarthritis was more frequently identified at the medial aspect rather than the lateral aspect of the TMJ, whereas the frequency of osteoarthritic involvement of the dorsal and ventral compartments did not differ significantly. In cats, fractures were the most common TMJ disorder, followed by osteoarthritis. Clinical signs were observed in all dogs and cats with TMJ fractures, dysplasia, ankylosis, luxation, and tumors; however, only 4 of 15 dogs and 2 of 4 cats with osteoarthritis alone had clinical signs.

Conclusions and Clinical Relevance—Results indicated that TMJ disorders were frequently present in combination. Osteoarthritis was the most common TMJ disorder in dogs and the second most common TMJ disorder in cats. Computed tomography should be considered as a tool for the diagnosis of TMJ disorders in dogs and cats with suspected orofacial disorders and signs of pain. (J Am Vet Med Assoc 2013;242:69–75)

The TMJ is a synovial joint in which the condylar process of the mandible articulates with the mandibular fossa on the squamous portion of the temporal bone, and both the condylar process of the mandible and the mandibular fossa of the temporal bone are covered with a unique fibrocartilaginous layer.1,2 A fibrocartilaginous articular disk separates the TMJ cavity into dorsal and ventral compartments.2 The disk extends medially from the articular surface of the condylar process of the mandible to the temporal bone via a ligamentous extension; thus, the disk fills the void between the condylar process and the mandibular fossa, which promotes the congruity of the joint.1,3 The TMJ joint capsule attaches to the articular disk circumferentially, and the lateral aspect of the joint capsule is additionally strengthened by a lateral ligament.2 Relative to the cranium, the mandibular fossa remains stationary; it is only the mandible that moves via the TMJ joint.1 The TMJ is primarily responsible for the hinge movement necessary for opening and closing the mouth, although in dogs, it also allows for a slight laterotrusion movement.1 In cats, the morphology of the TMJ is more restrictive such that independent movement of the mandible aside from hinge movement is minimal.1,4

Studies of TMJ disorders in dogs and cats are lacking and have been limited to those involving fractures resulting from trauma, dysplasia, and ankylosis.6–11 Temporomandibular joint disorders are often debilitating and frequently require medical or surgical treatment. In humans with TMJ disorders, the most common pathological change is degenerative joint disease, also known as osteoarthritis or osteoarthrosis, which is generally caused by displacement of the articular disk or some other intra-articular derangement.12,13 For patients with advanced degenerative TMJ disease, osteoarthritis can become crippling and result in a variety of morphological and functional abnormalities.12 For human patients, MRI is currently the standard-of-care diagnostic method for evaluation of the soft tissue and osseous components of TMJ disease.14 In
veterinary patients, the role of the soft tissues in the TMJ (i.e., the articular disk and its attachments) in the development of TMJ disorders is unknown, and CT remains an important diagnostic tool for the evaluation of the TMJ. Computed tomography is valuable for evaluation of osseous lesions as well as the spatial position of the TMJ bones, and CT images with 3-D reconstruction may improve understanding of the pathogenesis of TMJ lesions for selected patients. Moreover, results of 1 study suggest that CT is superior to conventional radiography of the skull for identification of anatomic structures and lesions in the maxillofacial regions of dogs and cats. The aim of the study reported here was to describe CT findings, including incidental findings, associated with the TMJ in a case series of dogs and cats.

Materials and Methods

Case selection—Medical records and CT images of the skull were reviewed for dogs and cats that were examined by the Dentistry and Oral Surgery Service at the University of California-Davis William R. Pritchard Veterinary Medical Teaching Hospital between January 2006 and December 2011. The patients were evaluated because of oral masses, trauma, signs of pain, and difficulty opening or closing the mouth, among other reasons, or for preoperative evaluation prior to an oral surgical procedure. Patients were included in the study if they had CT findings consistent with any type of TMJ disorder.

Medical records review—For each patient enrolled in the study, information obtained from the medical record included age, sex, breed, skull configuration (e.g., brachycephalic, mesaticephalic, or dolichocephalic), body weight, history, and clinical signs. Computed tomographic images were reviewed and scored.

CT procedure and review—Each patient was anesthetized, and 1 of 2 CT scanners was used to obtain high-quality contiguous transverse collimated images of the skull. For dogs, the transverse collimated images were obtained at a thickness of ≤1.25 mm (n = 22 dogs), 2 to 3 mm (16 dogs), or 5 mm (3 large-breed dogs). For cats, the transverse collimated images were obtained at a thickness of ≤1 mm (n = 12 cats), 2 mm (4 cats), or 3 mm (1 cat). Evaluation of osseous structures was performed with a window width of 2,500 Hounsfield units and window level of 480 Hounsfield units, and evaluation of soft tissue structures was performed with a window width of 750 Hounsfield units and window level of 200 Hounsfield units. All digital CT images were evaluated on a medical-grade flat-screen monitor with com-

Figure 1—Computed tomographic images of the TMJs of 3 dogs with mild (semiquantitative score, 1; A), moderate (semiquantitative score, 2; B), or marked (semiquantitative score, 3; C) osteoarthritis. Notice the periarticular new bone formation at the medial aspect of the condylar process of the mandible (solid white arrows) in all 3 panels. Additionally, in panel B, notice the narrowing of the medial portion of the TMJ space, and in panel C, notice the biaxial, symmetric narrowing of the TMJ space, lysis of the subchondral bone of the mandibular fossa of the temporal bone (open arrow), and diffuse sclerosis of the condylar process of the mandible.

Table 1—Frequency distribution of TMJ disorders identified on CT images for 41 dogs evaluated at a dentistry and oral surgery specialty practice between 2006 and 2011.

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Osteoarthritis</th>
<th>Fracture</th>
<th>Dysplasia</th>
<th>Ankylosis</th>
<th>Luxation</th>
<th>Tumor or cyst</th>
<th>MMM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Osteoarthritis</td>
<td>15</td>
<td>1</td>
<td>7</td>
<td>4</td>
<td>3</td>
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<td>2</td>
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<tr>
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<tr>
<td>Dysplasia</td>
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<td>Ankylosis</td>
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<tr>
<td>Luxation</td>
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<td>0</td>
</tr>
<tr>
<td>Tumor or cyst</td>
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<td>0</td>
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<td>1</td>
<td>0</td>
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<tr>
<td>MMM</td>
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<td>0</td>
</tr>
</tbody>
</table>

MMM = Masticatory muscle myositis.

Dogs with >2 concurrent TMJ disorders are represented multiple times within a column or row (e.g., a dog that had osteoarthritis, fracture, and luxation would be represented in the osteoarthritis and fracture categories as well as the osteoarthritis and luxation categories).
mercially available software and scored by 2 investigators (BA and DDC), one of whom was a board-certified veterinary radiologist (DDC) who was unaware of the patient’s diagnosis. When necessary, 3-D reconstructive images were generated to assess the spatial relationship of the bones of the TMJ (eg, to diagnose luxations or subluxations). For each patient, the right and left TMJ were evaluated independently. Images were evaluated for the presence and location of fractures, joint space narrowing, ankylosis, periarticular new bone formation, and subchondral bone sclerosis or lysis. The severity of osteoarthritis in each TMJ was scored by the use of a 4-point semiquantitative system as follows: 0 = no osteoarthritis detected, 1 = mild (early signs of periarticular new bone formation with minimal or no joint space narrowing or subchondral bone change), 2 = moderate (moderate periarticular new bone formation, joint space narrowing, or subchondral bone sclerosis), or 3 = marked (severe periarticular new bone formation, joint space narrowing, or subchondral bone sclerosis or lysis; Figure 1).17

Statistical analysis—Computer software was used to perform all statistical analyses. A χ² test for independence was used to evaluate the distribution of TMJ fracture locations and the respective associations between osteoarthritis and each of the following: age, sex, skull conformation, and body weight. A χ² goodness-of-fit test was used to evaluate the distributions of osteophytosis and narrowing of the TMJ space. Binomial 95% confidence intervals were calculated for the presence of signs of pain and osteoarthritis only. For all analyses, values of $P < 0.05$ were considered significant.

Results

Between January 2006 and December 2011, 142 dogs and 42 cats underwent a CT examination of the skull, of which 43 (30%) dogs and 18 (43%) cats had CT findings consistent with TMJ disorders. However, 2 dogs and 1 cat with TMJ disorders were excluded from the analyses because the CT image quality was insufficient to evaluate all of the TMJ abnormalities examined in the study; thus, data from only 41 dogs and 17 cats are presented.

Dogs—The distribution of TMJ disorders in dogs was summarized (Table 1). Of the 41 dogs with TMJ disorders, 32 had osteoarthritis, 11 had fracture, 7 had dysplasia, 4 had ankylosis, 4 had luxation, 2 had a tumor, 1 had a cyst, and 2 had masticatory muscle myositis; some dogs had ≥2 TMJ disorders. Twenty-six of 32 (81.3%) dogs had evidence of osteoarthritis in both TMJs, whereas 6 dogs had evidence of osteoarthritis in only 1 TMJ. Osteoarthritis was observed as the only TMJ abnormality in 13 of the 41 (36.6%) dogs; the other 17 dogs with osteoarthritis also had at least 1 additional TMJ disorder. For dogs with osteoarthritis of the TMJ, osteophytes were more frequently detected at the medial aspect of the joint rather than at the lateral aspect of the joint (P < 0.001; Figure 2). Most dogs with osteoarthritis of the TMJ had narrowing of the joint space biaxially, but for those dogs without biaxial narrowing of the joint space, the joint space was more frequently narrowed at the medial rather than at the lateral aspect of the joint (P < 0.001; Figures 3 and 4). Age, sex, and body weight were not associated with the presence

![Figure 2](image-url) Location of osteophytes in the right (dark gray) and left (light gray) TMJs of 41 dogs with TMJ disorders as determined via evaluation of CT images. All dogs are represented twice (once for the right TMJ and once for the left TMJ). *Within a TMJ (ie, right or left), value differs significantly (P < 0.001) from that for lateral and biaxial aspects of the TMJ.

![Figure 3](image-url) Computed tomographic images of the TMJs of 3 dogs with concurrent osteoarthritis and narrowing of the medial (A), lateral (B), or biaxial (C) aspects of the TMJ. For all panels, medial is to the left.
or severity of osteoarthritis in affected dogs. Osteoarthritis of the TMJ was more frequently detected in dogs with a mesaticephalic skull conformation than in dogs with either a brachycephalic or dolichocephalic skull conformation ($P < 0.001$). Of the 15 dogs in which the only TMJ disorder detected was osteoarthritis, only 4 had clinical signs of pain during opening and closing of the mouth ($n = 2$) or decreased range of motion (2) in the joint. During physical and oral examinations, all 7 dogs with concurrent TMJ osteoarthritis and dysplasia had decreased range of motion in the joint and signs of pain during opening and closing of the mouth. Subchondral sclerosis of the temporal bone and the condylar process of the mandible was detected with similar frequency in both the left and right TMJs; however, subchondral sclerosis of both bones was more frequently detected in the right TMJ ($P < 0.05$; Figure 5). One dog had a multilobular tumor of the bone and 1 dog had an osteosarcoma. Another dog had a well-defined, non–contrast-enhancing, fluid-filled structure at the medial aspect of the joint, which was presumed to be...

**Figure 4**—Location of joint space narrowing in the right (dark gray) and left (light gray) TMJs of 41 dogs with TMJ disorders as determined via evaluation of CT images. All dogs are represented twice (once for the right TMJ and once for the left TMJ). *Excluding biaxial TMJ narrowing, within a TMJ (ie, right or left), value differs significantly ($P < 0.001$) from that for the medial aspect of the TMJ.

**Figure 5**—Location of subchondral bone sclerosis in the right (dark gray) and left (light gray) TMJs of 41 dogs with TMJ disorders as determined via evaluation of CT images. All dogs are represented twice (once for the right TMJ and once for the left TMJ). *Between TMJs (ie, right or left), value differs significantly ($P < 0.05$).

**Figure 6**—Computed tomographic images of the TMJs of 3 dogs with a comminuted fracture of the condylar process of the mandible (A), simple fracture of the mandibular fossa of the temporal bone (B), or comminuted fracture of the mandibular fossa of the temporal bone and a simple displaced fracture of the medial aspect of the condylar process of the mandible (C). For all panels, medial is to the left.

**Figure 7**—Location of fractures in the bones of the TMJs of dogs ($n = 11$; dark gray) and cats ($n = 9$; light gray). *Within a location, value differs significantly ($P < 0.05$) from that for dogs.
the skull during the study period, which allowed us to identify TMJ abnormalities even in patients that did not have clinical signs of disease.

Investigators of human and animal studies\(^{10,18}\) concluded that advanced imaging such as MRI and CT was critical for the assessment of the underlying etiology and pathological mechanisms of TMJ disorders. Furthermore, during evaluation of a TMJ disorder, an attempt should be made to identify all of the components of the disease rather than focusing only on the obvious abnormality. For example, patients with or without clinical signs of TMJ disorders such as subluxation or dysplasia that subsequently develop osteoarthritis of the TMJ may have an unfavorable long-term prognosis.\(^{12,19,20}\)

Osteoarthritis of the TMJ is an arthritic condition characterized by minimal inflammation that is either primary or secondary to trauma, abnormal morphology, or other acute or chronic overload situations.\(^{11,21}\) The pathogenesis of osteoarthritis of the TMJ is characterized by erosion, deterioration, and abrasion of the articular fibrocartilage as well as localized thickening and remodeling of the subchondral bone and development of marginal osteophytes.\(^{13,15,22}\)

We were surprised to find that osteoarthritis was the most common TMJ disorder in dogs because osteoarthritis of the TMJ of dogs has been reported by investigators of only 1 other study.\(^{13}\) The prevalence of osteoarthritis in the TMJ of dogs in the present study was similar to that for human patients.\(^{23}\) Moreover, CT findings for human patients with osteoarthritis of the TMJ suggest that affected patients have a high rate of bony changes (condylar process involvement, 61%; temporal bone involvement, 47%).\(^{24}\) Although the etiology of osteoarthritis in human patients likely differs from that in dogs because osteoarthritis of the TMJ in human patients is commonly associated with TMJ disk displacement (ie, internal derangement),\(^{12,24}\) Also, in human patients, osteoarthritis of the TMJ develops more frequently in women,\(^{13,22}\) whereas in the present study, we did not find an association between sex and the presence of osteoarthritis in the TMJ. In a study\(^{25}\) in which human autopsy results were reviewed, macroscopic or microscopic evidence of osteoarthritis or articular remodeling was detected in the TMJ of 57 of 102 (56%) middle-aged and older individuals.

In the present study, no association was found between the presence and severity of osteoarthritis of the TMJ and age or body weight. This finding is contrary to the development of osteoarthritis in appendicular joints, in which both age and body weight are associated with the incidence and severity of osteoarthritis.\(^{17,26,27}\) The reason for the contrary findings for the effect of age and body weight on the development of osteoarthritis in TMJs versus appendicular joints is unknown, but we suspect that it may be related to the difference in load-bearing forces sustained by the TMJs, compared with those sustained by the appendicular joints.

Results of the present study indicate that periarticular new bone formation and narrowing of the joint space develop more frequently at the medial rather than the lateral aspect of the TMJ of dogs. In humans, the TMJ is considered to be load bearing during mastication.

Table 2—Frequency distribution of TMJ disorders identified on CT images for 17 cats evaluated at a dentistry and oral surgery specialty practice between 2006 and 2011.

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Fracture</th>
<th>Osteoarthritis</th>
<th>Luxation</th>
<th>Ankylosis</th>
<th>Tumor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fracture</td>
<td>5</td>
<td>2</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Osteoarthritis</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Luxation</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ankylosis</td>
<td>0</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Tumor</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

Cats with ≥ 2 concurrent TMJ disorders are represented multiple times within a column or row (eg, a cat that had fracture, osteoarthritis, and luxation would be represented in the fracture and osteoarthritis categories as well as the fracture and luxation categories).
osteoarthritis in the joint.12,22,31,32 Similarly, parafunc-
tional movement of the TMJ may result in initiation and progression of
the normal adaptive capacity of the articular structures
altered mechanical forces.

The medial aspect of the joint to osseous remodeling via
TMJ results in excessive movement at the lateral aspect
ings contradict the assumption that the obliquity of the
creased load bearing or mechanical stress. These find-
dogs, the medial aspect of the TMJ is subjected to in-
chronic arthritic changes were detected in the TMJ of 12 of 34
mouth.15 In patients with suspected TMJ disorders,
pain during rest or during opening or closing of the
decreased range of motion of the TMJ, or signs of jaw
masticatory muscle myositis may result in altered mecha-
nical forces in the TMJ and cause degenerative changes.33
In the present study, both dogs with masticatory muscle
myositis also had concurrent osteoarthritis of the TMJ.

Patients with TMJ disorders commonly have signs of
pain and decreased function (ie, decreased range of
motion) of the joint.12 It is likely that the signs of pain
develop because the soft tissues around the affected
joint and the masticatory muscles undergo a protective
reflex spasm in accordance with Hilton’s law,34 which
states that the nerves that innervate a joint also inner-
vate the muscles that move that joint. Thus, contrac-
tion of the surrounding muscles in response to injury
or disease of the TMJ may protect the joint from further
damage.12 Signs of pain may also develop as the result of
the arthritic destruction of the subchondral bone of the
TMJ.12 In the present study, only 4 of 15 dogs and 2
of 4 cats in which the only TMJ disorder detected was
osteoarthritis had clinical signs of pain. Those findings
were similar to findings in human patients, in which
arthritic changes were detected in the TMJ of 12 of 34
(35%) patients who had no clinical signs35 and in 19
of 30 (63%) and 24 of 32 (75%) patients with juvenile
idiopathic arthritis, most of whom had no clinical signs
at the time of evaluation.36–38

Temporomandibular joint fractures and luxations
generally result from trauma16,39 and are often detected
concurrently with other maxillofacial injuries, especial-
ly in cats.4,16 In the present study, TMJ fractures were
the most common TMJ disorder detected in cats and the
second most common TMJ disorder detected in dogs.
The condylar process of the mandible was fractured in all
the study cats with TMJ fractures, whereas in the study
dogs with TMJ fractures, the condylar process of the
mandible and the temporal bone were affected with
similar frequency. It is possible that the difference in the
configuration of the skull of cats, compared with the
configuration of the skull of dogs, caused the difference
in the distribution of TMJ fracture locations between
cats and dogs. In human patients, fracture of the con-
dylar process of the mandible can cause a displacement of
the articular disk, which removes the physical im-
pediment to transarticular bony fusion and may result in
TMJ ankylosis.40–42 Also, the position of the articular
disk in the TMJ was significantly associated with the
position of the fractured bone fragments.40 However,
despite the association of articular disk displacement
with fractures of the TMJ, post-traumatic TMJ ankylo-
sis is rare in human patients, with an annual incidence
rate of approximately 0.4%.41 Post-traumatic ankylo-
sis of the TMJ was similarly rare in the cats and dogs
of the present study; none of the cats and only 2 dogs
with TMJ fractures had concurrent ankylosis. The role
of displacement of the articular disk following fracture
of a bone of the TMJ in cats and dogs remains to be
elucidated.

High-quality CT images are essential for accurate
diagnosis of TMJ disorders. In the present study, we
included 3 dogs in which the TMJ was evaluated via
transverse collimated CT images with a slice thick-
ness of 3 mm; however, all 3 dogs were large-breed
dogs and the CT images were of sufficient quality that
all of the various TMJ characteristics described in the
study could be evaluated. For dogs or cats with sus-
ppected TMJ disorders, it is recommended that evalua-
tion of the TMJ should be performed with collimated
transverse CT images at a slice thickness of ≤ 1 mm
evertheless possible. Furthermore, it is critical to care-
fully position the patient’s skull within the CT gantry to
achieve near-perfect symmetry between the right and
left sides of the skull. Evaluation of thicker collimated
transverse CT images or failure to position the skull
appropriately within the CT gantry will make diagnosis
of TMJ disorders more difficult because of the potential
introduction of artifacts associated with slice thickness
and asymmetry on the images.

High-definition CT imaging of the TMJ is an es-
ential part of a diagnostic workup for dogs and cats
with trauma to the skull, malocclusion of the jaws,
decreased range of motion of the TMJ, or signs of jaw
pain during rest or during opening or closing of the
mouth.15 In patients with suspected TMJ disorders,
the TMJ should be comprehensively evaluated before
treatment because TMJ disorders are characterized by
intra-articular positional or structural abnormalities
and often involve multiple disease process. Also, on the
basis of the results of the present study, osteoarthritis of
the TMJ was common alone and in combination with
other TMJ disorders and should be included as a dif-
ferential diagnosis during evaluation of all patients
with suspected TMJ disorders. Further research is neces-
sary to determine the role that the soft tissues of the TMJ
have in the development of TMJ degenerative changes.

a. HiSpeed Fx/i, GE Healthcare, Little Chalfont, Buckinghamshire,
England.
b. Lightspeed 16, GE Healthcare, Milwaukee, Wis.
c. eFilm Workstation 2.1.0, eFilm Medical Inc, Toronto, ON, Canada.

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