Equine Temporomandibular Joints (TMJ): Morphology, Function, and Clinical Disease

Gordon J. Baker, BVSc, PhD, MRCVS, Diplomate ACVS

TMJ are complex but well designed fulcra that leverage the masticatory power of muscles and dental apparatus (teeth). Newer imaging techniques and arthroscopic evaluation have expanded the clinician’s ability to evaluate and treat TMJ disease. Author’s address: University of Illinois College of Veterinary Medicine, 218 LAC, 1008 W. Hazelwood Drive, Urbana, IL 61802. © 2002 AAEP.

1. Introduction

The clinical signs of TMJ disease may include muscle asymmetry, heat and pain on palpation and mandibular manipulation, and changes in the range of mandibular movement. These are often accompanied by observable changes in the way the horse carries its head, prehends and chews food materials. There may be changes in accepting the bit and other head harness, as well as abnormalities detected by the rider or driver when horses with TMJ disease are exercised. It is the purpose of this presentation to review the TMJ structural morphology and function, and to give guidelines for clinical diagnosis and treatment.

2. Morphology

The temporomandibular joints (TMJ) are the diarthrodial articulations between the condylar processes of the mandibles and the articular tubercles of the temporal bones. Each TMJ has an articular disc—shaped as a slightly straightened “C”—that functions to eliminate articular incongruities (Fig. 1). Ligaments on the lateral aspects of the joints attach dorsally to the zygomatic arches and retroarticular processes and ventrally to the mandibular necks. The ligaments of the TMJ are incorporated into the joint capsules and stabilize the intraarticular discs. The caudal ligaments have large discal attachments. The discs divide the TMJs into dorsal and ventral components. Recent studies, documenting the use of radiography, ultrasonography, and computed tomography (CT), have described TMJ morphology. It has, in fact, been shown in a further study using cadaver dissection and CT, that there are three joint pouches of the equine TMJ and that they all connect.

The sizes and shapes of the osseous components of the TMJ are modified proportionally with the size of the head. There is, however, a consistency about the angles of these components. The mandibular condyles angle at 15° in the two planes—from latero-dorsal to ventro-medial and from medio-caudal to latero-rostral. The temporal facets are mirror images of the mandibular condyles (Figs. 2 and 3).

In dissections and measurements from fresh and prepared specimens of skulls, mandibles and teeth, it can be seen that the 15° angulation of the TMJ in
both planes is reflected in the ridges and lophs of the occlusal surfaces of the cheek teeth, in both vertical and transverse directions. Similarly, the palatine ridges are also set at a 15° angle from a ventro-mesial position to a dorso-distal position.

3. Function

The movements of the TMJ take place around a transverse axis passing through both joints. As the mouth is opened and closed around this hinge-like action, there is a slight rostral gliding. When the mouth is shut the condyle of the mandible lies under the mandibular fossa. When the mouth opens (essentially a passive movement), the condyle moves rostral as a result of the weight of the mandibles.

Chewing is based upon the repetition of a cyclical movement that results from controlled rhythmic contraction of all the muscle groups associated with opening (depression) and closing (elevation) of the jaws. The muscles of mastication are all supplied by the fifth cranial nerve. They are primarily the paired lateral muscles from the maxilla and cranium to the mandible, these are the masseter and temporalis muscles that close the jaw and pull to the acting side. The medial pterygoideus muscles also close the jaw.

In comparison to the large bulk of jaw closure muscles, the bulk of mandible depressor muscles is small. Jaw opening results from the contraction of the anterior belly of digastricus combined with the contraction of geniohydeus, and the inferior fibers of genioglossus coupled with the sternohyoides and omohyoides. In many mammals, particularly carnivores, jaw opening is aided by elevation of the head. This component is not, however, as important in herbivores.

The disproportionate muscle mass between the jaw elevators and depressors is easily understood when the nature of jaw movements in feeding is studied. The jaws close against resistance, whereas opening is a free movement synergized by gravity. Food breakdown is accomplished during jaw closure and requires forces that exceed the requirements of simply elevating the mass of the mandibular structures. Jaw muscles have faster contraction rates than most other striated muscles, with a total cycle contraction rate that ranges from 333 to 500 cycles/min in the pygmy goat.

The muscles of the cheeks and lips are supplied by the seventh cranial nerve and consist of the levator and depressor labii maxillaris and mandibularis, the orbicularis oris, the incisivus mandibularis and maxillaris, the buccinator and zygomaticus muscles. These muscles control the functions of lip closure, elevation, retraction, and depression as well as flattening of the cheeks.

The arrangement of the teeth within the upper and lower arcades is such that the curve of the upper dental arcade is not fully accommodated by the conformation of the lower arcade, i.e., the lower arcade is straighter and the distance between the left and right arcades is less in the mandible than in the upper jaw (anisognathism). At the same time the cheeks of the horse are, compared to other species, relatively tight fitting.
In studies of the chewing cycle in many species it was found that, with the exception of man, mammals have consistent chewing patterns both individually and specifically within species. There is, however, no “standard pattern.” What happens to the food and how it is broken down depends on the form of the cheek teeth. The literature may be confusing because of the absence of a standard start point of the chewing cycle. In this description of the chewing cycle of the horse, the start point will be assigned to incisor contact. Other conventions use maximum incisor gap as the start point.

Recent video analysis of horses feeding and observations of masticatory movements have recently yielded interesting data. The masticatory movements of horses fit the general masticatory cycle of herbivorous mammals. They have been described as having a masticatory cycle of three phases: the opening stroke (O) the closing stroke (C) and the power stroke (P) (Fig. 4). It is the relative displacement of the mandible that defines the phases. It was observed that, in this horse, there is, in fact, a fourth stroke after the power stroke, the “recovery” stroke (Fig. 5).

It has been observed for sometime that horses appear to be either right-sided or left-sided chewers. This observation is not strictly accurate even though some horses consistently demonstrate major lateral mandibular excursion to one side only. The masticatory movements of 400 horses in a veterinary medical teaching hospital with a variety of feeds including fresh grass, grass hay, alfalfa, hay, oats, and various sweet feeds and proprietary horse diets were documented. The observations were made on a wide range of horse ages, breeds, and a considerable range of medical and surgical disorders. Incomplete observations were made in 63 horses (16%), 45 horses (11%) were seen to chew both to the left and to the right, 163 horses (41%) moved the mandible to the right (i.e., clockwise as viewed from the front) and 131 (32%) chewed counter clockwise (i.e., mandibular movement to the left).

It has been suggested that during the power stroke there is only contact with one side of the arcade at a time. However, the measured extent of anisognathism negates this observation, i.e., there has to be some contact with both sides. It is however true that major pressure is first applied to one side and then, as the surfaces slide across each other, is transferred to the other side. It might be concluded from these observations that there is a tendency for unequal attrition as a result of the variation in masticatory physiology. However, this cannot be confirmed by examination of the wear of occlusal surfaces at necropsy.

Fig. 4. Representation of the power stroke component of the chewing cycle. (From Tremaine 1997, with permission of the editor of In Practice.)
When eating, the horse uses its upper and lower lips as instruments to select, “test,” and pull food into the mouth between the incisor teeth. Short sliding strokes of the incisors cut or grasp the food material. This process continues until the rostral portion of the mouth is filled with food material and cheek-tooth grinding of food is initiated. Just as the food-processor analogy of mastication is valid, the “auger” analogy may be applied to the process of the movement of food across the mouth from each arcade and distally within the oral cavity. The tight-fitting cheeks contain the feed material within the intradental oral cavity (IDOC).

The loph basins of the cheek teeth (the food channels across the occlusal surfaces) direct food as it is crushed into the IDOC. Collinson’s 1994 study of molar function in horses describes how cheek teeth occlusal shape facilitates this process.6 The canal of the entoconid and the tray of the metaconid of the mandibular teeth directs food into the parastyle of the maxillary teeth (the terms entoconid and metaconid refer to the specific slopes of the occlusal surfaces). Subsequent masticatory cycles crush and move food into the IDOC. The auger analogy is continued by examination of the morphology of the palatine ridges. There are a total of 18 pairs of palatine ridges. Each ridge is curved from lateral to midline and is incomplete and offset in the midline. Food material is squashed into the IDOC and pressed against the palatine ridges by the tongue. The rotary action of mastication and tongue and cheek compression moves the food caudally in a spiral fashion.

As boluses of food collect in the oropharynx, pharyngeal constriction, elevation of the soft palate, epiglottic retraction, and laryngeal contraction results in movement of food through the lateral channels around the larynx into the esophagus and this constitutes swallowing.

The rotatory auger analysis concept has been confirmed by observations of food-bolus shape in toothless horses. Horses without teeth can survive on special feeds—e.g., crushed and soaked feeds. If however they try and feed on grass or hay they produce long, spiral boluses of a rope-like consistency that may lead to esophageal obstruction.

Factors that influence masticatory movements include fiber and moisture content of the diet. Chew rates have been calculated from electromyographic data. It was noted that horses were capable of attaining higher than 11/s chew rates, particularly at the onset of feeding. The data in Table 1 were recorded over a 10-min period. This study, however, did not confirm earlier observations that higher fiber content and lower moisture content reduces the extent excursions of the mandible. The video analysis studies reported here did, in fact, confirm the observation that food type influences chewing pattern. The molar teeth initiate triturations (“grinding to powder”) with a series of sliding and chopping actions, similar to the puncture/crushing portions of the power strokes in other species. Once the IDOC has filled with a critical mass, a “mouthful,” further lip and incisor function is limited and true arcade “sliding” takes over, resulting in complete breakdown of food materials. It can be seen that there is greater lateral excursions with lush feeds—the drier the feed, the less the lateral excursion. Observations also suggest that there is rostral movement of one side at a time of the lower jaw during the masticatory cycle. This is achieved by the configuration of the temporomandibular joint and the contraction and relaxation of the masseter and medial pterygoid muscles. These movements
result in oblique contacts with the upper and lower dental arcades. As the mouth is closed, there is a complex series of movements that result in some slight retraction of the mandible, primarily from the sequence of zygomatic muscle components contracting and also a swinging lateral movement that is reformed medially in the power stroke of mastication.

4. Clinical Signs of TMJ Disease

TMJ fractures and luxations are the result of local trauma, kicks, or accidents in which the horse’s head is caught and jammed through an opening and, as the horse panics to extricate itself, the head, mandible, and TMJ may be injured. Such conditions present as acute cases and show pain on palpation and manipulation, local swelling, and asymmetry of the face and incisor alignment.7

TMJ arthritis and chronic “wear and tear” lesions from dental arcade irregularities, myopathic and fibrous scarring are difficult to isolate from the etiopathologic condition, e.g., wave, shear (Figs. 6 and 7), and step mouths are diagnosed by oral examination and radiography.

5. Diagnosis of TMJ Disease

A complete history and basic physical examination should localize disease conditions to the oral cavity and the TMJs (and should detect dental irregularities or muscle atrophy.) Using a 7.5-MHz linear array transducer and a minimum of 3 transverse views, ultrasonographic images of the TMJ are diagnostic and support radiographic images (Fig. 8).2 Arthrocentesis of the TMJ may be diagnostically in infected joints and joint blocks aid diagnosis.3

In horses with TMJ disease, new bone formation may be seen on radiographs. With septic arthritis

<table>
<thead>
<tr>
<th>Mastication Parameter</th>
<th>Low</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gram/mouthful”</td>
<td>12.1 ± 2.1</td>
<td>9.5 ± 2.4</td>
<td>8.1 ± 1.3</td>
</tr>
<tr>
<td>Chew rate/10 s</td>
<td>11.6 ± 0.6</td>
<td>11.5 ± 0.2</td>
<td>11.4 ± 0.2</td>
</tr>
<tr>
<td>Energy/g/chew</td>
<td>9.4 ± 4.8 × 10^{-3}</td>
<td>8.9 ± 6.4 × 10^{-3}</td>
<td>1.4 ± 1.4 × 10^{-2}</td>
</tr>
<tr>
<td>Duration of grind(s)</td>
<td>0.51 ± 0.08</td>
<td>0.53 ± 0.03</td>
<td>0.55 ± 0.02</td>
</tr>
<tr>
<td>Incisor displacement (cm)</td>
<td>4.4 ± 0.6</td>
<td>4.5 ± 0.6</td>
<td>4.4 ± 0.3</td>
</tr>
<tr>
<td>Premolar 4 velocity (sm.s^{-1})</td>
<td>10.4 ± 1.8</td>
<td>9.7 ± 2.4</td>
<td>8.5 ± 0.4</td>
</tr>
</tbody>
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From Collinson, 1994, 6. with permission.
the TMJ meniscus could not be seen ultrasonographically and was replaced by fibrous tissue with interspersed hyperechoic calcification. Joint capsule thickening is also seen in chronic degenerative joint disease of the TMJ.

Arthroscopic evaluation of the TMJ has been described using a caudodorsal approach. This technique allowed complete examination of the dorsal compartment of the joint but access to the ventral compartment was precluded by the location of the transverse facial artery and vein.8

5. Treatment
In chronic disease the key to treatment is attention to the primary etiology. The correction of dental arcade irregularities, overgrown or super-erupted teeth, dental hooks and ramps, and “balancing” of the arcades will facilitate recovery and rehabilitation. Major corrections should be done in stages and treatments supported with analgesics and, if indicated, dietary changes, e.g., Equine Senior.

Traumatic, acute injuries require examination under anesthesia and manipulation to reduce luxations. Infectious TMJ disease may require long-term antibiotic therapy and drainage surgery.9

References and Footnotes