

# A Tangential Radiographic Projection for Investigation of the Equine Temporomandibular Joint

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**Objective**—To (1) describe a tangential radiographic projection of the equine temporomandibular joint (TMJ) and (2) optimize the radiographic angle and determine its use in standing sedated horses.

**Study Design**—Descriptive study.

**Animals**—Cadaveric equine skulls (n = 11); 8 horses with a history of quidding or headshaking.

**Methods**—Tangential radiographic projections were taken of a TMJ of a cadaveric skull before and after intra-articular injection of radiographic contrast. Additional tangential radiographic projections were taken after TMJ dissection and placement of a wire along the articular surface of the mandibular condyle. Subsequently, 3 tangential radiographs were taken of both TMJs of 10 skulls at 75°, 70°, and 65° to the dorsal plane (Rt/Le15Cd70D-Le/RtRVO). Each of the 3 images for each TMJ was ranked by 4 observers who were unaware of the projection angle. Interobserver variation was calculated using a Friedman analysis of variance and significance of the most prevalent angle with a 1-sample repeated measures test. Tangential radiographic projections of both TMJs were then taken of 8 standing sedated horses.

**Results**—Tangential radiographic projections allowed the lateral half of the TMJ to be viewed without superimposition of other structures and the anatomic orientation was determined. A 70° projection to the dorsal plane was ranked as significantly better than other views ( $P < .001$ ). There was no significant interobserver variation and the technique was safely performed in standing sedated horses with excellent image quality obtained.

**Clinical Relevance**—Tangential radiography of the TMJ may complement and add to information obtained from clinical examination and ultrasonography before referral for more advanced imaging techniques.

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## INTRODUCTION

THE EQUINE temporomandibular joint (TMJ) is a diarthrodial joint between the condylar process of the mandible and the zygomatic process of the temporal bone, bordered caudally by the retroarticular process.<sup>1</sup> A fibrocartilage disc present within the joint divides the TMJ into a separate discotemporal joint dorsally and a ventrally located discomandibular joint.<sup>1,2</sup> The anatomy has been described in cadaver specimens by gross dissec-

tion,<sup>2</sup> and the intraarticular anatomy by arthroscopic observation.<sup>3,4</sup> Unlike in humans, there are relatively few reports of TMJ disease in horses, but traumatic injuries<sup>5</sup> and septic arthritis<sup>6–8</sup> have been described. Standard lateral and lateral oblique radiographic projections of the equine TMJ are difficult to evaluate because of superimposition of other osseous structures.<sup>6,9–11</sup> The paucity of reports of TMJ disease in horses may reflect difficulties in adequately imaging the TMJ, making a definitive diagnosis of TMJ disease difficult.

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We developed a radiographic technique to investigate the lateral aspect of the equine TMJ without superimposition of other osseous structures. Our purpose is to describe the technique, determine the optimum projection angle, and confirm its use in standing sedated horses.

**MATERIALS AND METHODS**

*Radiographic Technique and Determination of Anatomic Orientation*

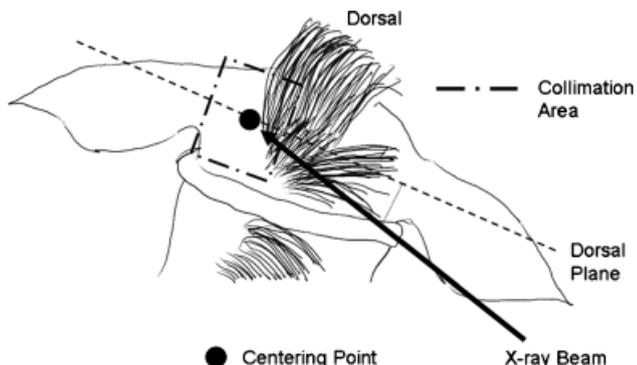
One cadaver equine skull was supported so that the angle of the frontal bone was  $\sim 25\text{--}30^\circ$  to the vertical. A large cassette ( $40 \times 45$  cm AGFA General CR cassette, AGFA, London, UK) was positioned vertically on the left side of the skull and the X-ray beam positioned at  $15^\circ$  caudal to the transverse plane (Fig 1) and angled dorsoventrally from the contralateral side at  $70^\circ$  to the dorsal plane with a film focal distance of 1 m (Figs 2 and 3). Using standardized radiographic nomenclature<sup>12</sup> relative to the hard palate this gives a projection of right caudodorsal to left rostroventral (Rt15Cd70D-LeRVO). The angle to the dorsal plane was set using the scale on the gantry mounted X-ray tube, which had been verified by a goniometer and the transverse angle estimated with a goniometer. The beam was centered on a line drawn between the ears midway between the base of the ipsilateral ear to the cassette and the midline (Fig 1) and a radiograph taken at 70 kV and 6 mAs and processed using a CR system (AGFA CR 25). A 19 G 1" needle was then inserted in the dorsal pouch of the left TMJ and 4 mL radiographic contrast (Omnipaque™, GE Healthcare, Bucks, UK) injected into the TMJ of interest using a standard arthrocentesis protocol.<sup>13</sup> The needle was withdrawn and another radiograph taken using the same technique. The left TMJ was then dissected, a wire placed along the articular surface of the mandibular condyle and another radiograph taken to confirm precise anatomic orientation.

*Optimization of Radiographic Angle*

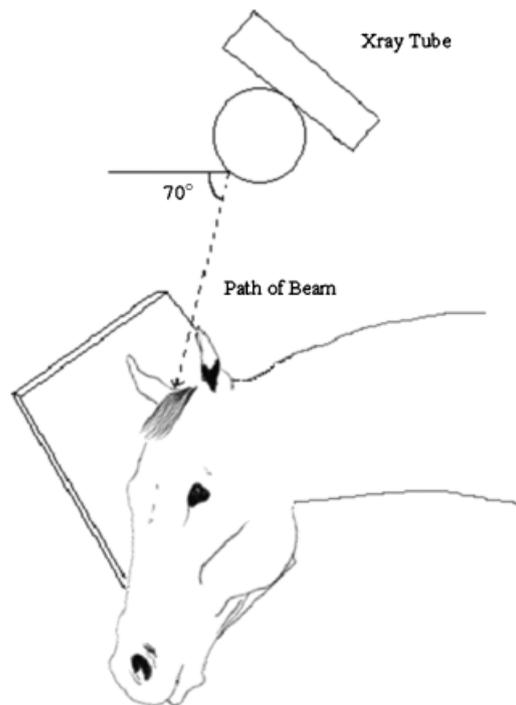
Ten cadaver skulls from horses euthanatized for reasons other than TMJ or dental disease were used. Both left and



**Fig 2.** Setup of the left tangential projection shown in Fig 7 in the standing sedated horse. The horse's nose is resting on a stool.



**Fig 1.** A dorsal view of the radiographic projection showing the beam angle at  $15^\circ$  to the transverse plane, the centering point, and the collimation area.



**Fig 3.** Dorsolateral view of the radiographic projection showing the X-ray beam angle at  $70^\circ$  to the dorsal plane and cassette position.

right TMJs of all heads were radiographed 3 times each by the primary author using the technique we describe with the X-ray beam directed at 15° caudal to the transverse plane and at 75°, 70°, and 65° to the dorsal plane. Five of the 10 skulls were consequently disarticulated and examined for presence of gross TMJ pathology.

The 3 radiographs of each TMJ were blindly evaluated by 4 clinicians experienced in reading equine head radiographs. The 3 projections were ranked (1–3, with 1 being the best) for each TMJ as to which projection provided the best image of the TMJ without superimposition of other structures and minimal distortion of the osseous structures of the joint. A 1-sample proportion test was used to determine the significance of the radiographic angle most prevalently ranked the best. The clinicians were also asked to comment on any artifacts identified or the image quality if appropriate. Interclinician variability was calculated using a Friedman repeated measures analysis of variance for nonparametric data. The same test was used to detect interskull variation of rankings between left and right TMJs. Statistical significance was set at  $P$ -value  $< .5$ .

#### Clinical Application

The tangential radiographic projection was used in 8 horses referred with histories of quidding or headshaking, where an oral examination and standard skull radiography had revealed no major abnormalities. Horses were sedated (romifidine, 0.03–0.05 mg/kg IV and butorphanol, 0.01 mg/kg IV) to position the head as low as possible, and hence obtain the radiographs safely. A radiolucent rope halter was used for restraint. The X-ray cassette was held in a cassette holder to prevent exposure of personnel to the primary beam. Left and right TMJ radiographs were taken using the Rt/Le15Cd70D-Le/RtRVO technique either by the primary author or by another radiographer. Radiographs were evaluated for the ability of the projection to image the TMJ and symmetry between left and right TMJs.

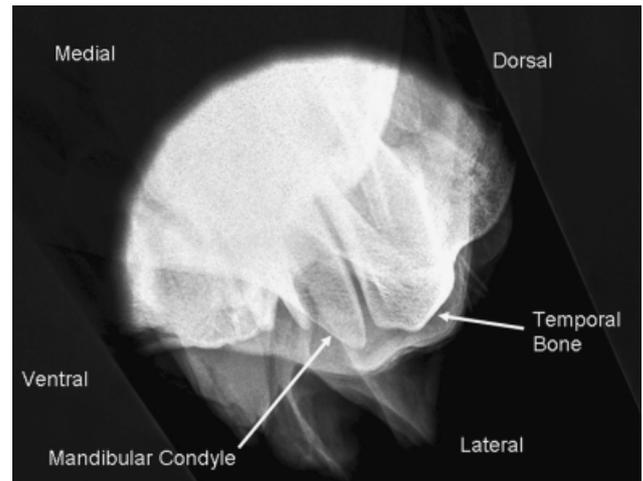
## RESULTS

#### Radiographic Technique and Determination of Anatomic Orientation

Tangential radiographs of a left TMJ before (Fig 4) and after intra-articular administration of radiographic contrast (Fig 5) were obtained and the extent of the TMJ capsule outlined. Radiographs of the dissected TMJ with wire in place along the articular surface of the mandibular condyle (Fig 6) allowed anatomic orientation of the radiographs (Fig 3). The lateral half of both the temporal and the mandibular articular surfaces and subchondral bone could be observed without superimposition of other structures.

#### Optimization of Radiographic Angle

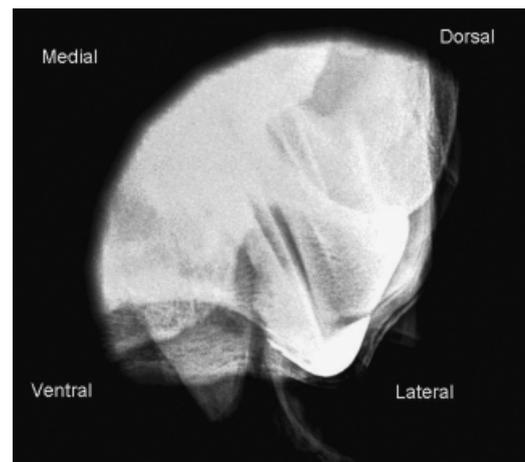
The radiographic projection at 70° to the dorsal plane was most prevalently ranked “1” (Table 1). This was



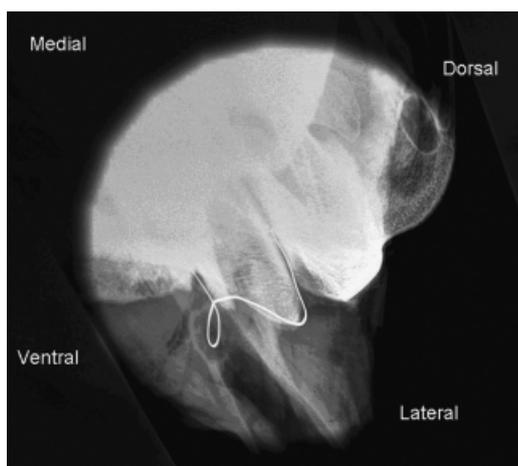
**Fig 4.** A 70° tangential projection of a left temporomandibular joint of a cadaver skull.

significantly greater than either the 75° or 65° projections ( $P < .001$ ). A 75° projection was ranked “3” (i.e. worst) significantly more often than other radiographic views ( $P < .001$ ; Table 1). A 1-sample proportion test performed on the data from each individual clinician indicated 70° to be ranked significantly as the best projection in results from 3 of the 4 clinicians (Table 2).

No significant interclinician variation was noted between left and right TMJs for any radiographic projection. Significant interskull variation was noted in the ranking of the 75° radiographic angle for both left ( $P = .016$ ) and right ( $P = .035$ ) TMJs. No significant interskull variation was noted between left and right TMJs for the 70° or 65° projections. None of the 5 disarticulated skulls had gross evidence of TMJ disease, although



**Fig 5.** A 70° tangential projection of a left temporomandibular joint (TMJ) of a cadaver skull after intra-articular injection of 4 mLs of radiographic contrast indicating the lateral extents of the TMJ capsule.



**Fig 6.** 70° tangential projection of a left temporomandibular joint of a cadaver skull following dissection and placement of a wire along the articular surface of the mandibular condyle.

minor differences in the shape of the lateral margin of the temporal articular surfaces were noted in 3 skulls.

*Clinical Application*

It was possible to obtain both left (Fig 7) and right TMJ radiographs in 8 sedated horses (Fig 2) using the 70° tangential projection and images were subjectively judged to be of comparable quality to those obtained in cadaver skulls. There was an inevitable learning curve transferring the technique from cadaver specimens to live horses initially with up to 3 exposures required to obtain a diagnostic image in the first few patients. With practice, diagnostic images of a TMJ could be routinely obtained using a single exposure. Left and right images were comparable, subchondral bone density in both the mandibular condyle and the temporal bone could be appreciated and no abnormalities were detectable, although the shape of the temporal articular surfaces did vary slightly as was described in cadaver skulls.

*Image Artifacts*

Each observer commented on an artifact created by the pinna, in radiographs from 3 of the 10 heads, which may be superimposed over the TMJ (Fig 8). Specific

Table 1. Ranking Prevalence (%) for All 4 Observers of Each Radiographic Angle

Ranking	75°	70°	65°
1	3	62*	35
2	11	34	55
3	86*	4	10

\*Significance ( $P < .05$ ) using a 1-sample proportion test.

Table 2. P-values from a 1-Sample Proportion Test for Each Observer Determining the Significance of 70° Projection Being Ranked Above the Others

Observer	P-value
1	.031*
2	.152
3	.031*
4	<.001*

\*Significance ( $P < .05$ ).

comments from the observers indicated that the 75° projection provided the least superimposition of other structures, but because of the oblique angle there was marked distortion of the articular margins and appearance of the subchondral bone. There was less image distortion in the 70° and 65° projections, although more superimposition of other osseous structures such as the occipital bone was evident in the 65° projection.

**DISCUSSION**

Our results indicate that a tangential projection can successfully image the lateral half of the equine TMJ without superimposition of other osseous structures. Results from our cadaveric study indicate that the most favorable angle from the dorsal plane is 70°. There was more superimposition of other structures using the 75° projection, whereas the 70° projection gave a balance between angular distortion of the image and preventing excessive superimposition of other structures. The 65°



**Fig 7.** A 70° tangential projection of a left temporomandibular joint taken from a live horse.



**Fig 8.** A 70° tangential radiograph showing an image artifact that the pinna may create. The thinner arrows indicate the outline of the pinna and the thicker arrow indicates how this may obscure the temporomandibular joint.

projection was ranked the best projection in 35% of cases. Although not statistically significant because of the relatively small numbers, it may suggest that the ideal angle for projection is 65–70°. The effect of different width of skull or breed of horse may have an effect on the optimal angle for an individual patient; however, this was not investigated.

One clinician (Observer 2) ranked the 65° projection as the best in both TMJs from 1 horse and the left TMJ in another. This created significant interskull variation for the 65° projection. Comments for these projections provided by the observer suggested that this particular observer preferred lesser superimposition of other structures provided by this projection.

A standard 15° angle ventral to the transverse plane was used, as the TMJ has been reported to be angulated at 15° in both transverse (being higher laterally) and rostrocaudal (being higher caudally) planes.<sup>14</sup>

Radiography is widely used in the diagnosis of equine TMJ disease, although it is seldom able to yield a definitive diagnosis without the aid of other imaging techniques. This is because of the difficulty in interpretation of standard lateral and oblique radiographic views, where the consequence of converting a 3-dimensional structure such as the skull to a 2-dimensional radiographic image unavoidably causes superimposition of many other structures.<sup>6,9–11</sup> The shape of the mandibular condyle and its oblique orientation in 2 planes makes interpretation difficult.<sup>9–11</sup>

Consequently, other imaging techniques are being increasingly used in the diagnosis of TMJ disease. Percutaneous ultrasonography has been used to describe the anatomy of the equine TMJ,<sup>11,15</sup> and in the diagnosis of TMJ arthropathy,<sup>11</sup> but is limited to the lateral 1/3 of the joint and gives limited indication of subchondral bone pathology.<sup>10,15</sup> Nuclear scintigraphy has been used in the diagnosis of TMJ disease, but is relatively expensive and time consuming and fails to characterize the disease process.<sup>11</sup> In 1 study, ultrasonography was able to localize and characterize a TMJ lesion, whereas nuclear scintigraphy could only localize the lesion and radiography was inconclusive.<sup>11</sup>

More recently, computed tomography (CT) has become a superior technique for diagnosing TMJ disease in both human and veterinary medicines.<sup>6,8,16</sup> It is a superior imaging technique to ultrasonography and radiography because the transverse images obtained have no superimposition of other structures, and the whole TMJ can be evaluated rather than just the lateral half.<sup>8,16</sup> The disadvantage is that CT scanners for equine use usually require general anesthesia of the patient and are generally poor for evaluation of the intra- and periarticular soft tissue structures.<sup>17</sup> Standing CT in horses has been described<sup>18</sup> but is not yet widely available.

To date, the radiographic technique described has only been performed in cadavers and in clinical cases where TMJ disease has not been identified. A variation in appearance of the periarticular portion of the temporal bone was noted in both the cadaver specimens and horses, and is evident in the difference between Figs 4 and 7. This variation was present in 3 of 5 skulls that had no gross pathology and may indicate a normal variation rather than pathologic change.

A safety consideration when using the technique is that the level of sedation should be such that the horse does not raise its head during the procedure because this may result in damage to the radiographic equipment or traumatic injury to the patient. Observation while radiographing the cadaver specimens suggests that if the ears are in a more forward position, superimposition of the pinna on the TMJ is more likely. To avoid this, the patient's ears may be taped back to the neck or a rope halter.

We developed a 70° tangential projection (Rt/Le15-Cd70D-Le/RtRVO) to radiograph the equine TMJ, which we anticipate will both complement and add to the information provided by clinical examination, standard radiographic views of the TMJ, and percutaneous ultrasonography in the diagnosis of TMJ disease. This technique can be safely performed in a standing sedated horse and could be carried out in general practice before referral for more specialized imaging techniques. Further work should include using this technique on confirmed cases of TMJ disease to assess its sensitivity and specificity.

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