J Vet Sci. 2022 May;23(3):e44
https://doi.org/10.4142/jvs.21318
pISSN 1229-845X·eISSN 1976-555X

Original Article
Medical Imaging

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Computed tomographic features of the temporomandibular joint in 10 Jeju horses

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Received: Jan 5, 2022
Revised: Feb 10, 2022
Accepted: Feb 28, 2022
Published online: Mar 22, 2022

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ABSTRACT

Background: The equine temporomandibular joint (TMJ) has a complex anatomical structure that makes diagnosis of TMJ disorders difficult. Computed tomography (CT) is now available in equine medicine; hence, TMJ evaluation has become more convenient.
Objectives: The objectives of this study were to describe the CT features of the TMJ in Jeju horses and to compare these features with those of Thoroughbreds.
Methods: In this report, the TMJs of 10 Jeju horses (mean age: 4.5 ± 1.9 yr; mean body weight: 282.6 ± 40.3 kg) and 6 Thoroughbreds (mean age: 7.3 ± 1.6 yr; mean body weight: 479.7 ± 44.0 kg) were examined using CT. After CT scanning, the Hounsfield units (HU) and height to width ratio (H:W) of the mandibular condyle were measured.
Results: The mean H:W in Jeju horses was significantly lower than that in Thoroughbreds. The mean HU in Jeju horses was lower than that in Thoroughbreds; however, the difference was not significant. The most frequent CT finding was an irregular medial margin of the mandibular condyle in both breeds.
Conclusions: In this study, the shape of the mandibular condyle in Jeju horses was flatter than that in Thoroughbreds. This report could be useful in evaluating the TMJ in Jeju horses. Moreover, CT could be a pragmatic choice for the examination of the TMJ in horses.

Keywords: Temporomandibular joint; computed tomography; jeju horses; horses

INTRODUCTION

The equine temporomandibular joint (TMJ) is a synovial joint between the zygomatic process of the temporal bone and the condyle of the mandible. The articular disc and two synovial pouches are situated between incomplete conjugation of the articular surface. Other structures including vessels, nerves, the parotid salivary gland, the temporohyoid joint are located adjacent to the TMJ. The complexity of its own and adjacent anatomical structures makes TMJ evaluation challenging. Although free-ranging horses graze for 21 h a day [1], equine TMJ disorders have sparsely been reported. Headshaking, quidding, and difficulty in chewing are often observed in horses with TMJ disorders [1]. These clinical signs are easily confused with those of neurological disorders, dental disorders, and behavioral problems. The most frequently reported cases of TMJ disorders are trauma or septic arthritis because

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Conflict of Interest
The authors declare no conflicts of interest.

Funding
This research was supported by the 2022 scientific promotion program funded by Jeju National University.

of relatively obvious clinical signs [2-6]. Considering the ambiguity of symptoms and the complex structures of the TMJ, TMJ disorders in horses might be under-diagnosed [1].

Conventional imaging has limitations in showing abnormalities of the TMJ [7-10]. Radiography has been the preferred method for the assessment of osseous changes in the TMJ. Although radiography is a practical and non-invasive technique, only the lateral portion and bone of the TMJ can be observed on radiographs [7,8]. Ultrasonography can reveal changes in soft tissue and bone in the lateral TMJ [9]. Additionally, arthroscopy could be employed as a method of diagnosis or treatment, but this tool may not only be unable to examine the TMJ thoroughly but would also be invasive [10]. Advanced imaging modalities such as computed tomography (CT) and magnetic resonance imaging (MRI) have allowed clinicians to evaluate the TMJ from the lateral aspect to the medial aspect [11,12]. Research on the equine TMJ using CT and MRI has been recently reported [2,6,11-15]. Advanced imaging such as CT and MRI is employed to evaluate bone and soft tissue, respectively. MRI is preferred to evaluate of the TMJ because of superior visualization of soft tissue. Despite this fact, CT is more frequently reported to evaluate the equine TMJ [2,5,6,12,13,15].

Jeju horses are native horses to Jeju Province, South Korea. The mean height and bodyweight of Jeju horses are reported as 123.72 cm [16] and 267.00 kg, respectively [17]. Genetic, anatomical, and physiological differences between Jeju horses and Thoroughbreds have been discussed [16,18,19]. The value of Jeju horses has increased with the commencement of horse racing in South Korea. However, veterinary research on Jeju horses is lacking and TMJ disorders in these horses have also not been reported to date.

The objectives of this study were to describe the CT features of the TMJ in Jeju horses and to compare these features with those of Thoroughbreds.

MATERIALS AND METHODS

Animals

Sixteen horses were used in this study: 10 Jeju horses (age: 3–9 yr; mean age: 4.5 ± 1.86 yr, bodyweight: 243–380 kg; mean weight: 282.6 ± 40.3 kg) and 6 Thoroughbreds (age: 4–9 yr; mean age: 7.3 ± 1.6 yr, bodyweight: 443.5–560 kg; mean weight: 479.7 ± 44.03 kg; **Table 1**). Physical examination and blood analysis were performed as pre-anesthesia examinations (complete blood count: VetScan HM5, Abaxis, Inc., USA; Serum chemistry examination: VetScan VS2, Abaxis, Inc.). All animal procedures were approved by the Institutional Animal Care and Use Committee at the Jeju National University (2020-0040).

Radiography and ultrasonography

Radiography and ultrasonography were performed to exclude horses with TMJ abnormalities [7-9]. Two radiographs of each TMJ were obtained (**Fig. 1**): the lateral-lateral view and the rostral 35° lateral 50° ventral-caudodorsal oblique view. Three ultrasonographic images of each TMJ were also obtained (**Fig. 2**): the latero 45° dorso 45° caudal-medio ventro-rostral oblique plane, the rostro 20° latero 15° dorsal-caudo medio-ventral oblique plane, and the caudo 10° dorso 45° lateral-rostro ventro-medial oblique plane.

Table 1. Signalment of horses

Variables	No.	Age (yr)	Sex	Bodyweight (kg)
Jeju horses	1	4	F	305
	2	3	F	277
	3	3	F	280
	4	3	M	280
	5	4	M	274
	6	3	M	243
	7	9	F	380
	8	6	F	230
	9	6	G	270
	10	4	G	287
Mean ± SD		4.5 ± 1.86		282.6 ± 40.3
Thoroughbreds	1	9	F	490
	2	8	G	480
	3	8	G	465
	4	4	G	443.5
	5	7	F	440
	6	8	F	560
Mean ± SD		7.3 ± 1.6		479.8 ± 43.9

F, female; M, male; G, gelding.

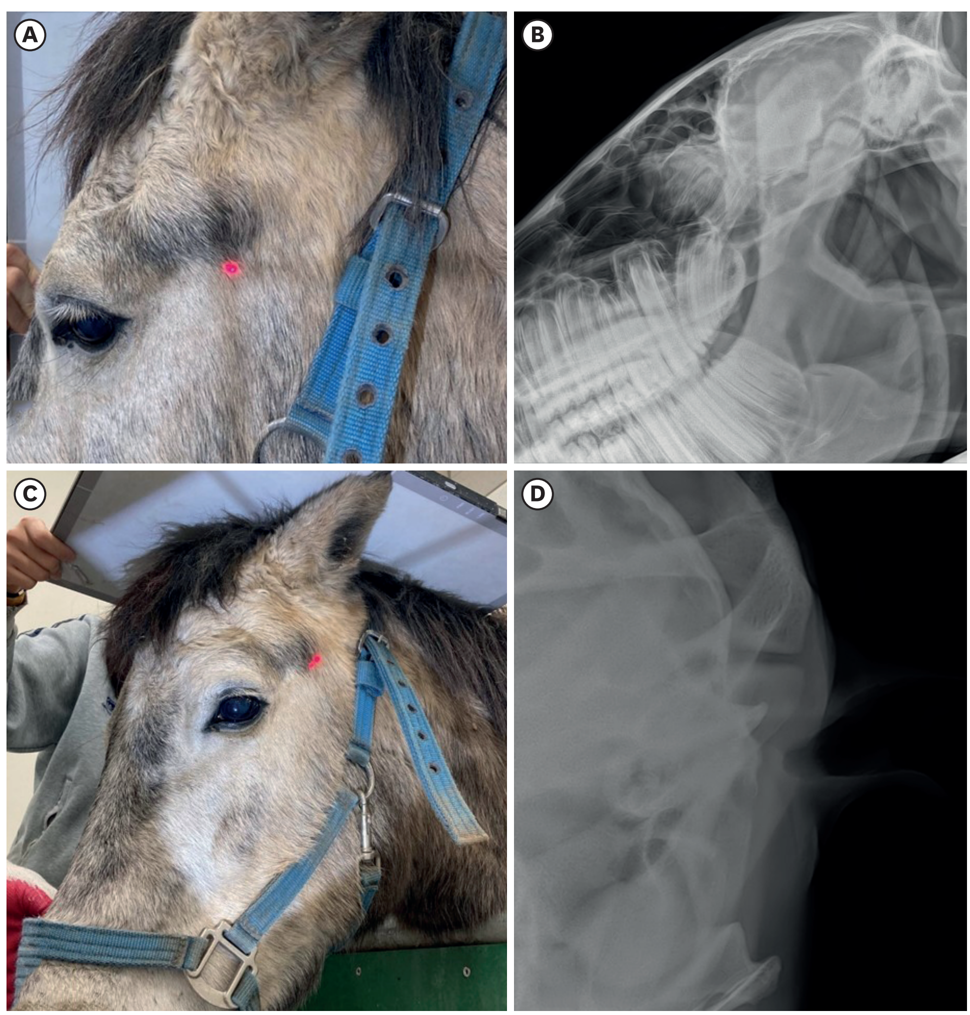

Fig. 1. Radiographs of the temporomandibular joint in horses. (A, B) Lateral-lateral view of the temporomandibular joint. (C, D) Rostral 35° lateral 50° ventral-caudal dorsal oblique view.

https://doi.org/10.4142/jvs.21318

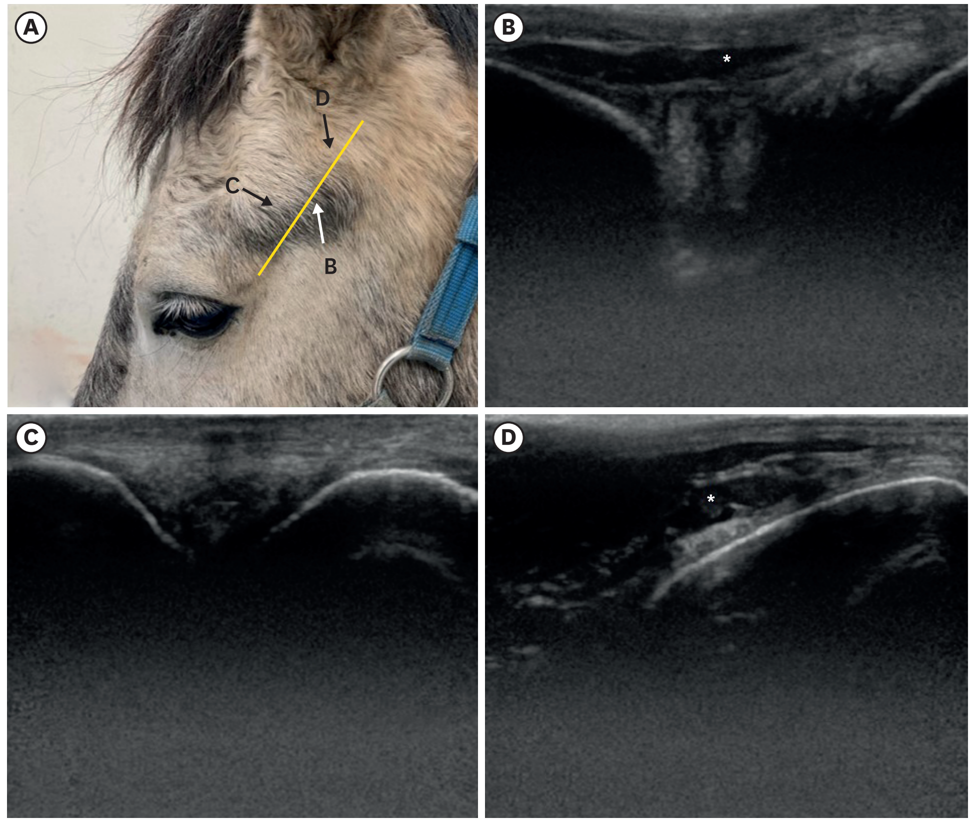

Fig. 2. Ultrasonography of the temporomandibular joint. (A) Lateral aspect of the equine head. Each view is marked with a letter on the imaginary line from the lateral canthus of the eye to the base of the ear. (B) Latero 45° dorso 45° caudal-medio ventro-rostral oblique plane. (C) Rostro 20° latero 15° dorsal-caudo medio-ventral oblique plane. (D) Caudo 10° dorso 45° lateral-rostro ventro-medial oblique plane.
*The parotid salivary gland.

CT scanning

Each horse was sedated using detomidine hydrochloride (0.01 mg/kg, I.V., Equadin, DongBang Co. Ltd., Korea). Diazepam (0.05 mg/kg, I.V., Diazepam inj., Samjin Pharm. Co. Ltd., Korea) and ketamine (2.2 mg/kg, I.V., Ketamine 50 inj., Yuhan, Korea) were injected as induction agents. The anesthesia was maintained with isoflurane (Ifran, Hana Pharm. Co. Ltd., Korea) with a 100% oxygen supply. A helical CT scanner (Aquilion Lightning, Canon, Japan, 32-slice, 16-row CT) was employed. Horses were placed in dorsal recumbency on the custom-made table and put under general anesthesia. The scanning parameters were as follows: 120 kV, 250 mA, 1 mm slice thickness, and 0.75 sec rotation time, 2 mm section collimation thickness, 2 mm slice interval, and 0.938 pitch. Field of view dimension was collimated to the head size: 338.2–390.6 mm in 10 Jeju horses; 414.1–464.8 mm in 6 Thoroughbreds. The horses were allowed to recover in padded stalls after CT scanning.

Evaluation of CT images

CT images were evaluated based on the transverse, sagittal, and coronal plane. Bone evaluation was performed with reconstructed images using the bone algorithm (window level: 429, window width: 1,078); soft tissue evaluation was performed with reconstructed images using the soft tissue algorithm (window level: 135, window width: 394). The Hounsfield units (HU) and height to width ratio (H:W) of bilateral mandibular condyles were measured as previously reported by the primary author [13] (**Fig. 3**). The HU of the mandibular condyle

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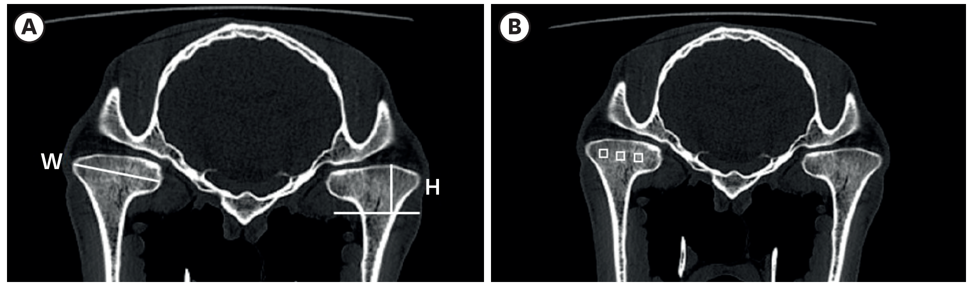

Fig. 3. Measurement of width and height of the mandibular condyle in computed tomography scans. Measurement was processed at the widest point of the mandibular condyle. (A) W was estimated from the lateral condyle to the medial condyle. H was measured from the neck of the mandibular condyle to the dorsal surface of the mandibular condyle at the highest point. (B) HU measurement of the mandibular condyle. Mean HU was measured in a square in lateral, central, and medial regions of the mandibular condyle.
W, width; H, height; HU, hounsfield unit.

was measured in the lateral, central, and medial sites (**Fig. 3B**) and the mean HU was calculated. Height and width of the mandibular condyle were measured (**Fig. 3A**). Height was measured from the neck to the dorsal surface of the mandibular condyle; width was measured from the lateral to the medial extent of the head of the mandibular condyle. H:W was then calculated [13] (**Table 2**). All measurements were processed on the plane in which the width of the mandibular condyle was the widest. Additionally, the following TMJ CT findings were recorded (**Table 3**): an irregular margin of the medial mandibular condyle attached to the pterygoid muscle, a focal hypodense region with a hyperdense rim, diffuse hyperdensity in the mandibular condyle, and mineralization of adjacent soft tissue.

Statistical analysis

Statistical tests were performed using RStudio (RStudio, USA). A Shapiro–Wilk test was performed for normality. Based on normality and variance, Welch's-*t*-test was selected to evaluate differences in the HU; the *t*-test was selected to evaluate H:W between Jeju horses and Thoroughbreds. $p < 0.05$ was considered statistically significant.

Table 2. Means and standard deviation of H:W and the HU of the temporomandibular joint

Variables	Right	Left	Bilateral
Height, width, and H:W			
Jeju horses			
Height	27.55 ± 2.31	25.73 ± 2.14	26.39 ± 2.01
Width	46.80 ± 4.05	46.58 ± 4.62	45.99 ± 4.21
H:W	0.59 ± 0.07*	0.56 ± 0.08*	0.57 ± 0.07*
Thoroughbreds			
Height	32.95 ± 2.78	33.00 ± 2.88	32.98 ± 2.78
Width	49.83 ± 4.69	48.68 ± 4.88	49.26 ± 2.62
H:W	0.66 ± 0.05*	0.68 ± 0.03*	0.67 ± 0.04*
HU			
Jeju horses			
Lateral	456.21 ± 107.31	479.25 ± 115.22	467.73 ± 106.96
Center	499.84 ± 79.98	494.7 ± 463.84	497.29 ± 64.68
Medial	495.70 ± 281.42	513.61 ± 66.40	504.66 ± 72.18
Mean	483.92 ± 89.53	495.87 ± 83.41	489.89 ± 82.03
Thoroughbreds			
Lateral	674.96 ± 249.79	616.12 ± 246.44	645.54 ± 244.89
Center	525.73 ± 167.83	621.42 ± 290.76	573.57 ± 216.79
Medial	462.30 ± 135.65	474.83 ± 151.61	468.56 ± 134.92
Mean	554.33 ± 201.15	570.79 ± 233.17	562.56 ± 205.96

H:W, the ratio of height to width; HU, Hounsfield units.
*Comparison of H:W between Jeju horses and Thoroughbreds was statistically significant ($p < 0.05$).

https://doi.org/10.4142/jvs.21318

Table 3. CT findings of the temporomandibular joint

Variables	No.	CT finding 1	CT finding 2	CT finding 3	CT finding 4
Jeju horses	1	O			
	2		O		
	3		O		
	4				
	5	O			
	6	O			
	7	O			
	8	O			
	9				
	10	O	O		
Thoroughbreds	1	O			O
	2	O		O	
	3	O	O	O	
	4	O			
	5	O			
	6	O			

CT finding 1: Irregular margin of the medial mandibular condyle attached to the pterygoid muscle. CT finding 2: Hypodense region with hyperdense rim. CT finding 3: Diffuse hyperdensity of the mandibular condyle. CT finding 4: Mineralization of soft tissue around the temporomandibular joint.
CT, computed tomography.

RESULTS

None of the horses in this study had significant findings in physical examinations or blood analysis. Radiography showed no bony changes in any of the TMJs. No structural changes were observed during ultrasonography. All horses recovered from anesthesia uneventfully.

The mean HU in the mandibular condyle of Jeju horses was 489.89 ± 82.03 and that of Thoroughbreds was 562.56 ± 205.96. This result was not significant ($p = 0.32$; **Table 2**). The mean H:W in Jeju horse was 0.57 ± 0.07 and that in Thoroughbreds was 0.68 ± 0.036. The mean of Jeju horses was significantly lower than that of Thoroughbreds ($p = 0.004$; **Table 2**). Most horses had more than one finding for the mandibular condyle in CT images (**Table 3**). The most frequent CT finding was the irregular margin of the mandibular condyle and it was shown in 5 of the 10 Jeju horses and all 6 Thoroughbreds (**Fig. 4F**). Although diffuse hyperdensity was found in 2 Thoroughbreds (**Fig. 4B**), none of the Jeju horses shared this finding. The focal hypodense region with a hyperdense rim was found in 2 Jeju horses and in 1 Thoroughbreds (**Fig. 4C and D**). Mineralization of adjacent soft tissue was found in a single Thoroughbred mare (**Fig. 4E**).

DISCUSSION

The present study is the first to describe the CT characteristics of the TMJ in Jeju horses and to compare these features with those of Thoroughbreds. The authors measured the H:W and HU of the mandibular condyle. CT findings of the TMJ were also recorded. We observed a difference in the shape of the mandibular condyle between Jeju horses and Thoroughbreds as well as anatomical variations in the TMJ of asymptomatic horses.

In this report, the H:W in Jeju horses was significantly lower than that in Thoroughbreds, indicating that the shape of the mandibular condyle in Jeju horses is flatter than the shape of the mandibular condyle in Thoroughbreds. Two factors affecting the shape of the mandibular

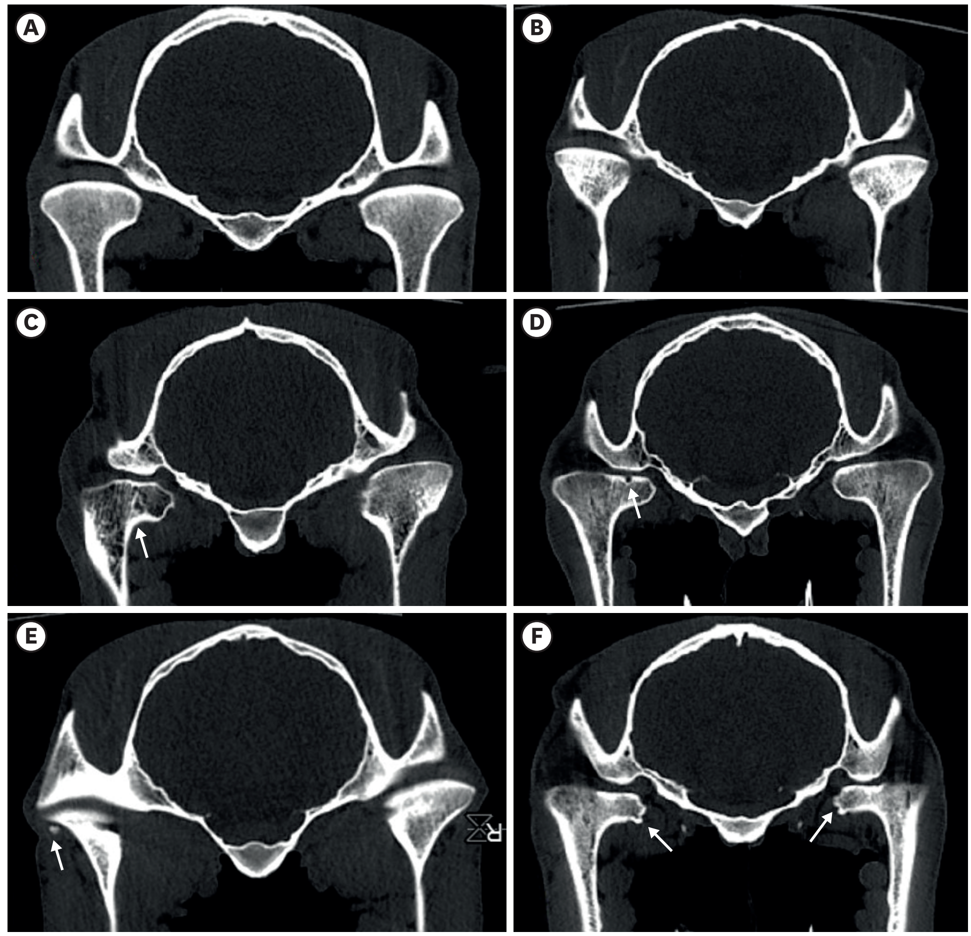

Fig. 4. Computed tomography findings of the TMJ. (A) No significant findings in the mandibular condyle of a 3-year-old male Jeju horse. (B) Diffuse hyperdensity in a 9-year-old Thoroughbred mare. (C) Focal hypodense region with a hyperdense rim (arrow) in an 8-year-old Thoroughbred gelding. (D) Focal hypodense region with a hyperdense rim (arrow) in the cortical articular surface of a 4-year-old a Jeju horse gelding. (E) Mineralization of soft tissue adjacent to the TMJ (arrow) of an 8-year-old Thoroughbred mare. (F) Irregular margin of the medial mandibular condyle attached to the pterygoid muscle (arrow) of a 9-year-old Jeju horse mare.
TMJ, temporomandibular joint.

condyle were reported: immaturity and pathological remodeling by degenerative joint diseases. In a previous report, the mean of H:W in horses aged < 1 yr was higher than in that older horses. The report suggested that the shape of the mandibular condyle became flat through the first 1 yr [13]. In our study, the result of H:W was not influenced by immaturity considering only horses over 3 yr of age were used. A flatter mandibular condyle on the sagittal plane in human patients with degenerative joint disease in the TMJ was previously reported [20]. However, the correlation between degenerative joint diseases and the shape of the mandibular condyle has not been reported in equine medicine. As horses in this study had no crepitus or masticatory difficulties, this result was not influenced by pathological remodeling. Therefore, a flatter shape of the mandibular condyle could be considered as a characteristic of Jeju horses.

In a previous report, the prevalence of TMJ osteoarthritis differed depending on the breeds of dogs. Osteoarthritis was more frequently observed in mesaticephalic breeds than other breeds [21]. In this study, we found a difference in the shape of the mandibular condyle between Jeju horses and Thoroughbreds. Although the relationship between

https://doi.org/10.4142/jvs.21318

skull conformation and TMJ disorders has still not been reported, differences in skull conformation might also influence the prevalence of TMJ diseases in horses.

The HU indicates the linear attenuation coefficient of observed tissue relative to the attenuation of water as 0 and air as −1,000 at standard temperature and pressure [22]. The mean HU of the mandibular condyle in Jeju horses was lower than that in Thoroughbreds; however, this difference was not significant. In a previous report, a difference in HU was reported between sites [13]; the HU of the medial mandibular condyle was significantly lower than that of other sites. However, in this study, the differences in the mean HU were not significantly different between sites. In Jeju horses, the HU of the medial mandibular condyle was relatively high compared with other sites. This might be caused by the small number of horses used in this study. Further research is needed to determine differences in HU between breeds and the HU value of the mandibular condyle.

In a previous study, 40.2% of asymptomatic horses had CT anatomical variations in the TMJ [13]. In this study, anatomical variations were identified by CT in 87.5% of horses: 8 Jeju horses (8/10) and 6 Thoroughbreds (6/6); however, the prevalence of anatomical variations in Jeju horses was lower than that in Thoroughbreds. This might be due to the different mean age (mean age of Jeju horses: 4.5 ± 1.9 yr, mean age of Thoroughbreds: 7.3 ± 1.6 yr) or usage of horses. Most Thoroughbreds were riding horses, but Jeju horses were used for breeding in this study. In this study, the most common finding was an irregular margin of the medial mandibular condyle that attached to the pterygoid muscle, suggested as an age-related change in a previous study [13]. The degree of change varied across horses. The second most frequent anatomical variation was a focal hypodense region with a hyperdense rim, previously suggested as a bone cyst with sclerosis [13]. Additionally, mineralization of soft tissue adjacent to the TMJ was detected in an 8-year-old Thoroughbred mare without symptoms of masticatory difficulty or head shaking. This might be interpreted as an incidental finding but still needs to be followed up.

Approximately 28% of humans have TMJ disorders; 3%–7% of adults have TMJ osteoarthritis [23,24]. However, equine TMJ disorders have sparsely been reported. Although trauma and septic arthritis have relatively frequently been reported [2-6], other cases including those involving osteoarthritis have rarely been reported [15]. Recently, there have been several anecdotes on performance improvement after local anesthesia into the TMJ of horses with low-grade lameness [1]. Also, Jørgensen et al. [14] reported the improvement of performance after local steroid injection into the TMJ in a horse. Considering the reports mentioned above and the fact that horses graze up to 21 h a day [1], equine TMJ disorders might be under-diagnosed.

Imaging plays a key role in evaluation of the TMJ. Among the imaging techniques, MRI is considered as the golden standard for diagnosing TMJ disorders because of the ability to observe soft tissue such as the articular disc and synovial pouch. However, MRI is not currently available in equine medicine in South Korea. In horses, when CT or MRI is employed, general anesthesia is usually required. MRI scanning requires longer anesthetic duration, suggesting that more anesthetic-related complications could be expected. Thus, CT could be a pragmatic choice for the examination of the TMJ in horses.

Limitations of the present study include the small number of horses, and the differences in mean age and utilization between Jeju horses and Thoroughbreds. The prevalence of anatomical variations in this study was higher than that in a previous study [13]. This difference could be due to the small size or the difference in mean age between the two studies. Differences in CT parameters could also be the reason. Although the difference in mean HU between the two groups was not significant, this difference could be due to different mean ages or usage of horses. Riding horses routinely have a bit placed in the mouth, causing the TMJ to be stressed. The difference in the mandibular condyle shape was not affected by these limitations, as none of the horses were aged < 1 yr and none of them also had a pathological abnormalities on CT.

This report described the CT features of the TMJ in 10 Jeju horses and compared these with those of 6 Thoroughbreds. We found that the mandibular condyle shape in Jeju horses was flatter than in Thoroughbreds. We also observed several anatomical variations and an incidental finding in the TMJ of asymptomatic horses. This report might be helpful in the development of our understanding of the TMJ in Jeju horses.

ACKNOWLEDGEMENTS

The authors would like to appreciate to staffs in Jeju National University Equine Hospital and Institute for Livestock Promotion, Jeju-Special Self-Governing Province who helped the process of computed tomography scanning without accidents, and Editage (www.editage.co.kr) for English language-editing.

REFERENCES

1. Carmalt JL. Equine temporomandibular joint (TMJ) disease: fact or fiction? Equine Vet Educ. 2014;26(2):64-65.
CROSSREF
2. Barnett TP, Powell SE, Head MJ, Marr WN, Steven WN, Payne RJ. Partial mandibular condylectomy and temporal bone resection for chronic, destructive, septic arthritis of the temporomandibular joint in a horse. Equine Vet Educ. 2014;26(2):59-63.
CROSSREF
3. Carmalt JL, Wilson DG. Arthroscopic treatment of temporomandibular joint sepsis in a horse. Vet Surg. 2005;34(1):55-58.
PUBMED | CROSSREF
4. Elzer EJ, Wulster KB, Richardson DW, Ortved KF. Standing arthroscopic treatment of temporomandibular joint sepsis in a horse. J Vet Dent. 2020;37(2):94-99.
PUBMED | CROSSREF
5. Nagy AD, Simhofer H. Mandibular condylectomy and meniscectomy for the treatment of septic temporomandibular joint arthritis in a horse. Vet Surg. 2006;35(7):663-668.
PUBMED | CROSSREF
6. Warmerdam EP, Klein WR, van Herpen BP. Infectious temporomandibular joint disease in the horse: computed tomographic diagnosis and treatment of two cases. Vet Rec. 1997;141(7):172-174.
PUBMED | CROSSREF
7. Ramzan PH, Marr CM, Meehan J, Thompson A. Novel oblique radiographic projection of the temporomandibular articulation of horses. Vet Rec. 2008;162(22):714-716.
PUBMED | CROSSREF
8. Butler JA, Colles CM, Dyson SJ, Kold SE, Poulos PW. The head. In: Butler JA, Colles CM, Dyson SJ, Kold SE, Poulos PW, editors. *Clinical Radiology of the Horse*. 4th ed. Hoboken: Wiley-Blackwell; 2017, 449-530.
9. Rodríguez MJ, Soler M, Latorre R, Gil F, Agut A. Ultrasonographic anatomy of the temporomandibular joint in healthy pure-bred Spanish horses. Vet Radiol Ultrasound. 2007;48(2):149-154.
PUBMED | CROSSREF
10. May KA, Moll HD, Howard RD, Pleasant RS, Gregg JM. Arthroscopic anatomy of the equine temporomandibular joint. Vet Surg. 2001;30(6):564-571.
PUBMED | CROSSREF

11. Rodríguez MJ, Agut A, Soler M, López-Albors O, Arredondo J, Querol M, et al. Magnetic resonance imaging of the equine temporomandibular joint anatomy. Equine Vet J. 2010;42(3):200-207.
PUBMED | CROSSREF

12. Rodríguez MJ, Latorre R, López-Albors O, Soler M, Aguirre C, Vázquez JM, et al. Computed tomographic anatomy of the temporomandibular joint in the young horse. Equine Vet J. 2008;40(6):566-571.
PUBMED | CROSSREF

13. Carmalt JL, Kneissl S, Rawlinson JE, Zwick T, Zekas L, Ohlerth S, et al. Computed tomographic appearance of the temporomandibular joint in 1018 asymptomatic horses: a multi-institution study. Vet Radiol Ultrasound. 2016;57(3):237-245.
PUBMED | CROSSREF

14. Jørgensen E, Christophersen MT, Kristoffersen M, Puchalski P, Verwilghen D. Does temporomandibular joint pathology affect performance in an equine athlete? Equine Vet Educ. 2015;27(3):126-130.
CROSSREF

15. Smyth T, Allen AL, Carmalt JL. Clinically significant, non traumatic, degenerative joint disease of the temporomandibular joint in a horse. Equine Vet Educ. 2017;29(2):72-77.
CROSSREF

16. Oh WY, Kim BW, Cho HW, Shin TS, Cho SK, Cho BW. Analysis of associated race performance and functional characterization of conformation in Jeju horse. J Agric Life Sci. 2014;48(1):99-106.
CROSSREF

17. Kong HS, Lee HK, Park KD, Choi BW. A breed comparison on the finishing times of racehorses. J Anim Sci Technol. 2011;53(1):23-27.
CROSSREF

18. Khummuang S, Lee HG, Joo SS, Park JW, Choi JY, Oh JH, et al. Comparison for immunophysiological responses of Jeju and Thoroughbred horses after exercise. Asian-Australas J Anim Sci. 2020;33(3):424-435.
PUBMED | CROSSREF

19. Yoon SH, Kim J, Shin D, Cho S, Kwak W, Lee HK, et al. Complete mitochondrial genome sequences of Korean native horse from Jeju Island: uncovering the spatio-temporal dynamics. Mol Biol Rep. 2017;44(2):233-242.
PUBMED | CROSSREF

20. Boeddinghaus R, Whyte A. Computed tomography of the temporomandibular joint. J Med Imaging Radiat Oncol. 2013;57(4):448-454.
PUBMED | CROSSREF

21. Arzi B, Cissell DD, Verstraete FJ, Kass PH, DuRaine GD, Athanasiou KA. Computed tomographic findings in dogs and cats with temporomandibular joint disorders: 58 cases (2006-2011). J Am Vet Med Assoc. 2013;242(1):69-75.
PUBMED | CROSSREF

22. Saunders J, Schwarz T. Principles of CT image interpretation. In: Schwarz T, Saunders J, editors. *Veterinary Computed Tomography*. 1st ed. Hoboken: Wiley-Blackwell; 2011, 29-34.

23. Guralnick W, Kaban LB, Merrill RG. Temporomandibular-joint afflictions. N Engl J Med. 1978;299(3):123-9.
PUBMED | CROSSREF

24. Tanaka E, Detamore MS, Mercuri LG. Degenerative disorders of the temporomandibular joint: etiology, diagnosis, and treatment. J Dent Res. 2008;87(4):296-307.
PUBMED | CROSSREF