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Anatomic Reference for Computed Tomography of the Paranasal Sinuses and Their Openings in the Rayini Goat

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Abstract

Objective- to provide a reference anatomy of the paranasal sinuses of the goat by using computed tomographic modality.
Design- Experimented study.
Animals- Five male Rayini goats.
Procedures- CT images were acquired from the head region perpendicular to the hard palate. CT windows were adjusted as necessary to obtain the optimal image for the paranasal sinuses.
The images were studied serially and compared anatomically with two dissected head and intact goat skulls..
Results- Maxillary, frontal, palatine, lacrimal and conchal sinuses were identified and labeled according to cheek teeth as landmarks**.**
Conclusion and Clinical Relevance- The results of this study can help better understanding of paranasal sinuses position and their communications in a live animal.
Key Words- Computed Tomography, Anatomy**,** Goat, Paranasal Sinuses.

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Introduction

The anatomic complexity of the head usually results in vague understanding of the extension, location, and size of the communications between the various compartments of the nasal cavity and paranasal sinuses. Spatial relation of these structures is a little difficult to find out without having a good imagination of their communication. In live animal, conventional radiography helps us to view these structures in a plating film but superimposition of the canals, teeth and bones make it impossible to accurately identify sinusal margins, their extensions and associated structures. In contrast, Computed Tomography (CT) is particularly useful for imaging anatomically complex structures due to its ability to obtain transverse images and manipulate image contrast and latitude[1].

CT is more accurate than conventional radiography in diagnosis of location, extension and characterization of nasal cavity lesions[2] and its usage is improving in detection of large animals disorders, especially in the head region[3-10].

The digital image format of CT results in improved tissue contrast and anatomic information is depicted in a plane parallel to the x-ray beam[11]. CT also provided more precise information for tumor staging[12]. prediction of possible treatment-related complications, and planning surgery and radiation therapy[11]. It has been used also in streotaxic atlas preparation[13], biometric indices determination[14] and other nonclinical studies in small ruminants[15,16].

In all abovementioned subjects, having access to a CT anatomic reference lead to a three dimensional understanding of the head structures and would results in valuable information for researchers and non anatomist veterinarians[1,4,17,18,19]. To our knowledge, there is no published material on the CT characteristics of ruminants paranasal sinuses. Therefore in present study, although the gross anatomy of these structures in the small ruminants has been described[20,21], we used Rayini goat, as an accessible native goat to reproduce another anatomic reference with more detailed information.

Materials and Methods

Five healthy adult male Rayini goats weighting 31.2 ± 3.8 kg with 4 to 4.5 years of age were used in this study. Each goat was given intramuscular atropine (0/4 mg/kg) and after 5 minute was anesthetized by intravenous injection of mixed ketamine (2/2 mg/kg) and xylazine (0.11mg/kg) .

The goats were positioned in sternal recumbency with the head taped in a symmetrical position relative to the plane of image acquisition. X- ray radiation was adjusted by an angle of 90 degrees to the hard palate and tomograms were acquired at a thickness of 5 mm using a general diagnostic CT system (Toshiba Xvision EX). The acquisition parameters were as follows: kVp 120, mA 100 and scan-time of 1-S. Window width and level were adjusted as necessary to obtain the optimal image for the paranasal sinuses.

Following image acquisition, two goats were euthanized with an overdose of pentobarbital while still under anesthesia and their heads were removed. CT images were labeled by comparison with the cross sections of removed heads and the skull. The necks of cheek teeth were used as landmarks to describe the location and extension of the structures and cavities. For documentation, the images were printed as hard copies and stored digitally.

Results

The results of this study have been shown in the 10 CT images (Figures 1-10) as labeled anatomic components of the paranasal sinuses and its associated structures. These images belong to one head which have been selected from the five goat's scans.

Figure 1. Scout view of the head.

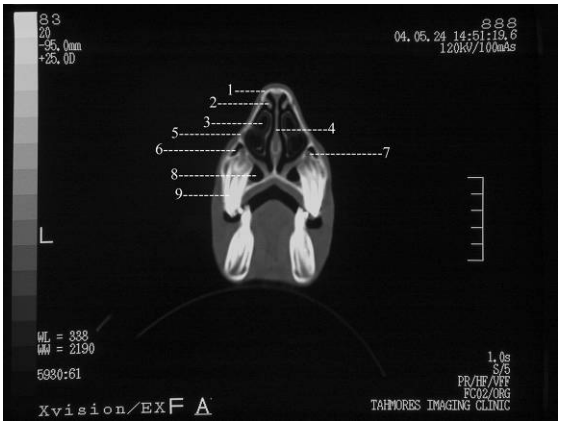

Figure 2. Transverse image through the 4th cheek tooth.
1- Nasal bone, 2-Straight fold, 3-Ventral nasal concha, 4-Nasal septum, 5-Nasolacrimal opening, 6-Maxillary sinus, 7-Infraorbital canal, 8- Palatine sinus, 9- 4th cheek tooth

The figure 1 is a scout view which depicts the location and angle of slice acquisition (dashed lines) for each image in Figures 2 through 10. In the next images, transverse view of each section has been illustrated. The images have been presented from rostral to caudal how the left and dorsal aspects of the head are in the left and dorsal side of the images respectively.

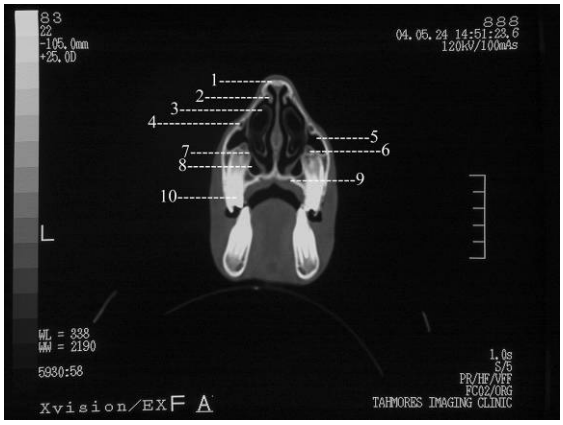

Figure 3. Transverse image through the 5th cheek tooth.
1-Nasal bone, 2-Dorsal nasal concha, 3-Ventral nasal concha, 4-Nasolacrimal duct, 5-Maxillary sinus, 6-Infraorbital canal, 7-Communication between maxillary and palatine sinuses, 8-Palatine sinus, 9- Palatine foramen, 10- 5th cheek tooth.

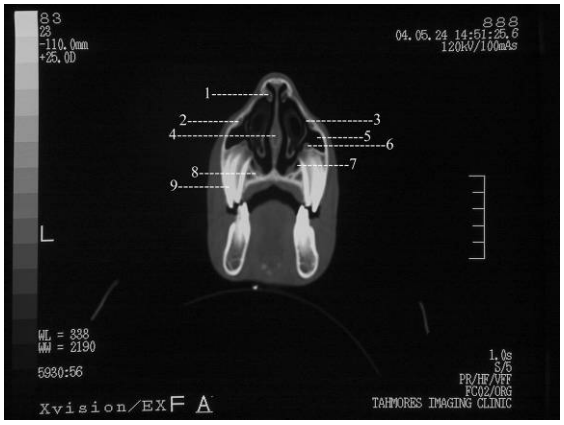

Figure 4. Transverse image through the 5th cheek tooth.
1-Dorsal conchal sinus, 2-Nasolacrimal duct, 3-Nasal opening of the maxillary sinus, 4-Nasal septum, 5-Maxillary sinus, 6-Infraorbital canal, 7- Palatine sinus, 8- Palatine canal, 9- 5th cheek tooth.

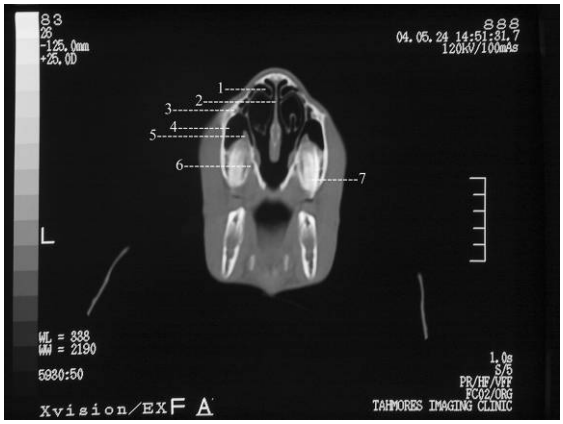

Figure 5. Transverse image through the 6th cheek tooth. 1-Dorsal conchal sinus, 2-Nasal septum, 3-Nasolacrimal duct, 4-Maxillary sinus, 5-Infraorbital canal, 6- Palatine canal, 7- 6th cheek tooth.

Figure 6. Transverse image through the post alveolar part of the head. 1-Frontal bone, 2-Dorsal conchal sinus, 3-Nasal septum, 4-Nasolacrimal duct, 5-Middle nasal concha, 6-Maxillary sinus, 7-Infraorbital canal.

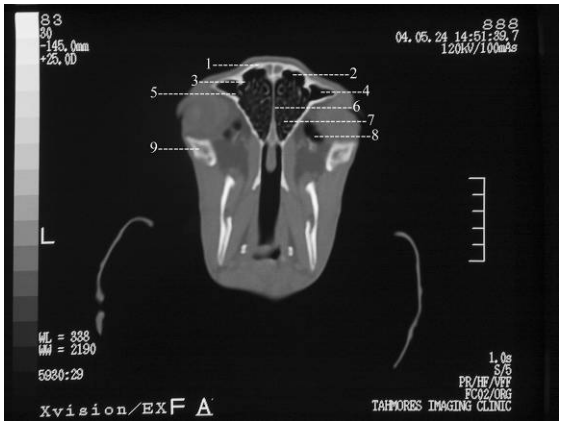

Figure 7. Transverse image through the rostral part of orbit. 1-Frontal bone, 2-Frontal sinus, 3- Frontal sinus opening, 4-Lacrimal sinus, 5- Lacrimal sinus opening, 6-Nasal septum, 7-Ethmoturbinates, 8-Lacrimal bulla, 9-Zygomatic bone.

Figure 8. Transverse image through the middle part of orbit. 1- Medial compartment of frontal sinus, 2- Lateral compartment of frontal sinus, 3- Lacrimal sinus, 4-Ethmoidal conchae, 5-Nasal septum, 6-Ventral border of orbit.

Discussion

According to the adjacent air and bone, the nasal cavity and the adjoining paranasal sinus system have more differential appearance within the CT slices in contrast to other body regions[1,19]. Moreover, the ability to manipulate the gray scale, allows optimal visualization of all tissues in the CT images. So, in present study, we used CT technique to provide the ability of having a new attitude to these structures.

Understanding of the position and extent of the paranasal sinuses, their communication with each other, associated structures and nasal cavity is important in interpretation of upper respiratory passages diseases and adjacent structures disorders[1,4,11,17,22]. Neoplasia, infectious and noninfectious inflammatory disease, trauma, dental and nasopharyngeal diseases can cause clinical signs localized to the nasal cavity and paranasal sinuses[2,4,22,23] which mostly are detectable by CT.

Figure 9. Transverse image through the caudal part of orbit. 1-Frontal bone, 2-Rostral chamber of lateral compartment of frontal sinus, 3-Caudal chamber of lateral compartment of frontal sinus, 4-Supraorbital foramen, 5-Orbital extremity of supraorbital canal, 6-Zygomatic arch.

Figure 10. Transverse image through the zygomatic arch. 1-Frontal bone, 2-Communication between rostral and caudal chambers of lateral compartment of frontal sinus, 3-Supraorbital canal, 4-Medial wall of orbit.

Among the studies about the CT anatomy of the head region of domestic animals, we could only find two articles which have mentioned ruminant head anatomy[13,15]. In those articles the authors have studied the neurocranium of the goat from the stereotaxic point of view post mortemly. So the head positioning have been occurred according to the external acoustic meatuses and other stereotaxic landmarks, which cannot be applied and performed on the live animal in the gantry.Positioning of the animal relative to the angle of the CT x-ray beam is critical to acquire images which can be compared to reference images, such as those provided here. Although it has been said that beam projection perpendicular to the hard palate should be modified[24], it has been used as the indicator of image angle acquisition in the nasal cavity[11,17]. So, according to the different curvature of the nasal bone in goat breeds, we acquired transverse CT images perpendicular to the hard palate.

Table 1. The location and extention of paranasal sinuses and their associated structures according to the cheek teeth.

Structure	Landmark							
	Toothless Part of Upper Jaw	1st Cheek Tooth	2nd Cheek Tooth	3rd Cheek Tooth	4th Cheek Tooth	5th Cheek Tooth	6th Cheek Tooth	Post Alveolar Part
Maxillary Sinus	-	-	-	-	+	+	+	+
Frontal Sinus	-	-	-	-	-	-	-	+
Palatine Sinus	-	-	-	+	+	+	-	-
Lacrimal Sinus	-	-	-	-	-	-	-	+
Dorsal Conchal Sinus	-	-	-	-	-+	+	+	+
Nasolacrimal Canal	-	-	-	-	+	+	+	+
Infraorbital Canal	-	-	+	+	+	+	+	+
Palatine Canal	-	-	-	-	-	+	+	+
Supraorbital Canal	-	-	-	-	-	-	-	+

Use of the cheek teeth neck as landmarks in this study was due to constant position of them in the hard palate and because of their easily recognition within cross-sectional images and in live animal. They have been employed for this purpose in other species too[17,24].

On the contrary to the Getty, which have mentioned rostral extension of the maxillary sinus at the level of the first cheek tooth[20], in this study the maxillary sinus had begun from the 4th cheek tooth as a pointed space medial to the root of this tooth (Fig. 2). The zygomatic bone excavation (Fig. 6) and caudal termination of sinus (Fig. 7) were seen as have mentioned in the anatomic references[20,21]. The lesser medial chamber was observed medial to the infraorbital canal. It had communicated with the palatine sinus through a slit along the 5th cheek tooth (Fig. 3) and had opened into the nasal cavity dorsomedially at the same level (Fig. 4). We could not find any exact description of site of two sinuses communication.[20, 21].

Despite of the statement that palatine sinus development occurs more rostrally and caudally[20], it was observed between the 3rd to 5th cheek teeth (Fig. 2-4). The greatest part of the sinus and its communication with the maxillary one, were seen at the level of the 4th and 5th cheek tooth respectively.

In all cases, dorsal conchal sinus had extended caudally to the level of cribriform plate, but its rostral limit was observed differently from case to case between the 4th and 5th teeth (Fig. 4). The size of sinus had moderately increased rostro-caudally.

The rostral end of the infraorbital canal was seen a few mm rostral to that of Getty says[20] at the level of the 1st cheek tooth. The canal which had developed medially to sit on the pulp of the maxillary cheek teeth, had extended caudally in the maxillary sinus and terminated behind the last cheek tooth (Fig. 2-6). Its cross section was seen rounded rostrally but triangular caudally.

Two extremities of the Supraorbital canal were observed at the same level but according to its curved course, intrasinusal part of the canal was identified in next two more caudal images.

The location and extension of aforementioned structures have been shown in the table 1.

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چکیده:

مطالعه کالبدشناختی تصاویر سی تی اسکن سینوس های اطراف حفره بینی و سوراخ های آنها در بز رائینی

بهادر شجاعی[1]، محمد ناصر ناظم[1]، داریوش وثوق[2]

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هدف - تهیه یک منبع کالبد شناختی از سینوس های اطراف حفره بینی بز به کمک سی تی اسکن.

طرح مطالعه - مطالعه تجربی.

حیوانات - پنج راس بز رائینی نر.

روش کار - تصاویر سی تی از ناحیه سر عمود بر کام سخت تهیه شدند. پنجره سی تی به نوعی تنظیم شد که بهترین تصویر از سینوس ها به دست آید. تصاویر سریال مطالعه و از نظر کالبد شناختی با دو سر تشریح شده و جمجمه سالم بز مقایسه شدند.

نتایج- سینوس های فک بالا، پیشانی، کامی، اشکی و بوکی مشخص و با توجه به دندان های آسیایی به عنوان نشانه نامگذاری شدند.

نتیجه گیری و کاربرد بالینی- نتایج این مطالعه می تواند به درک بهتر موقعیت سینوس های طراف حفره بینی و ارتباط بین آنها کمک کند.

کلید واژگان- سی تی اسکن، کالبدشناسی، بز، سینوس بینی.