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Gross and Morphometrical Studies on the Non-Osseous part of the Hard Palate in Domestic Pig (*Sus scrofa domesticus*)

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ABSTRACT

The present study was undertaken to investigate the gross and morphometrical features of the non-osseous part of the hard palate in the domestic pig. For this purpose, fresh head specimens from 12 adult domestic pigs, irrespective of sex, were collected immediately after slaughter. The upper and lower jaws were separated by dissection at the temporo-mandibular joint level to facilitate clear visualization of the non-osseous part of the hard palate. A well-defined central palatine raphe divided the mucous membrane of the hard palate into two equal halves. The total length of the hard palate was recorded as 19.8 ± 1.8 cm. The maximum width recorded at the level of canine tooth was 7.3 ± 0.5 cm. The number of palatine ridges ranged from 22-23 on the right side and 23-24 on the left side of the palatine raphe. The palatine ridges were smooth, curved, non-serrated and irregularly arranged. A rounded or diamond-shaped incisive papilla was present rostrally and was bordered on either side by fissures containing the openings of the nasopalatine ducts.

Key words: Non-osseous part of the hard palate, papilla incisive.

INTRODUCTION

Pigs are important experimental animals in biomedical and translational research because their anatomical, physiological, and metabolic features closely resemble those of humans (Lunney, 2007 and Swindle *et al.*, 2012). The non-osseous part of the hard palate plays an important role in mastication and deglutition and provides protection to the underlying bony palate. It is firmly attached to the periosteum and is well adapted to withstand mechanical stress during feeding **(**Sisson and Grossman, 1975a and Dyce *et al.*, 2010). Morphological and morphometrical studies on the hard palate have been reported in several domestic animals including cattle and buffaloes,highlighting species variations in palatine ridges, palatine raphe and mucosal adaptations associated with feeding habits and oral function (Maala, 2007). In addition, pigs are widely used as experimental models in craniofacial and oral research because of similarities in oral and maxillofacial structures with humans, particularly in studies related to wound healing, cleft palate repair, and reconstructive surgery (Swindle *et al.*, 2012 and Wong *et al.*, 2009). The literature available on the gross and morphometry of non-osseous part of the hard palate in domestic pigs is scanty. Therefore, the present study was undertaken to study the gross and morphometrical features of the non-osseous part of the hard palate.

MATERIALS AND METHODS

For the gross and morphometrical studies of the non-osseous part of the hard palate, fresh head specimens from 12 adult domestic pigs, irrespective of sex, were collected immediately after slaughter. The upper and lower jaws were separated by dissecting at the temporo-mandibular joint level to visualize the non-osseous hard palate clearly. The research protocol was approved by Institutional Animal Ethics Committee vide ref.No.281 /go /ReBi /S/2000/CPCSEA/CVSc/ TPTY/001/ Veterinary Anatomy/2023dated 08.05.2023. Immediately after collection, gross observations of the hard palate were recorded, including the number of palatine ridges and the

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shape and location of the incisive papilla. For morphometrical studies, parameters such as the total length of the hard palate, width of the hard palate, length of the palatine raphe and length and width of the incisive papilla were measured using a measuring scale and nylon thread. All the measured morphometrical observations were subjected to statistical analysis (Snedecor and Cochran, 1994) using SPSS software version 17and the results were expressed in Mean ± SE in cm.

RESULTS AND DISCUSSION

In the present study, the non-osseous part of hard palate was bounded laterally by the alveolar arches of the maxilla, rostrally by the incisive bone, and caudally by the fixed border of the soft palate (Fig.1) as reported by Sisson (1975 a) in equines. In contrast, the hard palate of buffaloes and Rahmani sheep was bounded rostrally by the dental pad, laterally by the upper dental arch and caudally by the soft palate as reported by Farrag *et al.* (2021) and Madkour *et al*. (2021) respectively. The mucous membrane of the hard palate extended rostrally from the level of the first pair of upper incisor teeth and terminated caudally at about 1-1.5 cm above the level of the last upper molar teeth (Fig.1). Contrary to this finding, the hard palate extended from the incisors to the last check teeth level in equines (Nickel *et al.*, 1979), while in cattle it extended cranially from the dental pad to the last molar tooth caudally (Maala, 2007) and in Rahmani sheep it extended from the dental pad anteriorly to the soft palate posteriorly (Madkour *et al.*, 2021). The total length of the hard palate, measured along the midline from lingual surface of the first pair of central incisors to the mid rostral edge of the soft palate, was recorded as 19.8 ± 1.8 cm (Fig.2), while in cattle it was 27.0 ± 1.53 cm as reported by Maala (2007), whereas Mahdy *et al.* (2018) in Egyptian goats and Madkour *et al.* (2021) in Rahmani sheep reported that the length was 96.9 ± 3.3 mm and 122.18 ± 2.54 mm, respectively. In the present study, the width of the hard palate gradually increased up to the tusk level (Table.1, Fig.3), as reported by Nickel *et al*. (1979) in pigs, and thereafter the width gradually decreased up to the level of the third molar teeth, and again increased caudally (Table.1, Fig.3). Contrary to this, the width of the hard palate was uniform throughout its length as reported by Nickel *et al.* (1979) in equines, while in goats (Habel, 1975 and Nickel *et al.*, 1979) and in Egyptian goats (Mahdy *et al.*, 2018) the width remained uniform but showed abrupt widening at the 1st and 2nd cheek teeth level, whereas in ox, (Habel, 1975 and Nickel *et al.*, 1979) the hard palate was wider cranially and caudally with a constricted middle portion. The maximum width of hard palate in the present study was7.3 ± 0.5 cm at the level of the canine tooth (Table.1, Fig.3). Contrary to this finding, the maximum width was recorded at the last molar teeth level in Egyptian goats (Mahdy *et al.*, 2018) and Rahmani sheep (Madkour *et al.*, 2021) was 34.4 ± 2.1 mm and 46.15 ± 2.20 mm respectively.

A central palatine raphe divided the mucous membrane of the hard palate into two equal halves (Fig.1) as reported by Sisson (1975)[a,b] in pigs and equines. Contrary to this, the median palatine raphe was indistinct in dogs and absent in cats (Ellenport, 1975). In the present study, the palatine raphe extended from the caudal limit of the incisive papilla rostrally to its junction with the soft palate caudally, as reported by Sisson (1975)[b] in pigs and Mahdy and Mohammed (2021) in domestic rabbits. However, Mahdy *et al.* (2018) reported a prominent palatine groove extending from the dental pad to the last upper premolar tooth level which continued posteriorly by a shallow groove and ended at the caudal end of the hard palate in Egyptian goats, while in Rahmani sheep (Madkour *et al.*, 2021), it extended from the dental pad to the first molar tooth and in tabby cats, (Mehmet and Ermis, 2023) it extended from the incisive papilla to the last molar tooth level. The length of the palatine raphe in the present study was 16.8 ± 1.7 cm (Fig.2), while in Egyptian goats (Mahdy *et al.*, 2018) and in Rahmani sheep (Madkour *et al.*, 2021) it was recorded as 87.9 ± 3.6 mm and 81.58 ± 3.10 mm, respectively. In the present study on either side of the palatine raphe palatine ridges were observed throughout the mucous membrane of the hard palate which were smooth, curved, non-serrated and non-pigmented (Fig.1) which concurs with the

findings reported by Sisson (1975)[b] in pigs. In contrast to this finding, Ellenport (1975) in carnivores and Maala (2007) in cattle reported that the mucous membrane of the hard palate was pigmented, while Habel (1975), Nickel *et al.* (1979) in ox and Farrag *et al.* (2021) in buffaloes reported that in the cranial half of the hard palate the free caudal borders of palatine ridges were serrated with caudally directed horny papillae.

In the present study, the palatine ridges began rostrally at the level of the second or third incisor teeth and extended caudally up to the junction of the hard and soft palates, which concurs with the findings of Nickel *et al.* (1979) in porcine. Contrary to this finding, palatine ridges in ox and goats began at the caudal limit of the dental pad and ended at the second cheek tooth level, while in sheep they extended up to the third cheek tooth level (Habel, 1975 and Nickel *et al.*, 1979). In the present study, the number of palatine ridges ranged from 22- 23 on the right side and 23- 24 on the left side of the palatine raphe as reported by Sisson (1975)[b] and Nickel *et al.,* (1979) in pigs, while in buffaloes (Farrag *et al.,* 2021) the number of ridges on the right side was 18 and on the left side was 19, sixteen to eighteen palatine ridges in equines(Nickel *et al.*, 1979), fifteen to nineteen palatine ridges in ox, fourteen palatine ridges in sheep and twelve palatine ridges in goat (Habel, 1975 and Nickel *et al.*, 1979). Similarly, eight to ten palatine ridges were found in the dog and seven to nine ridges with papilla between the ridges were observed (Ellenport, 1975). Sixteen palatine ridges in monkeys (Suri *et al.*,2019), fourteen to sixteen palatine ridges in rabbits (Mahdy and Mohammed, 2021) were observed on either side of the palatine raphe.

The palatine ridges were closely arranged up to the level of the last upper premolar or first upper molar teeth, beyond which they were widely spaced up to the caudal border of the hard palate in the present study (Fig.1). Contrary to this, these ridges in equines were farther apart at diastema but were closely arranged rostrally and caudally (Nickel *et al.*, 1979). In the present study the palatine ridges were irregularly positioned, with right and left ridges meeting alternately at the palatine raphe as reported by Habel (1975) in sheep and goats. In this study, in some specimens the ridges met directly at the palatine raphe up to the level of second or third upper premolar teeth, (Fig.1), which concurs with the findings of Habel (1975) in ox.

A rounded or diamond-shaped incisive papilla was located rostrally in the median plane between the caudal limit of the first pair of upper incisor teeth and the first pair of palatine ridges of the hard palate (Fig.1), which was in agreement with the findings of Sisson (1975)[b] and Nickel *et al.* (1979) in pigs. Contrary to these findings, the shape of incisive papilla was half-moon shaped in Bakerwali goats (Sarma *et al.*,2012), triangular shaped in buffaloes (Farrag *et al.*, 2021). The incisive papilla was located between the dental pad and the first ridge of hard palate in ruminants (Habel, 1975), cattle (Maala, 2007) and buffaloes (Farrag *et al.*, 2021). In present study the papilla incisiva was bordered on either side by fissures containing the openings of the nasopalatine ducts (Fig.1) as reported by Sisson (1975)[b] and Nickel *et al.* (1979) in pigs, Habel (1975) in ruminants and Maala (2007) in cattle. In contrary to this finding, incisive papilla was surrounded by fissures but incisive ducts were not opened in to the fissures as reported by Sisson (1975)[a] and Nickel *et al.* (1979) in equines.

In the present study, the length of the incisive papilla measured from base to apex of papilla was recorded as 1.8 ± 0.7 cm (Fig.3), while in Bakerwali goats (Sarma *et al.*, 2012) and in Rahmani sheep (Madkour *et al.*,2021) it was 0.58±0.97 cm and 8.21± 0.29 mm, respectively. The width of incisive papilla was measured at its widest point, i.e., at the opening of nasopalatine ducts was recorded as 0.8 ± 0.3 cm (Fig.3), while in Bakerwali goats (Sarma *et al.*, 2012) and in Rahmani sheep (Madkour *et al.*,2021) it was 0.62±1.00 cm and 8.73 ± 0.27 mm, respectively.

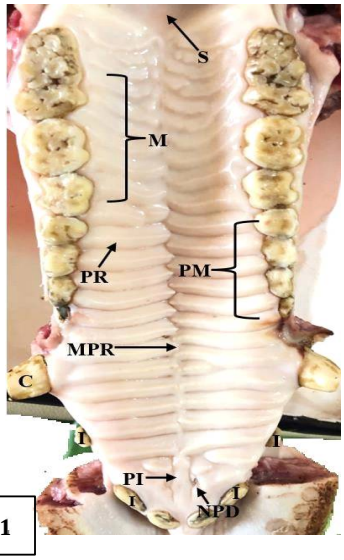

Fig.01

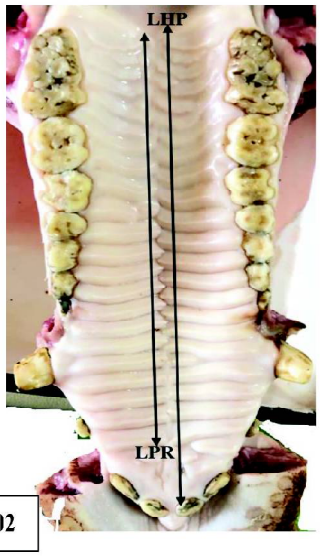

Fig.02

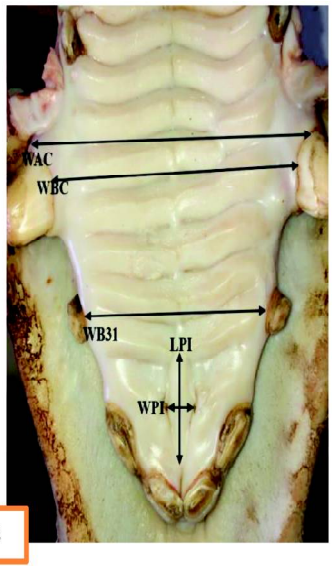

Fig.03

Fig.1. Photograph of the hard palate of pig showing papilla incisiva (PI), nasopalatine duct (NPD), mid palatine raphe (MPR), palatine ridge (PR) and soft palate(S). C- Canine teeth I- Incisor teeth M- Molar teeth PM-Premolar teeth. **Fig.2.** Photograph of hard palate of pig showing the length of hard palate (LHP), length of mid-palatine raphe (LPR). **Fig.3**. Photograph of hard palate of pig showing width of the hard palate just behind the canine teeth (WAC), width of the hard palate at canine teeth level (WBC), width of the hard palate at 3rd incisor teeth level (WB31), length of papilla incisiva (LPI) and width of papilla incisiva (WPI).

Table 1: Morphometrical parameters of the non-osseous part of the Hard palate in Domestic Pig (Sus scrofa domesticus)

S.No.	Parameter- Width	Mean ±SE (cm)
1.	At 1st incisor teeth level	2.2 ± 0.6
2.	At 2nd incisor teeth level	3.0 ± 0.5
3.	At 3rd incisor teeth level	5.2 ± 0.3
4.	Just infront of canine tooth (At diastema)	6.3 ± 0.7
5.	At canine teeth level	7.3 ± 0.5
6.	Just behind canine tooth (At diastema)	7.2 ±0.4
7.	At 1st premolar teeth level	5.5 ± 0.5
8.	At 2nd premolar teeth level	5.1 ± 0.3
9.	At 3rd premolar teeth level	4.6 ± 0.5
10.	At 4th premolar teeth level	4.35 ± 0.4
11.	At 1st molar teeth level	3.9 ± 0.5
12.	At 2nd molar teeth level	3.7 ± 0.4
13.	At 3rd molar teeth level	3.6 ± 0.2
14.	Just behind the 3rd molar tooth	5.0 ± 0.4
15.	At posterior border of bony palate	5.2 ± 0.5
16.	Length of papilla incisiva	1.8 ± 0.7
17.	Width of papilla incisiva	0.8 ± 0.3

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