Observations on the Function of the Transverse Palatine Muscle (Broman) in the Mouse Hard Palate

By

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Summary: The muscles of the mouse hard palate were studied in 12 adult mice by observations based on light microscopy and macroscopy. As a result, an undescribed muscle was found and named the “oblique palatine muscle” by the authors. The running direction of this muscle indicated a functional role whereby the incisive foramina would be dilated by traction of this muscle. On the other hand, it was noted that the bundle of the transverse palatine muscle pressed the incisive papilla backwards and the incisive foramina were shut by traction of this muscle. The authors assume that the functional role of the taste buds in the incisive papilla is essential for the protective reflex in the nasopalatine duct.

The occurrence of taste buds in the incisive papilla was demonstrated in the rat by Kolmer (1927). In the mouse, it has also been found that taste buds occur in the wall of the nasopalatine ducts and incisive papilla (Kutuzov and Sicher, 1953; Yoshioka, 1962). Previously, the present authors have observed the taste buds of the mouse incisive papilla by light and scanning electron microscopy (Ozeki et al., 1975) and the postnatal development of numbers of its taste buds (Ohta-Yamakita et al., 1982). Recently, Hofer (1977, 1978, 1980) and Wöhrmann-Repenning (1978) described the occurrence of taste buds in the incisive papilla of several primates (Prosimiae). Many investigators have supported the hypothesis that the taste buds in this area represent chemosensors conveying information on taste substances to release protective reactions. Broman (1919) considered that the transverse palatine muscle described by him would block the nasopalatine ducts between the oral and nasal cavities. In the present study, an attempt was made to assess the role of the transverse palatine muscle in the mouse.

Materials and Methods

The Material used for this experiment were 12 SMA adult mice (2 males and 10 females). Six of them were killed under chloroform anesthesia and their hard palates were fixed in 80% alcohol or 10% formalin. They were observed under a dissecting microscope after preparing
their transverse palatine muscle (Boman).

The incisive papilla and surrounding tissue taken from 4 mice were fixed in 10% formalin, and after decalcification in 5% nitric acid they were passed through a graded ethanol series and embedded in paraffin. They were cut serially into frontal and sagittal sections at a thickness of about 10 to 15 microns and stained with hematoxylin-eosin. The other 2 mice were fixed in 10% formalin with traction of the labial fold towards the lateral direction, and treated by the same method as the above 4 mice.

Results

The middle part of the transverse palatine muscle between the incisors and incisive papilla was found to run mainly towards a transverse direction (Fig. 1). Both sides of the transverse palatine muscles were joined on the medial sides with a palatal raphe consisting of dense connective tissue on the midsagittal line, and fanning out laterally, crossed with fibers of the m. levator labii superioris. The anterior and middle bundles of the transverse palatine muscle were inserted into the subcutaneous part of the upper lip. The posterior bundle of this muscle ran posterolaterally, passing the lateral sides of the incisive papilla and oral angle, and was inserted into the margin of the bundle. Between the premaxilla and the transverse palatine muscle, fatty tissue was noted but little existed among the muscle fibers.

The m. levator labii superioris arose from the anterior surface of the premaxilla, radiated to both sides of the upper lip and was inserted into the subcutaneous part. Some of these muscle fibers extended to the follicles of the tactile hairs (Fig. 2).

M. incisivus, initially described by Broman (1919), arose from the lateral side of the premaxilla, and ran almost vertically downwards to the subcutaneous part of the lateral margin of the upper lip (Fig. 3). The lower part of these muscle fibers of the transverse palatine muscle.

Apart from the m. incisivus, an undescribed muscle was found to be attached to the median part of the premaxilla, running downwards along the anterior surface of the bone, and to reach the median part of the transverse palatine muscle. However, it was not apparently inserted into the subcutaneous part of the palatal mucosa (Fig. 4).

A pair of lower ends of the nasopalatine ducts, incisive foramina, opened near the lateral margin of the incisive papilla (Fig. 5). Moreover, by traction of the transverse palatine muscle, a mass of this muscle pressed the incisive papilla backwards and the incisive foramina became shut (Fig. 6).

Taste buds occurred abundantly near the lower part in the anteromedial wall of the nasopalatine ducts, but there were few on the oral surface of the incisive papilla. In the posterior part of the papilla, backwards to the incisive foramina, was Merkel's papillary cartilage, its long axis being situated towards the transverse direction.

Discussion

Many investigators have supported Merkel's hypothesis that the incisive papilla may have some specialized sensory functions, and it has been considered that the papilla may be highly sensitive to external stimuli because of the dense innervation, the restrictive distribution of different types of nerve endings and the presence of specialized epithelial papillae (Yohro, 1980). Otherwise, it is known that there exist in only several animals, taste buds on the lower part of the naso-
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Generally speaking, the role of the taste buds outside the oral cavity has been assumed to be as chemosensors, like the taste buds of the oral cavity. Wilson (1905), who reviewed the early literature on the taste buds of the larynx, hypothesized that epiglottal taste buds were components of the reflex mechanism protecting the airway. Electrophysiological studies have also demonstrated that the nerve supply of the epiglottis contains chemosensitive fibers (Storey, 1968; Storey and Johnson, 1975; Harding et al., 1978). Recently, Bradley et al. (1980) supported the theory that the epiglottal taste buds had a functional role in the upper airway protective reflex, based on the large number of taste buds and the duration of their density on the epiglottis, also adding review of the literature.

Concerning the role of the taste buds of the incisive papilla, Hofer (1977, 1978, 1980) and Wöhrmann-Repenning (1978) stated that in several Prosimiae, taste buds stimulated by a substance approaching the sulcus papillae could convey their information to the central nervous system before the substance reached the orifice of the ductus nasopalatinus and vomeronasalis, and if the substance was detrimental, a protective reaction could be released by the central nervous system. Furthermore, they considered that the taste buds of the incisive papilla were functionally related to both the olfactory system through the nasopalatine ducts and the vomeronasal organ through the vomeronasal ducts, based on the distribution and orientation of the taste buds, occurring exclusively in the epithelium of the lateral wall of the incisive papilla, opening into the sulcus. The vomeronasal organs are related to sexual behavior as has been demonstrated recently (Winans and Scalia, 1970; Powers and Winans, 1973, 1975; Scalia and Winans, 1975; Winans and Powers, 1976). Hofer and Wöhrman-Repenning hypothesized that the sensory cells of the taste buds might receive pheromones as well as those of the olfactory epithelium of the vomeronasal organ.

The present authors consider from previous research that the taste buds of the incisive papilla may serve as chemosensors like other oral taste buds (Ohtayamakita et al., 1982). Although in the Prosimiae examined by Hofer et al., the vomeronasal duct opens into the nasopalatine duct, in the mouse, rat and guinea pig the vomeronasal ducts open directly into the nasal cavity anteriorly to the orifice of the nasopalatine duct. The results of our study do not indicate the finding on which Hofer's hypothesis was supported. The present authors suggest, therefore, that these taste buds may have a functional role in the protective reflexes of the nasopalatine duct, based on the large numbers of the taste buds on the lower part of the nasopalatine duct.

In 1919, Broman described several muscles in the hard palate of several rodents. That is, he found in the rat and mouse a superficial muscle, named the transverse palatine muscle (Gaumenquermuskel), between the incisor and incisive papilla; in the guinea pig, these were three muscles comprising a V-form muscle, superficial anterior transverse palatine muscle and deep posterior transverse palatine muscle; and in the rabbit, only an oblique palatine muscle existed which was analogous to the V-form muscle. Based on the passage of the posterior bundle of the transverse palatine muscle, running through the anterior and lateral sides of the incisive papilla and oral angle and inserted into the mandibular margin, Broman assumed that contraction of this muscle would press the surrounding fatty tissue of the incisive
papilla, and serve to shut the incisive foramina.

In the present study, the bundle of this muscle between the oral atrium and oral cavity (in the strict sense) showed interception of the nasopalatine ducts as in Broman's hypothesis by traction of the labial fold lateralwards. This finding was never observed in a flaccid condition. At this time, it is assumed that Merkel's palatal cartilage probably performed a role supporting this pressure.

The above muscle, tentatively named the oblique palatine muscle by the present authors, arose from the midsagittal part of the premaxilla and was inserted into the median part of the transverse palatine muscle. It is considered that contraction of this muscle may force the median part of the transverse palatine muscle upwards and dilate the incisive foramina.

References

5) Hofer, H.O.: Further observations on
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PLATES
Explanation of Figures

Plate I

Fig. 1. Anterior part of the mouse hard palate. The major part of the upper lip and mucous membrane between the incisor and incisive papilla have been removed. The transverse palatine muscle is observed to fan out from the midsagittal line of the hard palate. On the left side of the hard palate, a few bundle of the TPM have been removed and the nasal cavity can be seen. ×18
  I: incisor
  IP: incisive papilla
  TPM: transverse palatine muscle
  PR: palatal rugae

Fig. 2. Frontal section of the mouse head. The premaxilla and m. levator labii superioris are observed. The m. levator labii superioris runs laterally at the lower end of the premaxilla and extends to the subcutaneous part of the upper lip. ×160
  P: premaxilla
  ML: m. levator labii superioris
  TH: tactile hair

Fig. 3. Sagittal section through the incisor. The m. incisivus has been cut longitudinally, and the fibers cross the TPM and extend to the subcutaneous part of the upper lip. Fatty tissue can be seen surrounding them. ×160
  MI: m. incisivus
  TPM: transverse palatine muscle
  F: fatty tissue
Plate II

Fig. 4. Frontal section. The oblique palatine muscle runs along the premaxilla, and reaches the median part of the TPM. ×100
   P: premaxilla
   OPM: oblique palatine muscle
   TPM: transverse palatine muscle

Fig. 5. Frontal section of the hard palate. The lower end of the nasopalatine duct and a taste bud can be seen (arrow). ×220
   IP: incisive papilla
   C: Merkel's cartilage
   NP: nasopalatine duct
   TPM: transverse palatine muscle

Fig. 6a. Macrophotograph of the mouse maxilla. The upper lip was forced laterally with pins (arrow). ×3.6

Fig. 6b. Sagittal section of the specimen shown in Fig. 6a. The lower end of the nasopalatine duct was shut. ×160