NEW INSIGHTS INTO THE ANATOMICAL BASIS OF HUMAN CLEFT PALATE SURGERY

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HIGHLIGHTS

- **Microanatomy of the soft palate in relation to the surrounding bony structures.**
- **Extending cadaveric dissection with histological analysis of slices of whole cadaveric heads.**
- **Analysis of the relationship between the tensor veli palatini muscle, the superior pharyngeal constrictor and the hamular region based on nanoCT images of a newborn head.**

INTRODUCTION

The anatomy of the hard and soft palate is generally accepted to be fully described and not to offer much more to be explored. However, the experience of maxillofacial surgeons during minimally invasive procedures for palatal cleft repair has raised the need for more detailed anatomical knowledge regarding the palate and its surroundings. Specifically, the micro-anatomical junction between the soft palatal aponeurosis and the tendon of the tensor veli palatini, as well as between the palatal aponeurosis and the periost of the medial pterygoid process, was examined and discussed in relation to soft palatal mobility.

MATERIALS & METHODS

- **Traditional dissection of formaldehyde-fixed adult human heads.**
- **Methylmethacrylate (MMA) embedding: MMA-embedded sections were ground to a thickness of 250 µm and a combination of toluidine blue epoxy and Masson-Goldner trichrome staining was applied.**
- **Nanotom® (phoenix|x-ray, GE Sensing & Inspection Technologies GmbH, Wunstorf, Germany) was used to image the plastinated head of a newborn human. Pixelsize: 45-50 µm.**

RESULTS

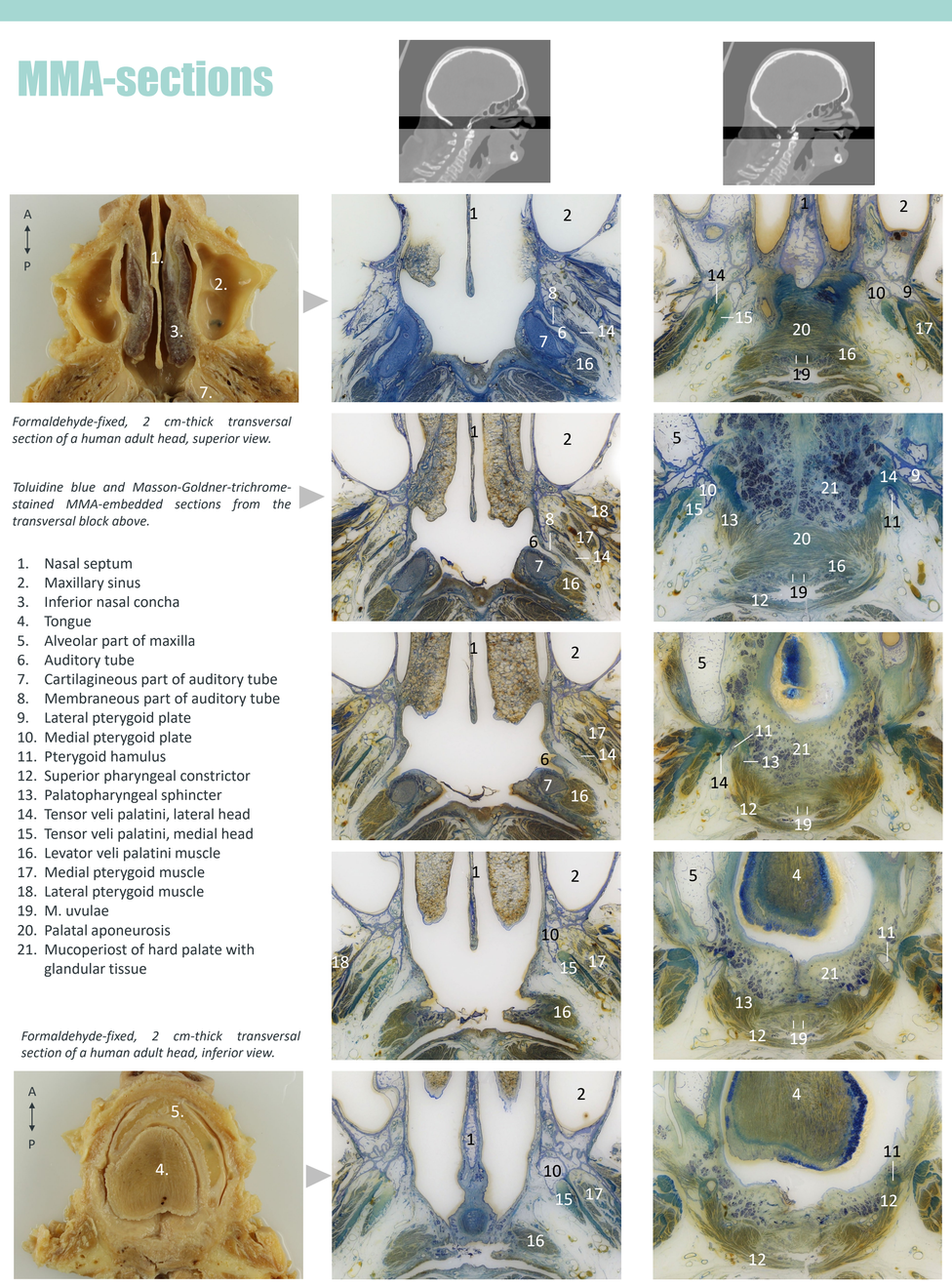
Tensor veli palatini (TVP)

Our results support the description by Rüdinger (1870) (revisited by Abe, 2004), that the tensor veli palatini muscle can be anatomically and functionally divided up into a lateral and medial head. The lateral head is attached to the outer cranial base and its tendon swings lateromedially around the pterygoid hamulus to radiate into the superior-anterior layer of the aponeurosis in the soft palate. Accessory insertion of the lateral head reaches the maxillary tuberosity. The medial head (in historical literature: dilator tubae) is superiorly attached to the lateral lamina of the tubal cartilage and inserts in the inferior part of the pterygoid fossa.

Superior pharyngeal constrictor (SPhC)

Our methods, both in adult and newborn, reinforce the findings of Whillis (1930) and Sumida et al. (2017) based on traditional dissection. The superior pharyngeal constrictor (SPhC) inserts along the posterior edge of the medial pterygoid plate and continues beyond the hamulus along the pterygo-mandibular raphe. An additional fibre tract radiates from the superior border of the SPhC into the lateral palatine aponeurosis, corresponding to the palatopharyngeal sphincter lifting up Passavant`s ridge during velopharyngeal closure (Whillis, 1930; Sumida, 2017).

MMA-sections



Formaldehyde-fixed, 2 cm-thick transversal section of a human adult head, superior view.

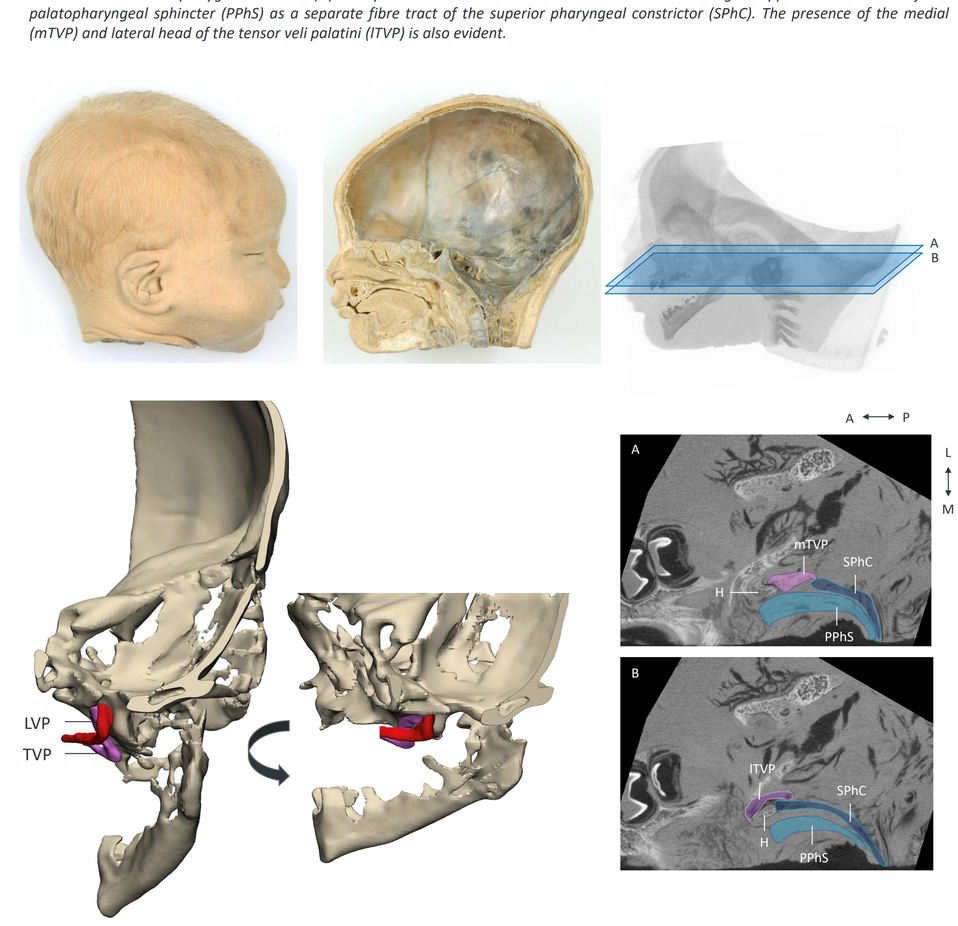
Toluidine blue and Masson-Goldner-trichrome-stained MMA-embedded sections from the transversal block above.

1. Nasal septum
2. Maxillary sinus
3. Inferior nasal concha
4. Tongue
5. Alveolar part of maxilla
6. Auditory tube
7. Cartilagineous part of auditory tube
8. Membraneous part of auditory tube
9. Lateral pterygoid plate
10. Medial pterygoid plate
11. Pterygoid hamulus
12. Superior pharyngeal constrictor
13. Palatopharyngeal sphincter
14. Tensor veli palatini, lateral head
15. Tensor veli palatini, medial head
16. Levator veli palatini muscle
17. Medial pterygoid muscle
18. Lateral pterygoid muscle
19. M. uvulae
20. Palatal aponeurosis
21. Mucoperiost of hard palate with glandular tissue

Formaldehyde-fixed, 2 cm-thick transversal section of a human adult head, inferior view.

Nanotom®

The area around the pterygoid hamulus (H) in a plastinated hemisectioned newborn head. The images support the existence of the palatopharyngeal sphincter (PPhS) as a separate fibre tract of the superior pharyngeal constrictor (SPhC). The presence of the medial (mTVP) and lateral head of the tensor veli palatini (lTVP) is also evident.



3D-reconstruction of the levator veli palatini (LVP, red) and the tensor veli palatini (TVP, purple) show the anatomical relations and the topographical arrangement to surrounding bony structures in newborn.

CONCLUSIONS

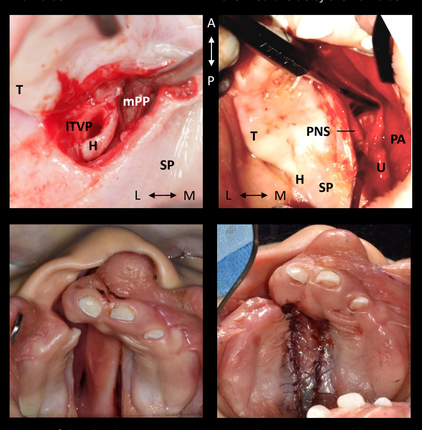
Minimal incision palatoplasty using the medial approach has several advantages:
1. It preserves the anatomical-functional unit of the palatal aponeurosis with the auditory tube via the mTVP.
2. It maintains velopharyngeal function by keeping the attachment of the superior pharyngeal constrictor on the hamulus intact.
3. It helps to avoid growth-related disturbances resulting from scarring at the maxillary tuberosity, a known growth zone of the maxilla.

CLINICAL RELEVANCE

Based on the anatomical conditions, a purely intravelar, medial approach is possible in order to mobilise the palatine aponeurosis for soft palate closure in the midline. It is enough to release the lateral TVP tendon next to the pterygo-palatine suture, antero-medially of the hamulus. A lateral incision at the maxillary tuberosity to access the tensor tendon can thus be avoided. Consequently, the functional association between the tubal cartilage and the medial head of the TVP can be maintained. Moreover, the connection between the lTVP and the maxillary tuberosity also remains intact. As a further advantage, the functional connection between the palatine aponeurosis and the superior pharyngeal constrictor can also be preserved.

Use of the old two-flap push-back method with lateral incision exposes the whole hamulus .

The new minimal incision medial approach releases the palatal aponeurosis only from the medial side of the hamulus.



Successful palatal reconstruction using the new minimal incision medial approach, in which structures located posterolaterally to the hamulus are preserved intact.

***H** Hamulus; **lTVP** lateral tensor veli palatini; **mPP** medial pterygoid plate; **PA** palatine aponeurosis; **PNS** posterior nasal spine; **SP** soft palate; **T** maxillary tuberosity; **U** M. uvulae*

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Ethical disclosure – all steps were carried out in accordance with the guidelines of the Swiss Federal Office of Public Health.
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1. Abe M., Murakami G., Noguchi M., Kitamura S., Shimada K. and Kohama G. I.: **Variations in the tensor veli palatini muscle with special reference to its origin and insertion.** Cleft Palate Craniofac J 2004 41(5):474-84.
2. Sumida K., Ando Y., Seki S., Yamashita K., Fujimura A., Baba O. and Kitamura S.: **Anatomical status of the human palatopharyngeal sphincter and its functional implications.** Surg Radiol Anat 2017 39(11):1191-1201.
3. Rüdinger: **Beiträge zur vergleichenden Anatomie und Histologie der Ohrtrompete.** J.J. Lentner, München, 1870.
4. Whillis M.B.: **A note on the muscles of the palate and the superior constrictor.** J Anat 1930 65:92-95.