Pathophysiology of the Eustachian tube – Relevant new aspects for the head and neck surgeon

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SUMMARY. Objectives: The impact of cranio-maxillofacial procedures upon Eustachian tube function is still largely unknown. The aim of this presentation is to depict new aspects of Eustachian tube function and to demonstrate its importance to cranio-maxillofacial surgery. Methods: Two different groups of patients were examined both clinically and by MRI of the Eustachian tube region. One of these groups comprised 15 adult patients with a history of cleft palate; another consisted of 32 patients with a history of a so-called patulous Eustachian tube. Results: Clinical and MRI-findings revealed that the problem of persistent chronic middle ear disease with cleft palate patients depends crucially on the integrity of the pterygoid hamulus and of the tensor veli palatini muscle after cleft palate repair. The masticatory muscles on the other hand also play an important role in Eustachian tube function in non-cleft patients. Conclusion: The maxillofacial surgeon should be aware that he holds a key position for preventing as well as treating Eustachian tube pathophysiology.

Keywords: eustachian tube; cleft palate; masticatory muscles

INTRODUCTION

The Eustachian tube plays an important role in middle ear function as it provides ventilation and drainage, as well as protection of the middle ear (Leuwer et al., 2003). From the pathophysiological point of view the key function of the Eustachian tube is to protect the middle ear against reflux, organisms and sound and air pressure changes in the pharynx (Tasker et al., 2002; Leuwer, 2004). The compliance of the Eustachian tube crucially depends on the tensor veli palatini muscle. A peculiarity of this muscle is its position as a ‘spider’s web’ in a skull base niche between the pterygoid process and the spine of the sphenoid bone. Thus its activity is almost totally isometric. Hence, its physiological function depends on certain anchors that change the direction of the muscle tension, so-called hypomochlia i.e. a kind of fulcrum. Three hypomochlia have been identified:

1. the pterygoid hamulus,
2. Ostmann’s fatty tissue between the lumen of the Eustachian tube and the tensor veli palatini muscle (Ostmann, 1893; Pahnke, 2000) and – recently discovered –
3. the medial pterygoid muscle (Leuwer et al., 2002, Fig. 1).

There still is controversy about the relevance of fracturing the hamulus during palatoplasty for adverse otological sequelae (Kane et al., 2000; Sheahan et al., 2004). On the other hand, until now, the practical role of the medial pterygoid muscle on the compliance of Eustachian tube was largely unknown.

The aim of the present study was to demonstrate typical sequelae of impairment of Eustachian tube function and to examine the clinical impact of the pterygoid hamulus and the medial pterygoid muscle upon Eustachian tube function.

 PATIENTS AND METHODS

This study evaluated two completely different patient groups:

One group consisted of 15 adult patients with a cleft lip, alveolus and palate (11 unilateral, 4 bilateral). Fourteen of these had undergone cleft repair, one patient had an untreated cleft palate. Cleft surgery had been performed in different hospitals. For the present study they were recruited from the ENT-Department as well as from the Department of Oral- and Maxillofacial Surgery at Hamburg University Medical
At the time of examination, the cleft palate patients were between 13 and 45 years old (mean 25).

The second group consisted of 32 patients suffering from the so-called ‘syndrome of the patulous Eustachian tube.’ The pathophysiology of this complex syndrome is failed closure of the Eustachian tube and thus an impaired protection function especially against sound pressure from the patient’s own voice. Patients complain of very distressing symptoms such as autophonia and the feeling of fullness of the ear being relieved by the prone position or digital pressure on the internal jugular vein by a physician. The patients of this group were between 18 and 75 years old (mean 37).

All 47 patients underwent ear microscopy by the same experienced ear surgeons (R.L. and S.W.) and cross-sectional T1 magnetic resonance imaging (MRI) of the nasopharynx as well as of the pterygopalatine and infratemporal fossae (MRI parameters see Table 1).

Ear microscopy is the otological standard procedure to detect acquired middle ear pathology caused by an impaired Eustachian tube function (i.e. otitis media with effusion, retraction pockets and cholesteatomas, defects of the tympanic membrane, middle ear atelectasis).

The purpose of the MRI was to visualize morphologic changes of the peritubal structures (i.e. size, course and integrity of the tensor veli palatini, the size of the medial pterygoid muscle, the presence of the pterygoid hamulus and the size of Ostmann’s fatty tissue). The purpose was experimental and was approved by the ethics committee.

### RESULTS

#### Ear microscopy

Severe bilateral chronic middle ear disease (i.e. chronic atelectatic middle ear disease (3), recurrent cholesteatoma (1), chronic suppurative otitis media (2)) was found in 6 of the 15 cleft palate patients (2 bCLAP, 4 uCLAP) by using ear microscopy; one

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1. Both studies were approved by the ethics committee of the Hamburg Medical Council (No. 1047-10/95, 09/97; OB/II/03-2/03).
other cleft patient (uCLAP) had a unilateral choles-
teatoma. The one patient with an untreated cleft palate (uCLAP) had a mild retraction of the tympanic membrane with a well-pneumatized middle ear cavity. Seven cleft palate patients (2 bCLAP, 5 uCLAP) had normal ear findings.

All 32 patients with a patulous Eustachian tube had normal ear microscopy findings.

**MRI-findings**

**Cleft palate group**

All of the patients without middle ear pathology had an intact pterygoid hamulus and tensor veli palatini muscle (Fig. 2a).

In the patient with an untreated cleft palate there was a thin but complete tensor muscle and an intact pterygoid hamulus. In 4 of 7 cleft palate patients with chronic middle ear disease the pterygoid hamulus could not be palpated or detected on MRI. In all of these 7 patients with chronic middle ear disease the tensor veli palatini muscle was clearly visible. But, as it is visible in Fig. 2b, the tensor veli palatini muscle (TM) had no continuity in any of the cases, neither towards the levator veli palatini muscle, nor towards the hamulus. In this example the tensor seems to have been amputated.

**Patulous Eustachian tube group**

Fifteen patients of the 32 patients had normal MRI-findings regarding the masticatory and paratubal muscles, and Ostmann’s fatty tissue. In Fig. 3a the tensor veli palatini muscle (TM) shows a clear lateral bend around the body of the medial pterygoid muscle (MPM): see the upper white arrows on the left side. The pterygoid hamulus (white triangle) is normal, the fat signal of Ostmann’s fatty tissue (lower white arrows) is typically club-shaped.

11 patients had atrophy of Ostmann’s fatty tissue. Fig. 3b shows the missing fat signal on the right side medial to the tensor veli palatini muscle (TM) and the thin fat signal on the opposite side (OF).

Eleven patients had some atrophy of the medial pterygoid muscle. In Fig. 3c, the masticatory muscles are very thin; on the right side (see the arrows) the tensor veli palatini muscle has a straight, unbent course towards the pterygoid hamulus (open white triangle).

Thus, 5 of these patients had both, some atrophy of the medial pterygoid muscle and some atrophy of Ostmann’s fatty tissue.

**DISCUSSION**

The task of the tensor veli palatini muscle is to actively open and close the Eustachian tube. Its mechanical impairment may lead to poor function of the tube and loss of middle ear integrity (Leuwer et al., 2003).

Kane et al. (2000) published a prospective study about the role of hamulotomy for the results of cleft palate repair and about its impact upon Eustachian tube and middle ear function. They examined 161 children of whom 85 received hamulotomy during cleft palate repair and 76 did not. The mean follow-up time was 1 year after palatoplasty. During that period most of the children received tympanostomy tubes (‘grommets’) at least once. At the time of their last assessment they were about 2 years old. The authors did not find a significant difference concern-
ing perioperative morbidity, hearing test results and preliminary speech results in both groups. However, from an otological point of view the authors measured the wrong parameter (hearing: brainstem evoked response audiometry) at the wrong moment (at the age of two). When looking at Eustachian tube function, the target organ is the middle ear. Hearing is a complex function only partly depending on the middle ear. Hence, a method for a reliable assessment of the middle ear integrity is to inspect the ear microscopically. Due to the tympanostomy tubes equally performed in both groups there was no difference concerning the target organ between both groups. Moreover, Handzic-Cuk et al. (2001) showed that due to the immature neuromuscular control, the tensor veli palatini muscle does not become completely functional before the age of seven!

Sheahan et al. (2004) reported a retrospective study of the medical records of 42 children with repaired cleft palate who were assessed at the age of 8 or older by different hearing tests and ear microscopy and by means of a questionnaire regarding incidence, treatment and outcome of middle ear problems in 68 children with repaired cleft palate, aged 9 or older. Hamular fracture was not found to have any significant effect on the history of any ear problems. Looking at the age of these children they still were too young to give a final prognosis concerning middle ear function. The authors stated that ‘just to suggest, that preservation of the hamulus during palatoplasty may result in less disturbance of Eustachian tube function may be an oversimplification of a complex problem’. This interesting statement doubtlessly is true.

The clear correlation between middle ear pathology and the lacking morphologic integrity of the tensor veli palatini muscle and the fact that the hamulus was fractured in only 4 cases in the present study underlines that it is necessary to morphologically assess the tensor muscle and the middle ear using ear microscopy and MRI. The message of this morphologic assessment of the tensor veli palatini muscle is clear: the integrity of the tensor veli palatini muscle has to be preserved during cleft palate repair, i.e. not sectioning the muscle or fracturing the hamulus. But the integrity of the tensor muscle is not itself able to guarantee muscular compliance of the Eustachian tube.

The function of the Eustachian tube is complex taking care of ventilation, drainage, and protection of middle ear. The possible mechanisms for its impairment are also complex. One typical example is the so-called ‘patulous Eustachian tube.’ The diagnostic evaluation of this very common complaint is clinical (autophonia, the feeling of the ‘full’ ear, relief when in the prone position). Up to now the traditional pathophysiologic explanation for the patulous Eustachian tube was loss of Ostmann’s fatty tissue between the tensor muscle and the Eustachian tube. The decrease of the tissue pressure on the tubal wall had been assumed to be the only reason for this syndrome (Pahnke et al., 1990). The present study for the first time reveals three completely different morphologic conditions causing the same clinical features:

1. apparently normal anatomy with no morphological explanation,
2. the well-known mechanism of atrophic Ostmann’s fatty tissue,
3. atrophy of the medial pterygoid muscle.

The three hypomochlia described above are acting as modulators of the isometric force vectors (Leuwer et al., 2002). Only the integrity of these hypomochlia together with the tensor activity guarantees a sufficient tubal function.

CONCLUSION

Maxillofacial plastic surgeons should keep the tensor veli palatini muscle and the pterygoid hamulus intact when performing veloplasty. The medial pterygoid muscle is not only a masticatory, but also an ‘Eustachian tube muscle.’

References


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