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Development of maxillary accessory ostium following sinusitis in rabbits*

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SUMMARY

Objectives/Hypothesis: *Maxillary accessory ostium is one of the anatomical variations that may play a role in the development of chronic maxillary sinusitis. Although some authors claim that accessory ostia develop following acute maxillary sinusitis, it is not clear whether they are congenital or acquired.*

Study Design: *Animal experimental study.*

Methods: *Ten New Zealand type rabbits were used in the study. In phase 1, lateral nasal walls of five New Zealand type rabbits were examined for the presence of natural and accessory ostia of the maxillary sinus and any area resembling fontanelles in humans. In phase 2, experimental sinusitis was induced in the right sides of the other five rabbits. Following sacrifice, lateral nasal walls were examined for the development of accessory ostia.*

Results: *Six of the ten sides of phase 1 animals contained a membranous part in the medial wall of the maxillary sinus resembling the fontanelles in humans (60%). None of them had an accessory maxillary ostium. Accessory ostia developed in two of the five sides with sinusitis (40%).*

Conclusions: *We have shown for the first time that accessory maxillary ostia develop following experimental sinusitis in rabbits. Further studies in humans are indicated.*

Key words: sinusitis, maxillary sinus, animal experimentation, ostium, accessory

INTRODUCTION

Chronic sinusitis causes significant morbidity despite appropriate medical and surgical therapy. Anatomical variations including maxillary accessory ostium have been implicated in the pathogenesis of chronic maxillary sinus infection. Maxillary accessory ostium disturbs mucociliary clearance of maxillary sinus due to the recycling of mucus between the natural and accessory ostia, and this process may result in chronic maxillary sinusitis [(1)].

It is not clear whether maxillary accessory ostia are congenital or acquired. Some authors claim that they develop following acute maxillary sinusitis [(2)]. However, the development of the maxillary accessory ostia following sinusitis has not been shown in animals or in a prospective clinical study up to date.

In this study, we investigated the development of maxillary accessory ostia following experimental sinusitis in rabbits.

MATERIALS AND METHODS

Animals

Ten New Zealand type healthy rabbits were used for the purposes of our study. None of the animals had been used as an experimental animal before. The weights of the rabbits ranged between 750-2000 g with a mean of 900.6 g. For the sedation of the animals, 50 mg/kg ketamine hydrochloride and 5 mg/kg xylazine were used. Intracardiac sodium penthotal was administered for sacrifice.

Study design

This study was approved by the ethical committee of our institution and consisted of two phases: In Phase 1, ten lateral nasal walls of five of the rabbits were explored for the presence of natural and accessory ostia of the maxillary sinus, as well as any area resembling the fontanelles in humans. Phase 1 animals were sedated and later sacrificed. They were decapitated and their mandibles were removed. The heads were divided

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sagitally in the midline. The nasal septum was removed and both lateral nasal walls were observed. The turbinates and the location of the natural ostium of the maxillary sinus were noted. The presence of an ostium other than the natural maxillary ostium was assessed. Lateral nasal walls were examined for the presence of a membranous region resembling the fontanelles in humans.

In Phase 2, experimental sinusitis was induced in the remaining five rabbits. Following sedation, Merocel® nasal sponges (Medtronic Xomed, Florida, USA) cut in the size of 0.3 x 0.5 x 2.5 cm were placed into the right nostrils of the animals. Later, 0.5 ml of the saline solution containing 10^8 colonies of *Streptococcus pneumonia* per milliliter was injected into the sponge. In this way, rhinogenic sinusitis was induced. Left nasal cavities were left open for nasal respiration.

Phase 2 rabbits were sacrificed on the 21st day. The lateral nasal walls were exposed in the same manner as the Phase 1 animals. The presence of sinusitis and development of the accessory ostia were assessed in the right lateral nasal walls. Left lateral nasal walls were also examined for the presence of inflammation and accessory ostia.

Histological examination

Specimens were obtained from the fontanelle-like regions and the accessory ostia from the sinusitis sides for histopathological examination. The specimens were stained with haematoxylin-eosin and examined under a light microscope.

RESULTS

Phase 1: Examination of the lateral nasal walls of the Phase 1 animals revealed that two major turbinate complexes existed in the lateral nasal walls of the rabbits. The maxillary sinus was situated lateral to the upper (second) turbinate complex (Figure 1). The natural ostium of the maxillary sinus was located medial to the anterior head of the upper turbinate (Figure 2).

Under magnification and through palpation, it was noted that 6 of the 10 sides contained a membranous part in the medial wall of the maxillary sinus (60%). Those fontanelle-like regions were situated in the posterior part of the medial wall of the maxillary sinus. None of the lateral nasal walls contained an accessory ostium.

Phase 2: Right nasal cavities of all Phase 2 animals with experimental sinusitis contained pus. After removal of the turbinates, pus was seen in the maxillary sinuses in all of the animals. Accessory ostia were observed in two of the five sides (40%) (Figure 3). It was noted that accessory ostia developed in the fontanelle-like regions of the lateral nasal walls of the rabbits. Merocel® nasal sponges did not extend to the region of accessory ostia in any of the animals (Figure 3).

The left nasal cavities, however, were not infected and they contained no pus. No accessory ostia were observed in the left sides.

Infiltration by inflammatory cells (mainly polymorphonuclear leucocytes) was seen on histopathological examination of the mucosal specimens. Eosinophils, lymphocytes and plasma cells were also present. There was ciliary loss, epithelial degeneration, areas of ulceration and lymphoid follicular hyperplasia in the mucosa.

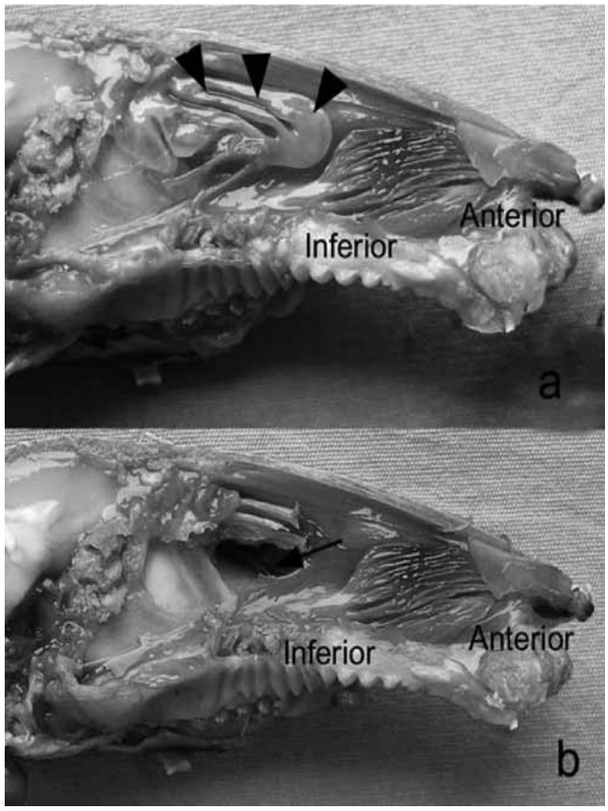

Figure 1. Left side of the rabbit, midsagittal section. a: The arrowheads show the upper turbinate. b: Surgical fenestration into the maxillary sinus (arrow).

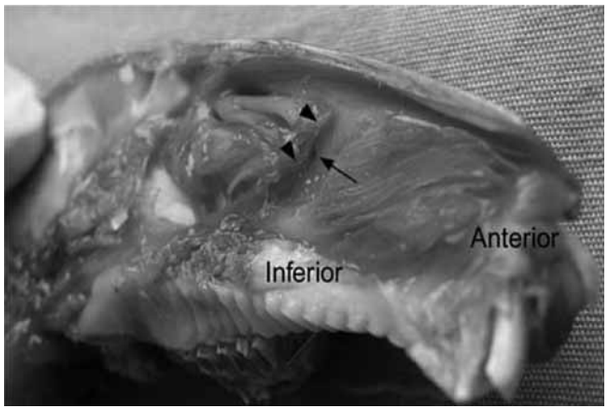

Figure 2. Left side of the rabbit, midsagittal section, anterior oblique view. The arrowheads indicate the anterior head of the upper turbinate. The arrow shows the natural maxillary ostium.

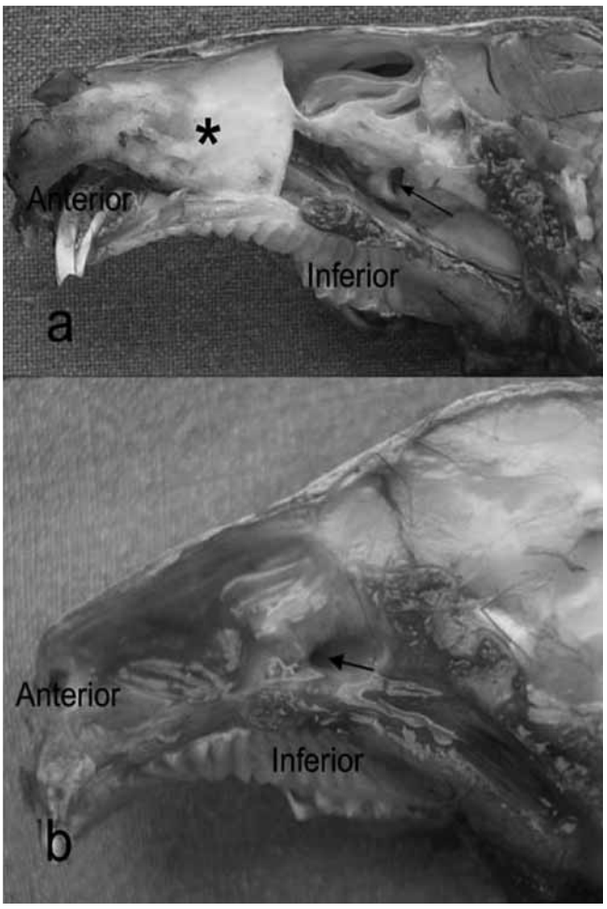

Figure 3. a and b: Right sides of the Phase 2 rabbits. The arrows indicate the maxillary accessory ostia formed in the region of fontanelles; *: Position of nasal packing.

DISCUSSION

This study shows for the first time that accessory maxillary ostia develop following sinusitis in rabbits.

Maxillary accessory ostia are situated most frequently in the posterior fontanelle in humans [3]. The term "fontanelle" refers to the areas of the medial wall of the maxillary sinus situated anterior and posterior to the inferior bony attachment(s) of the uncinate process. Those areas do not contain bone and are composed of two mucosal layers; maxillary sinus mucosa laterally and nasal mucosa medially, and some connective tissue in between [3].

Fontanelles are the weak parts of the medial wall of the maxillary sinus since they do not contain bone. The pus is captured in the maxillary sinus due to blockage of the natural maxillary ostium by mucosal edema in acute maxillary sinusitis. According to acquired development hypothesis of maxillary accessory ostia, the pus drains into the middle meatus by perforating the fontanelle, similar to the perforation of the tympanic membrane following acute otitis media [2]. However, no prospective studies up to date in either animals or in humans have shown the development of accessory ostia following acute sinusitis.

The prevalence of the accessory maxillary ostium in humans has been reported to be between 0-43% in various cadaveric and patient studies [4-8]. The active mucociliary transport of the maxillary sinus is towards the natural ostium and the accessory ostia do not take part in the physiological drainage of the maxillary sinus even if the natural ostium is blocked [3]. The mucus drained through the natural ositum may re-enter the maxillary sinus through the accessory ostium [1,3,9,10] and this process is called "recirculation phenomenon".

Recirculation may take place between the natural ostium and a surgically created opening [11]. The "missed ostium sequence" is seen if the surgeon cannot locate the natural ostium of the maxillary sinus correctly due to incompletely removed inferior part of the uncinate process and performs middle meatal antrostomy posteriorly to the natural ostium. In this case, the mucus recirculates between the natural ostium and the surgically created opening leading to persistent sinusitis [12]. Joining the natural and accessory ostia (or surgically created opening) eliminates this problem.

The presence of a fontanelle-like region and accessory maxillary ostia in the lateral nasal wall of the rabbits has not been investigated before. We have shown that 60% of the rabbits have fontanelle-like regions in their lateral nasal walls. We have demonstrated for the first time that the accessory maxillary ostia develop following experimental sinusitis in the rabbits (Figure 3). We used a rhinogenic model of sinusitis so as not to cause any surgical trauma to the maxillary sinus mucosa. In fact, the origin of sinusitis is rhinogenic in humans [13]. The rhinogenic model in rabbits allows the infection to spread into sinuses from the nose, in a way similar to the pathophysiologic process in humans [14]. In our study, 40% of the rabbits developed maxillary accessory ostia following sinusitis. We have histopathologically shown inflammation, mucosal epithelial degeneration and ulceration in the area where accessory ostia were formed.

We could not perform nasal endoscopy in rabbits before inducing sinusitis because of their narrow nostrils, and this may be regarded as a limitation of our study. However, we did not observe any accessory ostia in ten sides of Phase 1 animals in addition to five uninfected left sides of the Phase 2 animals.

Although this study has shown the development of the accessory ostia following acute sinusitis, it does not show what happens to them chronically. The accessory ostia may heal similarly to the majority of tympanic membrane perforations following acute otitis media or they may persist. This issue may be investigated in another study.

CONCLUSION

Rabbits have fontanelle-like regions in their lateral nasal walls and they develop accessory maxillary ostia following acute maxillary sinusitis.

Although our study shows for the first time that accessory maxillary ostia develop following experimental sinusitis in rabbits, further studies are needed in humans.

REFERENCES

1. Matthews BL, Burke AJ. Recirculation of mucus via accessory ostia causing chronic maxillary sinus disease. Otolaryngol Head Neck Surg 1997; 117: 422-423.
2. Parsons DS, Wald ER. Otitis media and sinusitis: similar diseases. Otolaryngol Clin North Am 1996; 29: 11-25.
3. Stammberger HR. Functional endoscopic sinus surgery: The Messerklinger technique. Philadelphia, PA: BC Decker, 1991.
4. Kuma RH, Choudhr YR, Kaka RS. Accessory maxillary ostia: Topography and clinical application. J Anat Soc India 2001; 50: 3-5.
5. Lang J. Clinical anatomy of the nose, nasal cavity and paranasal sinuses. New York, NY: Thieme Medical Publishers Inc, 1989.
6. Earwaker J. Anatomic variants in sinonasal CT. Radiographics 1993; 13: 381-415.
7. May M, Sobol SM, Korzec K. The location of the maxillary os and its importance to the endoscopic sinus surgeon. Laryngoscope 1990; 100: 1037-1042.
8. Jog M, McGarry GW. How frequent are accessory sinus ostia? J Laryngol Otol 2003; 117: 270-272.
9. Yanagisawa E, Yanagisawa K. Endoscopic view of recirculation phenomenon of the maxillary sinus. Ear Nose Throat J 1997; 76: 196-198.
10. Chung SK, Dhong HJ, Na DG. Mucus circulation between accessory ostium and natural ostium of maxillary sinus. J Laryngol Otol 1999; 113: 865-867.
11. Gutman M, Houser S. Iatrogenic maxillary sinus recirculation and beyond. Ear Nose Throat J 2003; 82: 61-63.
12. Parsons DS, Stivers FE, Talbot AR. The missed ostium sequence and the surgical approach to revision functional endoscopic sinus surgery. Otolaryngol Clin North Am 1996; 29: 169-183.
13. Kennedy DW, Zinreich SJ, Rosenbaum AE, Johns ME. Functional endoscopic sinus surgery: theory and diagnostic evaluation. Arch Otolaryngol 1985; 111: 576-582.
14. Marks SC. Acute sinusitis in the rabbit: a new rhinogenic model. Laryngoscope 1997; 107: 1579-1585.

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