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Development and surgical anatomy of the round window niche

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Summary

The round window niche is a bony pouch of the tympanic cavity and clinically frequently explored, therefore its topography has fundamental impact on microsurgery. A total of 783 macerated and formalin-fixed temporal bones were used to study the normal anatomy of the round window and its development. The ossification of the niche starts in the 16th fetal week and is complete at birth. A process of the otic capsule, called the cartilage bar, forms the inferior wall of the round window niche. The anterior and superior walls of the niche form by intramembranous ossification, whereas the posterior and inferior walls predominantly form by enchondral ossification. The uneven growth of different walls of the round window niche can alter the shape of the entrance, which results in eight different types of niches: extremely narrow, descending tegmen, anterior septum, bony membrane, open fundus, exostosis, jugular dome and trabeculae.

Introduction

The round window is a 2—3-mm long and about 1.5-mm wide channel connecting the middle and inner ears. It is of great clinical importance, because it is implicated in a series of common disorders or symptoms. Although the bottom of the niche is closed by the secondary tympanic membrane, it permits inner ear perfusion in case of Meniere's disease, sudden sensoneurineural hearing loss or tinnitus (Silverstein et al., 1997). Acoustic trauma or skull base fracture can result in rupture of the secondary tympanic membrane and perilymph leakage (Lyons et al., 1978; Pashley, 1982). Another cause of perilymph leakage is abnormal communication between the singular canal and the round window (Sato et al., 1993). Common diseases like acute and chronic inflammations of the

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tympanic cavity can also spread into the round window niche. After inflammation the bony walls of the niche might remain destroyed which results in the enlargement of the cavity. A special form of chronic otitis media, cholesteatoma, can also lead to destruction or obliteration of the round window (Stewart and Belal, 1981). Although the round window is typically not affected by otosclerosis, in certain cases, nevetherless, atresia of the round window occurs. Round window atresia is more frequently caused by congenital anomalies (Clifford et al., 1990; Linder et al., 2003; Okuno and Sando, 1988; Pappas et al., 1998; Richards, 1981).

The wide range of pathological disorders evidently suggests a special clinical relevance for the round window niche. The anatomy of the niche had been studied since the 18th century; however, fine details have been only determined in the second half of the 20th century (Franz et al., 1987; Hamamoto et al., 2000; Okuno and Sando, 1988; Stewart and Belal, 1981; Stidham and Roberson, 1999; Su et al., 1982). These authors described the round window niche as a conical or triangular fossa. Proctor et al. (1986) was the first who reported, that the entrance of the niche is of quadragular shape and the triangular form only a variant.

Bast and Anson (1952) were the first to study the development of the round window in detail. They were the first to mention a process of the otic capsule, called the cartilage bar, growing towards the secondary tympanic membrane. In 1972, Bollobás and, 25 years later, Bonaldi et al. (1997) published the morphological changes of the bony round window niche without mentioning the pathological significance.

Although the round window niche seems to be part of the medial wall of the tympanic cavity it develops completely from the otic capsule. This fact suggests that normal anatomy and the pathological alterations of this region can be understood from embryological aspects.

The purpose of our study has been to determine the essential developmental events of the round window niche, which may explain the shape of the niche and be helpful in distinguishing the normal and pathological specimens.

Materials and methods

This study included several hundred temporal bones of different ages from the 8th fetal week to elderly. Pre- and postnatal development of the round window niche was studied on histological slides and macerated temporal bones, aged from $8\frac{1}{2}$ fetal weeks to early childhood. For light microscopical investigations the tissue samples were fixed in 10% formalin, decalcified in 0.23% formid acid, embedded in paraffin wax and sectioned in the horizontal plane. The 7-μm slides were stained with hematoxylin and eosin and studied under a Leica light microscope. Parallel to the histological specimens, macerated temporal bones of same ages were also investigated under a stereomicroscope.

In order to establish clinically important variations of the round window niche, 688 macerated temporal bones of the skull collections of the Institutes of Anatomy and Forensic Medicine of Semmelweis University were used. Investigations were carried out using a 1.7 mm, 30°-rigid Olympus endoscope. The endoscope entered the tympanic cavity through the external acoustic meatus and the optic was positioned in its postero-inferior angle.

Results

The development of the bony round window niche begins in the 16th fetal week. Anterior, superior and posterior walls are first to appear while the inferior wall is completely absent at this time (Fig. 1A). One week later, a bony process grows into the niche forming its inferior wall but this process will only reach the anterior wall by the 18th week (Fig. 1B,C). In the 23-week-old fetus the most typical structure of the niche is a bony process which helps to establish the inferior wall; the so-called *fustis*. It runs in the middle of the inferior wall and points to the crest of the round window (Fig. 1D,E). The first sign of the crest can be observed in the 18th fetal week where anterior and inferior walls meet.

After the 20th prenatal week the walls of the niche show a great intensity of growth. All the walls lengthen, but the most intensive growth can be found in the anterior wall where the inferior tympanic artery and the tympanic nerve run. In some cases, a complete bony canal is formed around the tympanic nerve and the inferior tympanic artery, which runs parallel to the postis anterior (Fig. 1F).

The site of the secondary tympanic membrane can already be found in an $8\frac{1}{2}$-week-old fetus. The area of the future niche is filled with mesenchyme into which a short process of the cartilaginous otic capsule, the *cartilage bar*, grows in (Fig. 2A). Three weeks later, the secondary tympanic membrane is clearly defined and the cartilage bar has a dictinct