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BASIC AND TRANSLATIONAL RESEARCH

Degenerative disease of the head of stapes in the course of otosclerosis as assessed by scanning electron microscopy

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Abstract

Regardless of the progressing otosclerotic process, disturbance of the mobility of the auditory ossicle chain through overloading leads to damage to the articular surfaces of the auditory ossicles, which may be a factor limiting the improvement of hearing after surgical treatment.
Damage to the articular surface of the stapes head is the result of increasing the pressure at the junction of the immobilized elements of the ossicular chain in the course of otosclerosis in the absence of other visible factors damaging these ossicles.
Immobilization of the base of the stapes by otosclerotic foci leads to overloads in the incus and stapes joint and ultimately to the remodelling of the articular surface of the stapes head.
Our observations provide additional information on the depth of conductive hearing loss in patients with otosclerosis, pointing to factors other than immobilization of the stapes base due to the formation of an air bone gap.

Objectives

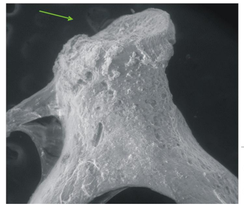
The aim of the study is to analyze the degree of damage to the stapes head as a component of the incus-stapes joint in the course of window otosclerosis.
Therefore, this prospective study of patients with otosclerosis aimed to assess overload changes in the stapes head secondary to the immobilization of the base of the third auditory ossicle.

Material and Methods

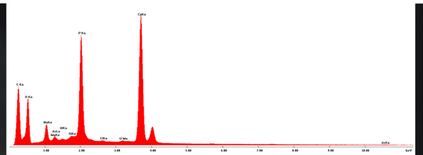
A prospective analysis included 31 patients operated on for otosclerosis in the years 2020-2021 and 5 patients operated on for a vestibular schwannoma. Thirty-one women and 5 men participated in the study. The youngest patient was 18 and the oldest 57 years old.The average age was 35.
The control group consisted of stapes removed during the surgery of the vestibular schwannoma using transcochlear approach. removed stapes suprastructures were examined by scanning electron microscopy (SEM). Healthy stapes that were surgical waste during surgery for a vestibular schwannoma were compared with stapes removed in the course of the otosclerotic process. The SEM assessment excluded damage to the articular surfaces resulting from the surgical methodology.
The surgical material for evaluation in the scanning electron microscope was prepared according to a standard protocol.
The LVSED (low vacuum secondary electron detector) was used to record the bone tissue surface topography using secondary electrons (SE - secondary electron), and the backscattered electron (BSE) signal was recorded using a vCD (low voltage-high contrast detector).
The EDS Genesis X-ray detector was used for the preliminary qualitative analysis of the chemical composition in the microareas of the stapes bones, and the PhiRoZet software was used for quantitative analysis.

Results

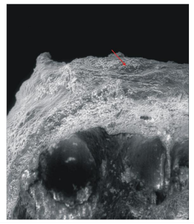
Analysis of the stapes head using SEM in patients with otosclerosis compared to the control group did not reveal differences in chemical composition and the presence of otosclerotic foci.
In all preparations obtained from patients diagnosed with otosclerosis, various types of damage to the surface of the bone tissue of the stapes head were observed.
Mild changes were observed in 90% of the preparations. Small linear fractures of the bone tissue were observed in 58% of the preparations. In 16% of the preparations minor osteophytic changes were found.



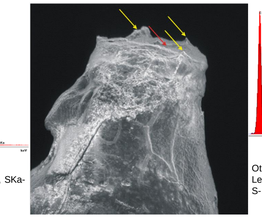
. Control group. The head of the stapes (green arrow). Magnification 150x. LVSED



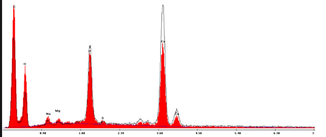
Control group. Result of the chemical composition of the stapes head.
Legend: CaKa - calcium, PKa- phosphorus, OKa- oxygen, CKa- carbon, NaKa- sodium, SKa- sulfur.



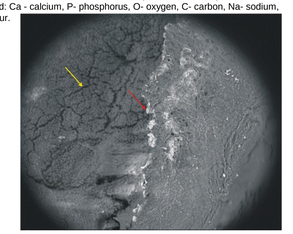
Otosclerosis. The head of the stapes. Magnification 350x. LVSED. Exfoliations of the articular surface of the stapes head (red arrow).



Otosclerosis. The head of the stapes. Magnification 150x. LVSED. Damage to the surface of the bone tissue of the stapes head: osteophytes (yellow arrow) and irregularity of the structure of the articular surface (red arrow).



Otosclerosis. Result of the chemical composition of the stapes head.
Legend: Ca - calcium, P- phosphorus, O- oxygen, C- carbon, Na- sodium, S- sulfur.



Otosclerosis. The head of the stapes. Magnification 500x. vCD. Small exfoliation of the articular surface (red arrow) and small linear cracks (yellow arrow) of the stapes head.

Conclusions

Analysis of the stapes head using SEM in patients with otosclerosis compared to the control group did not reveal differences in chemical composition or the presence of otosclerotic foci. Immobilization of the base of the stapes by otosclerotic foci leads to overloads in the incus and stapes joint and ultimately causes remodeling of the articular surface of the stapes head.

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