Evaluating bone conduction in mixed hearing loss

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The correct evaluation of bone conduction in mixed hearing loss often remains a paramount problem, especially as it often concerns the choice of an appropriate therapeutic planning. Actually, although it is well known that the bone conduction itself is roughly corresponding to the sensorineural function, in a number of pathological conditions the latter might be underestimated.

Bone conduction is essentially due to two phenomena, by which the skull vibration induced by sound results in a mechanical stimulation of the basilar membrane: inertia of the inner ear fluids, on one hand, and compression/expansion of the labyrinthine space, on the other hand (Stenfelt 2015); the former is predicted as the most important factor in normal ears (Stenfelt 2020). The influence of both factors changes in pathological ears (Stenfelt 2015), and it is intuitive that this change is linked to the anatomic alterations that characterize a specific pathology; an example of the width of this phenomenon is the finding of differences in bone conduction after mastoidectomy, as this procedure is reported to increase cochlear vibration responses (Prodanovic 2020).

However, in the common clinical practice a diffuse habit leads to first refer to pathological conditions involving a possible change in bone conduction linked to an increased impedance of the inner ear. This is a typical feature of otosclerosis and is well represented by the presence of Carhart's notch; moreover, after surgery, a change in bone conduction threshold of otosclerotic ears might simply depend on the performance of a stapedectomy vs a stapedotomy (Yazdi 2009,Pirodda 2018); this change has been hypothesized to derive from the extent of the fenestration (Pirodda 2018), thus witnessing how even relatively small differences in the size of labyrinthine windows may have an influence on its impedance.

Accordingly, the above cited underestimation may concern rarer affections, as round window ossification or other aspecific conductive defects that can interfere with some of the complicate mechanisms that permit bone conduction.

It must be underlined, however, that bone conduction may even be affected by means of any reduced impedance of the inner ear: it is noteworthy that some changes for low frequency sounds even occur in normal conditions depending on the size of vestibular aqeduct (Stenfelt 2020)

About this topic, a relatively recent chapter was opened by the deepening of the effect derived from a pathological "third window": when first described in 1998 (Minor 1998), superior semicircular canal dehiscence was regarded as an exceptional finding; on the contrary, over the years it appeared a more and more common condition than expected, thus complicating diagnoses that appeared very simple until then. Actually, the decreased impedance of the inner ear is not an exceptional condition to deal with, and it is able to induce very specific changes regarding the parameters that influence bone conduction: it is interesting to underline the detailed attention that has been dedicated to the effect of the dehiscence size, position and shape on the clinical manifestations: the difficulty of reaching an easy comprehension of the phenomena related to dehiscence is well represented by the finding of a different influence on bone conduction according to the direction of inertial excitation (Kim 2013), thus demonstrating the extent of this problem. In fact, the superior semicircular canal dehiscence has been reported to be more effective on bone conduction than on air conduction (Stenfelt 2020), and can result in an audiometric curve mimicking the early stage of otosclerosis (Stenfelt 2020). This explains the possibility of a misdiagnosis of otosclerosis in presence of a semicircular canal dehiscence that has been repeatedly underlined in the English literature.

Taken together, these observations underline the necessity to consider the concept of labyrinthine impedance whenever facing any problem in assessing bone conduction: simply, the conductive apparatus, habitually identified in the middle ear, cannot be separated from the "conductive" factors of the inner ear, and the best knowledge of these complicate phenomena is mandatory to reach a satisfactory assessment. Our tools aimed at achieving a correct definition of bone conduction in cases of mixed hearing loss include, in my opinion, not only VEMPs but even a systematic resort to HRCT: this classical exam, more recently enriched by Cone beam technique, permits to easily detect anatomic details of the labyrinth; in addition, the importance of classical exams as vocal audiometry, Weber test and stapedial reflex study must not be neglected due to their maintained utility in contributing to the clinician's orientation.

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DOI 10.14658/pupj-ijap-2020-1-3