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Hearing loss in postmenopausal women with low bone mineral density

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ABSTRACT

Objective: Several studies suggested the possible relationship between decreased bone mineral density (BMD) of the temporal bone and hearing loss, primarily of the sensorineural type. The aim of the present study is to determine the relationship between BMD and hearing loss and to evaluate the systemic Ca^{2+} and vitamin D status with relation to hearing sensitivity in the postmenopausal women who were diagnosed with primary osteoporosis.

Methods: The study involved a total of 324 patients who were referred between 2008 and 2013. Based on BMD scores, the subjects were divided into three groups: normal BMD ($n = 102$), osteopenia ($n = 106$) and osteoporosis ($n = 116$). Hearing sensitivity was evaluated with audiometric tests along with serum Ca^{2+} and vitamin D level.

Results: The age distribution among 3 groups was similar. Mean serum Ca^{2+}, phosphate, 25(OH)D and creatinine clearance were within the standard laboratory reference ranges in all patients. There was no difference in the proportion of vitamin D deficiency among groups. The typical type of hearing loss was sensorineural hearing loss (SNHL) and the patients with reduced BMD showed higher prevalence of SNHL than the patients with normal BMD. Pure-tone thresholds average was significantly higher in all frequencies in women with osteopenia/osteoporosis than women with normal BMD. Multiple logistic regression analyses showed that age and lumbar BMD were associated with the presence of hearing loss (>25 dB).

Conclusion: Our findings suggest that the presence of decreased BMD in postmenopausal women might be associated with the higher prevalence of age-related SNHL.

1. Introduction

Age-related hearing loss, also known as presbycusis, is one of the most prevalent chronic conditions affecting older population. Hearing loss is usually bilateral, symmetrical and slowly progressive sensorineural hearing loss (SNHL), starting in high frequencies. As life expectancy has increased, an increasing number of individuals would be forced to endure hearing impairment in their senior years. Hearing loss in old ages has a significant impact on everyday living and can lead to the communication difficulties, social withdrawal and depression. In addition, unrecognized and untreated hearing loss is also common in geriatric population until speech communication is impaired [1].

The prevalence of age-related hearing loss is in approximately 30% of persons over 65 years old and 50% of persons over 75 years old [2,3]. The high incidence of SNHL in elderly subjects is previously assumed to be related with age-related progressive degenerative change of the peripheral auditory system as well as the plasticity of central neural processing [4]. However, age-related hearing loss is a multifactorial process in which there are wide individual variations in the expression of each factor. Various predisposing factors throughout the lifespan that could eventually damage the hair cells, such as genetic susceptibility, noise exposure, ototoxic medication, head trauma and ear-related diseases, could play the multiplicative or additive confounding effects on the development of hearing loss.

Demineralized petrous temporal bone including otic capsule and/or internal auditory canal, in conjunction with age-related bone mass loss, might also contribute to hearing loss in older population, which has been explored primarily through studies with Paget's disease of the bone and cochlear otosclerosis [5,6]. Demineralization of the otic capsule was primarily associated with SNHL and the degree of cochlear demineralization

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corresponded directly to the severity of hearing loss with secondary neuronal degeneration in later stage of disease [7,8].

Osteoporosis, which is characterized by generalized reduced bone mass and increased bone turnover, does not spare the bone of the skull [9], and abnormal bone remodeling of otic capsule affected by osteoporosis might share the mechanism of hearing loss of Paget's disease or cochlear otosclerosis [10]. Several studies have investigated the possible relationship between reduced bone mineral density (BMD) regarding osteoporosis and hearing loss in old age. An epidemiological study showed almost 2-fold increase in the risk of hearing loss among the postmenopausal women aged 60–85 years who have a low BMD in the femoral neck [11]. Auditory thresholds in the frequencies higher than 4 kHz were significantly increased in osteoporotic women than the postmenopausal women with normal BMD [12,13]. Large-scale epidemiologic study revealed that older people aged over 65 years with lower total BMD tended to report significant higher hearing complaints [14]. However, another study showed that there was no relationship between hearing sensitivity and hip BMD in aged White and Black women, while hearing loss was associated with hip BMD in Black men [15]. Limited number of studies and inconsistencies of existing data eventually need a further investigation. Since epidemiologic studies usually adopted a screening audiometer at particular frequency for hearing assessment, the results might not represent the exact type or level of hearing loss associated with osteoporosis. Frequency-specific full audiometric assessment including bone-conduction thresholds would be necessary to clarify the contribution of age-related bone mass loss to hearing impairments. In addition, low serum Ca^{2+} and vitamin D deficiency, which are often associated with osteoporosis by enhancing bone metabolism, should be analyzed as the independent risk factor for hearing loss. Vitamin D deficiency might lead to decrease in the hearing sensitivity through the changed Ca^{2+} metabolism and microcirculation in the cochlea, and supplementation with vitamin D could result in hearing improvement [16–18].

The aim of the present study is to determine the relationship between BMD and hearing loss and to evaluate the systemic Ca^{2+} and vitamin D status with relation to hearing sensitivity in the postmenopausal women who were diagnosed with primary osteoporosis.

2. Methods

2.1. Subjects

A total of 324 postmenopausal women who referred to Otolaryngology Clinic at CHA University Bundang Hospital between August 2008 and October 2013 were enrolled. The data were retrospectively reviewed. The patients who have clear cause other than presbycusis such as labyrinthitis, otologoc surgery, Meniere's disease and work in noisy environments without adequate auditory protection were excluded. Inclusion criteria were: (1) no evidence with active outer and/or middle ear disease; (2) availability of BMD and actual 25-hydroxy vitamin D (25(OH)D) value within 3 months from the hearing evaluation; (3) the patients without a history of head trauma or ototoxic drug therapy; and (4) the patients without any systemic or chronic disease influencing BMD results, such as chronic renal failure, liver or bile duct disease and hormonal disorders. The study was approved by the CHA University Bundang Hospital ethics committee.

2.2. Measurements of BMD and serum Ca^{2+} and vitamin D

Height and body weight were measured by standard method in light clothes. Body mass index (BMI) was calculated as weight divided by height squared (kg/m^2). A dual X-ray absorptiometry (DXA) scan (Discovery-W, Hologic Inc.) was obtained for all subjects. BMD (g/cm^2) was measured at central skeletal sites (lumbar spine (L1–L4), femoral neck and total hip). A *T*-score, derived from the DXA measurement, expresses an individual's BMD in standard deviations calculated from manufacturer-provided references. Diagnosis of osteopenia or osteoporosis was made using World Health Organization (WHO) *T*-score criteria; $T\text{-score} \geq -1$ is considered normal BMD; osteopenia is diagnosed with $-2.5 < T\text{-score} < -1$; and osteoporosis with $T\text{-score} \leq -2.5$.

The laboratory investigations included serum total calcium, phosphate, total cholesterol, low-density lipoprotein (LDL) cholesterol, transaminase activities (GOT and GPT), creatinine and albumin, which were measured by automated standard laboratory methods. Serum ionized calcium level (iCa^{2+}) was evaluated to identify calcium abnormality when serum total calcium corrected for albumin [19] was not within normal ranges. Actual 25(OH)D was measured by radioimmunoassay (CLIA, DiaSorin). The serum vitamin D deficiency was defined as a 25(OH)D $\leq$ 20 ng/mL [20]. Creatinine clearance was calculated from plasma creatinine [21]. Serum thyroid-stimulating hormone (TSH), free thyroid hormone (fT4) and level of parathyroid hormone were also evaluated.

2.3. Audiological evaluation

Audiometric tests were conducted by one trained audiologist using a GSI 61 audiometer (Grason Stadler Instruments, Madison, Wisconsin) and TDH-39 cushioned headphones. Prior to testing, an otoscopic examination was completed on each subject to identify possible external canal obstructions or tympanic membrane abnormalities. Pure-tone audiometry at 0.25, 0.5, 1.0, 2.0, 3.0, 4.0, and 8.0 kHz was performed in all participants. Hearing thresholds were determined following the guidelines of the American Speech-Language-Hearing Association (ASHA) [22]. Pure-tone averages (PTAs) across the frequencies of 500, 1000 and 2000 Hz were calculated separately for each ear. Averaged pure-tone hearing thresholds were also evaluated for the better ear and worse ear. The better ear was the ear with the lower PTA. If the PTAs were equal, the right ear was designated as the better ear. The high-frequency PTA was calculated as the averaged thresholds across the 4.0 and 8.0 kHz. The low-frequency PTA was calculated as the average across 0.25, 0.5 and 1.0 kHz thresholds. SNHL was defined as having a bone-conduction average higher than 25 dB HL with no air-bone gap. Conductive hearing loss was conservatively defined as having a normal bone-conduction threshold average, but an air-bone gap more than 15 dB HL. Mixed hearing loss was defined as having bone and air-conduction threshold averages higher than 25 dB HL with an air-bone gap more than 15 dB HL.

2.4. Statistics

The data were analyzed using IBM SPSS Statistics Version 22 for windows. Multiple means were compared among groups as indicators of discriminant validity by one-way ANOVA's, followed by pair wise post hoc tests. Two group comparisons were made using Student's *t*-test. A chi-square test was applied to analyze the significance of the multiple comparison of frequencies among three groups. Odds-Ratios were calculated. Multiple logistic regression analysis was used for estimating odds ratios for the association of hearing loss and the various factors. Test results with $P < 0.05$ were regarded as statistically significant.