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Influence of sex and age on posterior semicircular canal (PSC) thickness.

RUNNING HEAD: Sex and age on PSC thickness.

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ABSTRACT

Objective: This study was addressed to determine if sex and age influence posterior semicircular canal (PSC) thickness. **Design:** This observational study was conducted in three tertiary hospitals. The minimal distance between PSC and posterior cranial fossa (PSC thickness) was estimated by thin-section multi-detector row computed axial tomography (CAT scan) of the temporal bones. Non-selected consecutive

patients of all ages (607 temporal bones) were considered. **Results:** Significant effect was only detected for sex (F=5.418; *p*=0.020); PSC thickness showed a higher mean value in women (mean difference ± SE: 0.224±0.096 mm). A significant and negative r value was detected for >45 years old males (-0.173; *p*=0.026); in this group of patients, PSC thickness decreased as age increased (0.018±0.008 mm/year). For ≤ 45 years old females, a significant and positive r value was found (0.198; *p*=0.022); in this group, PSC thickness increased as age increased (0.020±0.008 mm/years). **Conclusion:** PSC thickness did not significantly evolve with age in young males (≤ 45 years) but it became thinner from 45 years onwards. On the other hand, PCS thickened with age in women until 45 years and it did not significantly change in older females.

Key Words: Age effects; Function of middle ear; Human; Middle ear; Middle ear mechanics; Otology; Positron emission tomography; Statistics; Temporal bone.

Introduction

Studies of the posterior semicircular canal (PSC) thickness are scarce in the literature. Nomiya et al. [2010] measured 1051 (N) temporal bones and concluded that the mean distance between the PSC and the posterior cranial fossa was 1.96 mm (SD 1.40mm) with the PSC thickness being higher for women (2.28mm) than for men (1.78mm). Gracia-Tello et al. [2013] reported similar results (mean ±SD: 1.90 ± 0.6 mm; N=602 temporal bones). However, Park et al. [2015] found lower values in a control group (mean ±SD: 1.61 ± 0.32 mm; N=68 temporal bones); the PSC thickness varied according to whether pneumatization was present (mean ±SD: 1.67 ± 0.34 mm) or absent (mean ±SD: 1.59 ± 0.34 mm), although no significant difference was found (*p*=0.428).

Park et al. [2015] observed that when superior semicircular canal dehiscence (SSCD) occurred, the PSC thickness was reduced (mean ±SD: 1.39 ± 0.31 mm; N=12 temporal bones). In contrast, Gracia-Tello et al. [2013] did not find any significant differences in the PSC thickness in patients showing SSCD (mean ±SD: 2.1 ± 1.2mm; *p*=0.49); however, these authors detected a reduced thickness in the posterior contralateral canal in the presence of PSCD (mean ±SD: 1.3 ± 0.3 mm; N=3).

The aims of the present study are to study the influence of sex and age on the minimal distance

between PSC and posterior cranial fossa (PSC thickness) and to compare our results with the previously detected influence of sex and age on the semicircular superior canal (SSC) thickness.

Material and methods

Data were collected between September 2007 and March 2008 in three tertiary hospitals. An informed consent form was signed by every participating patient. All the patients acknowledged that they cannot be identified via the paper; the researchers fully anonymized them. The ethics committee of each center approved this study in accordance with the guidelines of the Helsinki Declaration of 1983.

The patients were recruited from among those subjected to computerized axial tomography (CT scan) of the temporal bone because of hypoacusia, facial palsy, vertigo, tinnitus, and other single or combined symptoms. All mandatory health and safety procedures were complied. The CT scans were reviewed by senior radiologists (only one radiologist per participating hospital) who had more than 10 years of experience in neuroradiology.

A total of 607 temporal bones from 318 patients were considered: both bones in 289 individuals (90.9%), left bone in 11 individuals (3.4%), and right bone in 18 individuals (5.7%). Temporal bones were excluded from the study whenever anatomical alterations of labyrinth had occurred and when the degree of mastoid pneumatization or the thickness of the posterior semicircular canal roof could not be evaluated by means of CAT scans. Most of the patients were women (56.7%). The mean age was 50.440± 19.242 (SD) years, in the range of 2-88 years and 196 of the patients (61.6%) were older than 45 years.

The studies were performed by means of multisplice helical computed tomography equipment (Philips Brillance 6); the images were obtained on the axial plane with the patient’s neck in hyperextension, avoiding direct radiation damage to the crystalline lens. In all patients, both coronal and Pöschl plane reconstructions were carried out. The 'raw data’ have been reconstructed by using a bone algorithm. For image acquisition and formatting, the radiological protocols were as follows: 2 x 0.6mm collimation, 0.65mm splice thickness, 0.32mm splice increase, 0.75 seconds rotation time, 0.38 pitch, 120 CV, 300 mAs, 1024 x1024 matrix, 180mm field of vision, 0.5mm reconstruction thickness, and 0.5mm reconstruction increase. The thickness of bone overlying the PSC was measured on CT scan axial slices, in the thinnest

point between the PSC lumen and the intracranial space.

All statistical analyses were performed by using the IBM SPSS v.22 software (SPSS, Chicago, IL. USA). *P* values <0.050 were considered to be statistically significant. The analysis of variance (ANOVA) was used to evaluate the effect of sex and age (fixed effects) and sex*age interaction on the PSC thickness. For this analysis, age was considered as a qualitative variable with two categories; ≤ 45 years, >45 years. When a significant effect was detected, the effect size was estimated by eta^2 (percentage of PSC thickness variation explained by factor variation) and *a posteriori* simple contrast (mean difference ± SE). When age was considered as a quantitative variable, Pearson´s correlation coefficient (r) was used to study age-dependent evolution of PSC thickness. Simple linear regression analysis quantified PSC thickness modification by year (estimated slope of the line; B± SE).

Results

Table 1 shows PSC thickness mean and SE for each sex and age category and totals. The ANOVA did not find significant differences between the two age groups (F=0.032; *p*=0.858). No significant effect was detected for sex*age interaction (F=0.907; *p*=0.341). Significant effect was detected for sex (F=5.418; *p*=0.020); sex explained by 0.9% of PSC thickness variation (eta^2 = 0.009) and PSC thickness showed a higher mean value in women (mean difference ± SE: 0.224±0.096 mm).

Table 2 shows r and B values for PSC thickness and age as quantitative variable for every sex and age category. In males older than 45 years, a significant and negative r value was detected and the PSC thickness decreased as age increased (0.018±0.008 mm/year). In females up to 45 years old, a significant and positive r value was found and the PSC thickness increased as age increased (0.020±0.008 mm/year). No other significant relationships between PSC thickness and age were found (*p*>0.050).

Discussion

The vertical semicircular canals (SSC and PSC) have a common origin (otic capsule), show a similar ossification (each of them are formed from two primary and one secondary ossification centers), and both share a common region (*Crus commune)* [Nemzek et al., 2016; Richard et al., 2010]. However, once

development is complete, they differ in several features. As shown in Table 1, the mean PSC thickness was 1.959 mm (SE= 0.046 mm). The SSC was thinner, as showed previously; it ranged from 0.67±0.38 mm [Hirvonen et al., 2003] to 1.2±0.6 mm [Tsunoda, 2001].

Radiologic posterior semicircular canal dehiscence (PSCD) showed low prevalence in adults. Prevalence ranged from 0.3% [Crovetto et al., 2010] to 4.5% [Krombach et al., 2003]; variations in CT slide thickness or different estimations of prevalence (based on patients or temporal bones data) might account for this range. Reported prevalence values for SSCD were highly variable and ranged from 1% [Krombach et al., 2003] to 17% [Piton et al., 2008]. Elmali et al. [2013] found that 82.4% of canal dehiscence affected to SSC, 10.4% corresponded to PSC and 7.2% was located on the lateral canal. Therefore, the greater PSC thickness could explain for the low prevalence of PSCD, when using radiological diagnosis. Russo et al. [2014] also observed that prevalence was higher for SSCD than for PSCD (4.9% vs 1.2%) and concluded that if a unique cause would lead to both SSCD and PSCD, its effect should be more intense to develop PSCD since PSC ossification occurs later, as observed by Nemzek et al. [1996] and Richard et al. [2010].

In most of the previous reports, PSCD was more frequent in men; men percentage of PSCD patients ranged 71.4% [Saxby et al., 2015] to 100% [Russo et al., 2014; Erdogan et al., 2011], although values as low as 41.7 % [Gopen, et al., 2010] and 50% [Meiklejohn et al., 2015] have also been reported. According to our results, PSC thickness showed a lower mean value in men (table 1). Therefore, since PSCD was more frequent in men, reduced thickness would be more susceptible to develop PSCD.

Influence of age on the SSC thickness has been studied by Crovetto et al. [2012]. SSC thickness was higher in ≤45 years patients than in older ones (1.12 ± 0.52mm vs1.02±0.44mm, p=0.006); 7.1% of SSC in ≤45 years patients were thin as opposed to 13.8% in >45 years patients (p=0.013). Therefore, a light SSC osteopenia associated with aging would occur and this age-dependent effect seems to be more intense in menopausal women. In a retrospective study, Yu et al. [2012] associated osteoporosis with higher frequency of SSCD. Whyte et al. [2016] found a significant and negative correlation for age and SSC thickness (r=-0.121; p=0.003): SSC thickness decreased as age increased. Davey et al. [2015] detected an age–dependent reduction in SSC thickness, in both males and females (0.0047 mm/year, over a lifetime).

To the best of our knowledge, this is the first study analyzing the possible influence of sex and age on PSC thickness. We did not find significant differences between the two age groups for PSSC thickness (see table 1). However, age-dependent evolution for PSC thickness was different in males and females. As can be seen in Table 2, ≥45 years old men did not show significant age-dependent modification in PSC thickness, but from 45 years onwards PSC thickness decreased faster (0.0180 ± 0.0080mm/year) than Davey´s prevision for SSC [2015].In females, PSC thickness increased significantly until 45 years (0.0200 ± 0.0080mm/year) but it did not show significant age-dependent modification from 45 years onwards. So far, the causes for this different evolution by sex are unknown.

The risk for SSCD increased 93% every 20 years of lifetime [Nadgir et al., 2011]. A significant direct correlation was found for aging and SSCD prevalence: frequencies of SSCD grades 3 (predehiscence) and 4 (dehiscence) increased with age [Klopp-Dutote et al., 2016]. The temporal bone is submitted to a permanent, age-dependent remodeling [Hernández-Gil et al., 2006]. According to our results, the PSC thickness might evolve irregularly over the lifetime and in a different way than the SSC thickness. The results of Frisch et al. [2000] would support this hypothesis: in laboratory animals (dogs) the remodeling of the otic capsule shows a peculiar and unique pattern, with only 2.1% of bone remodeling in the labyrinthine bone compared to up to 10% in the rest of the bones.

In view of our findings, age and sex influence the thickness of PSC and SSC differently. An age–dependent reduction in SSC thickness, in both males and females, has been previously reported [Davey et al., 2015]. However, the PSC thickness did not significantly evolve with age in young males (≤ 45 years) but it became thinner from 45 years onwards. On the other hand, the PCS thickened with age in women until 45 years and it did not significantly change in older females.

Conflict of interest:

Authors disclose any sponsorship or funding arrangements relating to their research and all authors also disclose any possible conflicts of interest.

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