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Original article

A radiologic and anatomic study of the superior semicircular canal

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ABSTRACT

Objectives: The present study sought to determine whether there is a correlation between the prevalence of superior semicircular canal (SSC) dehiscence (SSCD) on temporal CT and population age. The secondary objective was to identify anatomic factors for SSCD by studying SSC diameter and its protrusion into the middle cranial fossa. The aim was to determine the acquired or congenital origin of SSCD (Minor's syndrome).
Material and method: A single-center retrospective radiological and anatomic study included 180 CT scans of 354 petrous parts of the temporal bone taken between January and December 2011 in a university hospital center. Bone thickness above the SSC was measured and classified in 4 grades: grade 1, > 2.5 mm; grade 2, < 2.5 mm: grade 3, predehiscent; grade 4, dehiscent. SSC diameter was also measured, as was the height of SSC protrusion into the middle cranial fossa.
Results: SSCD was found in 0.8% of cases and predehiscence in 12%. Patients with dehiscence were older; patients with grade 3 or 4 were significantly older than those free of dehiscence ($P < 0.05$). There was no significant difference in SSC diameter according to grade. In grade 1, protrusion was greater than in other subjects, with a significant correlation between age and reduced protrusion ($P < 0.05$).
Conclusion: The study demonstrated a correlation between aging and SSCD prevalence. Reduced SSC roof height with age suggests that SSCD may be an acquired phenomenon, related in some way to aging of the base of the skull.

1. Introduction

Minor's syndrome (superior semicircular canal dehiscence [SSCD]) is a pathology recently first described by Minor et al. in 1998 [1]. It is a bone defect of the roof of the superior semicircular canal (SSC), creating communication with the middle cranial fossa and dura mater. This "third window" of the bony labyrinth may induce a clinical syndrome associating sound-evoked vestibular signs (Tullio's phenomenon) and mixed hearing loss with conserved stapedial reflex. Congenital or acquired origin is presently still a matter of debate.

A radiological and anatomic study sought to shed light on the pathophysiology of SSCD by examining the temporal bone and SSC on temporal CT in a patient cohort. The principal objective was to determine whether SSCD is an acquired condition that may be related to skull base aging, by looking for a correlation between reduced SSC roof height and age. The secondary objective was to look for anatomic factors predisposing toward SSCD, by studying SSC diameter and protrusion into the middle cranial fossa.

2. Material and method

After approval from the North-West II institutional review board (France), a single-center retrospective analytic descriptive radiological and anatomical study was performed on a series of temporal CT slices acquired between January and December 2011 in the Amiens University Hospital Center (France). All patients undergoing temporal CT during the year 2011 were included. CT of the two temporal bones was performed using a LightSpeed® VCT (GE Healthcare) scanner with helical volume acquisition with orbitomeatal reconstruction, 0.1–0.2 mm interval and 0.4–0.6 mm slice thickness. Measurements were made on the coronal slice passing through the plane of the SSC (reconstructed Pöschl plane) using DXMM measurement software. SSC diameter was measured. Bone thickness between the SSC and the middle cranial fossa was classified as:

- grade 1, > 2.5 mm;
- grade 2, bone < 2.5 mm;
- grade 3, SSC in contact with middle cranial fossa;
- grade 4, SSC opening into middle cranial fossa.

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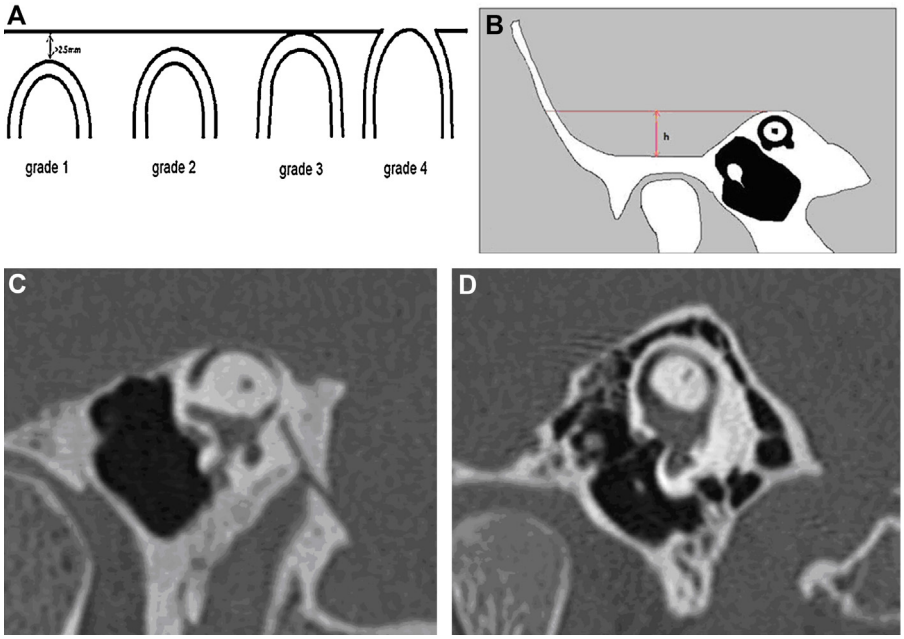

Fig. 1. Methodology: A) Determination of SSC dehiscence grade; B) Measurement of SSC height (h). Examples (right ears): C) Grade-4 SSC dehiscence. D) Normal grade-1 SSC.

Grades 1 and 2 were considered normal; grade 4 was considered true SSCD, and grade 3 as predehiscence. SSC meningeal protrusion into the middle cranial fossa was assessed as the height (*h*) between the base of the temporal bone at its lowest point and the tangent to the SSC roof on coronal SSC slice (Fig. 1).

Grades were compared according to age and SSC diameter and protrusion on covariance analysis and Student *t* test, with 95% confidence intervals and a significance threshold of $P < 0.05$. Age versus diameter and age versus protrusion were analyzed by linear regression (SAS Enterprise Guide® 4.2 software).

3. Results

One hundred and eighty patients were included (96 male, 84 female), for a total 354 temporal CT scans (179 right and 175 left ears). Mean age was 35 years. Three hundred and ten scans were considered normal: 257 grade 2, 53 grade 1 (respectively 73% and 15% of scans). Complete SSCD was found in 3 scans from 3 different patients (0.8% of scans and 1.7% of the population) (Fig. 1). Predehiscence was found in 41 scans (12%). Mean ages for grades 1, 2, 3 and 4 were respectively 24.6, 35.2, 47 and 65.4 years (Table 1). The age difference was significant between grade-4 and grade-1 patients ($P < 0.05$); the age difference between grade-4 and grade-2 and -3 patients was not statistically significant; that between grade 3 and grades 2 and 1 was significant ($P < 0.05$), as was that between grade 2 and grade 1. Grouping grade-3 and -4 patients (respectively, pathological and prepathological) together versus grades 1 and 2 (normal) showed the former to be significantly older than the latter ($P < 0.05$). Mean SSC diameter was 7.25 mm in grade 1, 7.34 mm in grade 2, 7.27 mm in grade 3 and 7.77 mm in grade 4, without significant difference. SSC protrusion into the middle cranial fossa was respectively 10.30, 8.28, 8.15 and 8.13 mm for grades 1 to 4: i.e., significantly greater in grade 1 than grades 2 or 3. There was a significant direct correlation between age and SSC diameter ($P < 0.01$) and a significant inverse correlation between age and protrusion (Fig. 2). Fig. 2 deals with A) Comparison between grade and age and B) Comparison between grade and SSC meningeal protrusion height, rather than "age and protrusion" as mentioned in the Results.

4. Discussion

SSCD (Minor's syndrome) is a recently discovered entity [1]. The various studies reported are progressively shedding light on the underlying pathophysiology. Incidence in the general population is hard to estimate, as the clinical presentation is complex and not well known. Minor [2] reported 65 cases over a 9-year period; age at diagnosis ranged from 13 to 78 years, with a mean of 43 years in case of vestibular signs and 53 years in case of purely auditory involvement.

In a cadaver study by Carey et al. [3], including 1000 specimens, 0.5% presented SSCD and 1.4% predehiscence (< 1 mm thickness). Crovetto et al. [4] reported 0.6% SSCD in 160 cadavers. In Minor's syndrome, SSC dehiscence is systematically confirmed on thin-slice temporal CT. The correlation between dehiscence on CT and clinical signs, however, is not systematic: the dura mater can form a patch at the SSC without accompanying otologic signs (as explained by Whyte Orozco et al.) [5]. Radiologic dehiscence, however, remains of indirect diagnostic value. The prevalence of Minor's syndrome can only really be assessed in symptomatic patients with SSCD, but the small numbers do not allow any large-scale anatomic study. The fact that all these patients show clear radiologic dehiscence, on the other hand, justifies a radiologic and anatomic study in the general population. Equally, anatomic cadaver study is the most reliable means of identifying dehiscence, but cannot feasibly include large numbers of greatly varying ages. The present temporal CT-based design allowed a large cohort to be studied with ages ranging from a few months to 90 years. The study population was homogeneously distributed for age and gender. CT slices were thin, but did not provide precise measurement of SSC roof thickness, which is generally less than 2.5 mm; we therefore considered a 4-grade classification to be better suited to our principal objective. In the 354 temporal bones studied on CT, the prevalence of SSCD was 0.8%, and that of predehiscence 12%. In the literature, Crovetto et al. [4] in 2010 found a prevalence of 3.6% in 604 CT scans, and Cisneros et al. [6] found 1.8% in 163 scans (with SSC roof thickness < 0.5 mm in 14.1% of cases). Nadgir et al. [7] in 2011 reported SSCD in 7.8% of 304 patients, with 45% showing a thin SSC roof.