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Clinical study

Incidence of intraoperative hearing loss during middle cranial fossa approach for repair of superior semicircular canal dehiscence

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ABSTRACT

Introduction: Superior semicircular canal dehiscence is a rare inner ear disorder characterized by an abnormal third opening between the superior semicircular canal and middle fossa. Symptoms include amplification of internal sounds, aural fullness, tinnitus, hearing loss, autophony, sound-induced vertigo (Tullio phenomenon), pressure-induced vertigo (Hennebert sign), disequilibrium, nystagmus, oscillopsia, and headache. While no cure exists for SSCD, surgical treatment has proven to effectively minimize these symptoms. This study reviewed brainstem auditory evoked potentials (BAEPs) that were monitored intraoperatively to better understand hearing loss risks associated with surgical treatment for SSCD.
Methods: A retrospective chart review was conducted at the University of California, Los Angeles on adult patients with a confirmed diagnosis of SSCD who had undergone a middle cranial fossa repair from March 2011 to October 2017. A total of 142 cases of SSCD in 118 patients were repaired.
Results: The majority of patients' BAEPs remained stable and had no intraoperative hearing changes (n = 135; 95.1%). Seven patients experienced intraoperative changes as determined by a prolongation and reduction of Wave V latency (4.9%). Of these seven cases, five experienced a return to baseline prior to the end of surgery, and had no post-operative changes in hearing (71.4%). Overall, only two of the 142 surgeries (1.4%) resulted in failure to normalize and, as such, these patients experienced permanent changes in hearing.
Conclusion: The results of this retrospective review demonstrate a low risk for hearing loss due to SSCD surgery via the middle fossa craniotomy approach.

1. Introduction

Superior semicircular canal dehiscence (SSCD) is an uncommon medical disorder in which the inner ear has an abnormal bone dehiscence, specifically located in the superior semicircular canal [1]. In normal patients, the fluid-filled inner ear has two mobile windows. These are known as the oval and the round windows, where sound enters and exits, respectively [2]. In SSCD, the abnormal "third mobile window" communicates between the superior semicircular canal and the middle fossa, ultimately causing various pathology to the vestibular and auditory systems [3].

SSCD was initially described in 1998 by Minor et al. [1]. Dehiscences in the posterior semicircular canal, lateral semicircular canal, and other areas have been reported, but are less common [4]. While the etiology is ambiguous, the clinical symptoms are well-defined and numerous [1,5]. The bony defect is usually millimeters long and can cause symptoms such as the amplification of internal sounds, aural fullness, tinnitus, hearing loss, autophony, sound-induced vertigo (Tullio phenomenon), pressure-induced vertigo (Hennebert sign), disequilibrium, nystagmus, oscillopsia, and headache [2,10–12]. Larger dehiscences may have more serious symptoms [6].

Diagnosis of SSCD is confirmed by clinical symptoms, but the dehiscence can be asymptomatic and may represent an incidental finding on a radiology test [13]. In symptomatic cases, diagnosis can be aided with the vestibular-evoked myogenic potential (VEMP) test, which detects low threshold responses for cervical responses or elevated amplitude responses for ocular responses in the contralateral eye [7,8]. The most accurate method to confirm a diagnosis, however, is a computerized tomography (CT) scan;

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such high-resolution, sub-millimeter images allow for confirmation of the bony defect (Fig. 1) [9].

While no cure exists for SSCD, surgical treatment has proven to be effective in resolving sound- and pressure-induced vertigo, autophony, oscillopsia, and aural fullness [3,14,15]. Common surgical approaches for SSCD repair include the transmastoid approach and the middle fossa craniotomy [16]. The former, an approach from below the dehiscence, involves drilling through the mastoid bone [17,18]. On the other hand, the middle fossa craniotomy is an approach from above, providing the most direct exposure to the dehiscence [19,20].

A brainstem auditory evoked potential (BAEP) is a potential evoked by an aural stimulus, recorded by electrodes placed on the scalp [21]. BAEPs, useful for intraoperative monitoring, can detect changes in hearing loss in patients under anesthesia [21]. This study is a retrospective review of medical records, specifically regarding BAEPs, for patients who have undergone SSCD surgeries. Reviewing patients' intraoperative monitoring will provide insight into the risk of hearing loss associated with surgical treatment of SSCD.

2. Methods

A single-institution retrospective review of electronic medical records (EMRs) was conducted at the University of California, Los Angeles on adult patients with a confirmed diagnosis of SSCD (through high-resolution CT scans) who had undergone a middle fossa craniotomy ranging from March 2011 to October 2017. Patients with SSCD undergoing non-surgical management or surgical repair through a different approach were excluded. This study was approved by the University of California, Los Angeles Institutional Review Board (IRB #17-001924).

2.1. Surgical technique

All 142 SSCD repairs involved a middle fossa craniotomy approach, whose advantage is a direct view of the dehiscence that allows for optimal repair. The dehiscence was identified through a combination of microscopic visualization and intraoperative neuronavigation technology, involving MRI and CT fusion images. Materials including bone wax, bone chips, DuraGen, and heliostat were used in various combinations to seal the dehiscence.

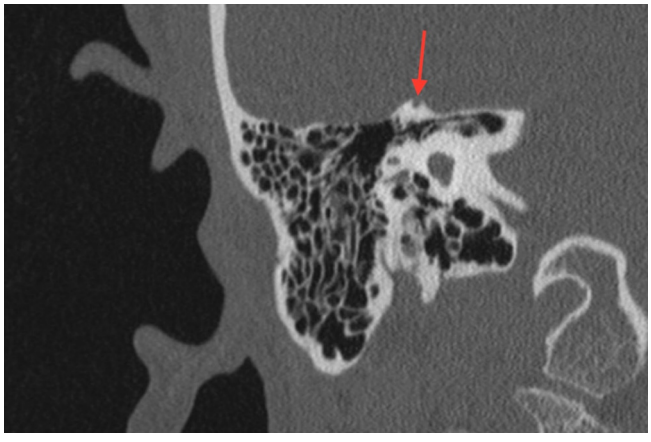

Fig. 1. High-resolution computed tomography (HRCT) of the right temporal bone, indicating superior semicircular canal dehiscence via a coronal view. HRCTs are the gold standard for confirming diagnosis of SSCD. This coronal view of the right temporal bone shows the bone dehiscence, as indicated by the red arrow; this dehiscence is the abnormal "third mobile window" that can cause a variety of vestibular and auditory symptoms.

2.2. Hearing loss

Intraoperative hearing loss was measured by reliable BAEPs. Prolongation or reduction of Wave V latencies indicated adverse hearing effects. Whether the potentials returned to the baseline value was recorded. Furthermore, any negative post-operative hearing changes were determined by a combination of follow-up audiometry tests and self-reported data.

3. Results

A total of 118 patients with SSCD, undergoing 142 middle fossa craniotomies for SSCD repair between March 2011 and October 2017, were identified. Females comprised 66.9% (n = 79) of the patients and males comprised 33.1% (n = 39), with a female-to-male ratio of 2.03:1. SSCD repair was most frequently performed exclusively on the left ear (n = 64; 54.2%), as opposed to either exclusively on the right ear (n = 30; 25.4%) or bilaterally on different occasions (n = 24; 20.3%). These baseline characteristics are summarized in Table 1.

All 142 repairs' BAEPs were monitored reliably. While the majority of patients' BAEPs remained stable and thus had no intraoperative hearing changes (n = 135; 95.1%), seven patients (4.9%) experienced intraoperative changes as determined by a prolongation of Wave V latency. Of these seven cases, five experienced a return to baseline prior to the end of surgery, and had no post-operative changes in hearing (71.4%). Overall, only two of the 142 surgeries (1.4%) resulted in failure to normalize and, as such, these patients experienced permanent changes in hearing. Table 2 summarizes both intraoperative monitoring and postoperative outcomes.

4. Discussion

Reviewing patients' intraoperative monitoring clarifies the surgical risks associated with SSCD, specifically regarding hearing loss. Interestingly, this paper analyzes intraoperative and postoperative changes in hearing loss from the largest single-institution cohort thus far; in fact, the cohort size of 118 patients is often multiple times larger than that of other studies [8,11,14–18,20,22]. All 142 cases involved a middle fossa craniotomy approach; consequently, this study adds depth to the debate between different surgical approaches for SSCD by highlighting the low risk associated with the middle fossa approach.

Five of the seven cases with intraoperative BAEP changes normalized before the end of the surgical procedure. This could be due to transient blood in the hearing apparatus which resolves or transient fluid dynamics within the inner ear that become

Table 1
Characteristics of patients who underwent SSCD repair via the middle fossa approach between March 2011 and October 2017.

Variable	n (%)
Total Surgical Repairs	142
Total Patients	118
Sex	
Male	39 (33.1)
Female	79 (66.9)
Repair Laterality	
Left	64 (54.2)
Right	30 (25.4)
Bilateral‡	24 (20.3)

‡ All patients who opted for bilateral repair via the middle fossa approach underwent surgery on two separate occasions.

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