

Transmastoid Approach for Resurfacing the Superior Semicircular Canal Dehiscence with a Dumpling Structure

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Abstract

Background: Superior semicircular canal dehiscence (SSCD) is gradually recognized by otologists in recent years. The patients with SSCD have a syndrome comprising a series of vestibular symptoms and hearing function disorders which can be cured by the operation. In this study, we evaluated the characteristics of patients with SSCD and determined the effectiveness of treating this syndrome by resurfacing the canal via the transmastoid approach using a dumpling structure.

Methods: Patients with SSCD, confirmed by high-resolution computed tomography and hospitalized at Beijing Tongren Hospital between November 2009 and October 2012, were included in the study. All of the patients underwent the unilateral transmastoid approach for resurfacing the canal, and received regular follow-up after surgery. Data from preoperative medical records and postoperative follow-up were comparatively analyzed to evaluate the effect of surgery.

Results: In total, 10 patients and 13 ears (three left ears, four right ears, three bilateral ears) were evaluated in the study, which included 7 men and 3 women. Different symptoms and distinctive manifestations of vestibular evoked myogenic potential were found in these patients. After surgery, 4 patients had complete resolution, 5 had partial resolution, and 1 patient, with bilateral SSCD, had aggravation. None of the patients suffered from serious complications such as sensorineural hearing loss, facial paralysis, cerebrospinal fluid leakage, or intracranial hypertension.

Conclusions: In patients with unilateral SSCD, resurfacing the canal via the transmastoid approach using a dumpling structure is an effective and safe technique. However, more consideration is needed for patients with bilateral SSCD.

Key words: Autophony; Pulsatile Tinnitus; Resurfacing; Superior Semicircular Canal Dehiscence; Surgical Treatment; Transmastoid Approach; Vestibular Evoked Myogenic Potential

INTRODUCTION

Superior semicircular canal dehiscence (SSCD), first reported by Minor *et al.* in 1998,^[1] and gradually recognized by otologists in recent years, is defined as local dehiscence in the bony wall on the top of the superior semicircular canal, which creates a third window into the inner ear. Thus, a syndrome comprising a series of vestibular symptoms and hearing function disorders arise in patients with SSCD, which are primarily caused by changes in the membranous labyrinth responding to the sound and pressure changes of the third window. The typical symptoms of SSCD include vertigo, disequilibrium, autophony, conductive hearing loss, hyperacusis of bone conduction, and pulsatile tinnitus, as well as typical signs such as the Tullio phenomenon (intense sound induced vertigo) and the Hennebert sign (pressure-induced vertigo).^[2,3]

Vestibular evoked myogenic potential (VEMP) and high-resolution computed tomography (HRCT) are used to diagnose SSCD. A lower VEMP threshold and larger VEMP amplitude are common manifestations in the affected ear.^[4-7] Even though the possibility of overestimation and false detection exists,^[8,9] HRCT plays an important role in the diagnosis of SSCD, as it shows local bone dehiscence on the top of the SSC near the arcuate eminence. In addition, low-frequency conductive hearing loss or hyperacusis of bone conduction in pure tone audiometry (PTA) with normal findings on tympanometry, acoustic stapedius reflex, and Gelle's test may also lead to a positive SSCD diagnosis.^[10-12]

Three approaches have been described in the literatures regarding surgical treatment; namely, middle cranial fossa, transmastoid, and transcanal approaches.^[1,13-15] The middle cranial fossa approach provides a direct view of the canal and is convenient for surgery; however, the invasiveness of the procedure and the high risk of infection cannot be ignored. The transmastoid approach clearly reduces the

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invasiveness but does not provide a direct view of the SSCD. The transcanal approach shows minimum invasion, but obliteration tissue of the round window is not persistent.^[16]

Two ways of treating SSCD have also been described in the literature, including plugging and resurfacing the canal defect.^[1,14] The difference in these approaches is that resurfacing only repairs the bone dehiscence, whereas plugging repairs the dehiscence with occlusion of the membranous labyrinth lumen of the SSC. Theoretically, plugging will produce worse vestibular symptoms shortly after surgery, because of the hindrance of endolymphatic fluid movement in the membranous labyrinth lumen.^[16] Considering the lower invasiveness, lighter irritation, and longer and more stable effects, we selected the transmastoid approach for resurfacing the canal in patients with SSCD who were hospitalized in the Department of Otolaryngology Head and Neck Surgery at Beijing Tongren Hospital.

One of the key points in resurfacing is the material. In previous studies, the temporalis fascia, tragal cartilage, tragal perichondrium, cortical bone graft, and silicone elastomer were used for resurfacing with satisfactory outcomes.^[14,17-19] In the present study, a dumpling structure consisting of the temporalis fascia and autologous bone powder were first applied to resurface the canal. We believe that this structure has better deformability, hardness, and biocompatibility, allowing it to fit into the space between the SSC and dura without shifting for a long time; in addition, it simplified the surgical procedures.

In this study, we evaluated the effect of the transmastoid approach for resurfacing the canal defect using the dumpling

structure and determined any changes in symptoms after surgery.

METHODS

We obtained approval from the Committee on Medical Ethics at Beijing Tongren Hospital prior to beginning the retrospective study. The population included patients who were hospitalized in the Department of Otolaryngology Head and Neck Surgery between November 2009 and October 2012, with a diagnosis of SSCD confirmed by HRCT. Preoperative data from the patients' medical records were collected and assessed, including age, gender, affected side, course duration, symptoms, signs, and audiologic and radiological examinations.

All of the patients underwent the transmastoid approach for resurfacing the canal defect as previously described.^[14] Briefly, under general anesthesia, cortical mastoidectomy was performed with identification of the horizontal semicircular canal, tegmen, sigmoid sinus, and mastoid antrum after making a postauricular incision. In addition, the labyrinth was outlined to locate the SSC and to identify the space between the tegmen and dura. In this space, a silastic was placed on the dura to lift and protect the dura during the process of exposing the SSCD. Once the location of the dehiscence was identified using a Buckingham mirror, a dumpling structure [Figure 1] was placed on the SSCD to repair the dehiscence, formed by autologous bone powders filling in the middle of the temporalis fascia. Medical adhesive (FAL; Beijing Fuaile Co., Beijing, China) was used to shape the bone powders according to the area surrounding

Table 1: Preoperative patient information

Patient number	Age (years)	Gender	Side	Course duration (years)	Symptoms	Tullio Hennebert sign	ABG (>10 dB)	VEMP threshold (dB)		VEMP amplitude (μV)		
								L	R	L	R	
1	47	Female	B*	10	Disequilibrium, hearing loss, tinnitus, vertigo	+	+	Yes	80	80	20.7	42.86
2	55	Male	L†	0.25	Autophony, hearing loss, pulsatile tinnitus, vertigo	+	+	Yes	80	100	37.68	38.97
3	40	Male	B	12	Autophony, ear fullness, oscillopsia, pulsatile tinnitus and tinnitus, vertigo	+	+	Yes	80	90	111.81	64.20
4	41	Male	L	10	Pulsatile tinnitus	-	-	No	100	100	721	592
5	49	Male	R‡	1	Autophony, disequilibrium, pulsatile tinnitus, vertigo	+	+	No	90	90	775	1516
6	38	Male	R	14	Disequilibrium, ear fullness, tinnitus, vertigo	+	+	Yes	100	70	31.13	211.5
7	44	Female	B	2	Autophony, disequilibrium, earfullness, hearing loss, pulsatile tinnitus	-	-	Yes	80	70	1822	2001
8	27	Female	R	1	Autophony, disequilibrium, hearing loss, pulsatile tinnitus	-	-	Yes	N§	N	N	N
9	44	Male	R	9	Autophony, hearing loss, pulsatile tinnitus	-	-	Yes	100	90	37.32	32.72
10	36	Male	L	0.5	Autophony, pulsatile tinnitus, tinnitus, vertigo	+	+	Yes	80	90	890	719

*Bilateral side; †Left side; ‡Right side; §Not found in medical records. +: Positive findings; -: Negative findings; VEMP: Vestibular evoked myogenic potential; ABG: Air-bone gap, it meant the average air-bone of 250, 500, 1000, 2000, 4000 Hz here.

the SSCD, as well as to fix the temporalis fascia. Finally, the dura was returned gently and slowly after the silastic sheet was removed. Seven days later, the patients were discharged.

After surgery, all of the patients received regular follow-up for at least 9 months. Questionnaires regarding changes in symptoms were made according to the conditions of the individuals. The efficacy of surgery was assessed by questionnaire and PTA when the symptoms were stable after the surgery (at least 6 months later), or when complications occurred.

RESULTS

In total, 10 patients and 13 ears were evaluated in this study, including 3 left ears, 4 right ears, and 3 bilateral ears (identified on HRCT; Figure 2). Preoperative information concerning these patients is shown in Table 1. The study population comprised seven men and three women with an average age of onset of 42.10 ± 7.69 years. The duration of patients with SSCD varied from 0.25 to 14 years before admission to the hospital. Half of the patients had head trauma before the symptoms arose (patients Nos.: 1, 2, 4, 7, 9).

The symptoms of the patients varied between individuals and included autophony, disequilibrium, ear fullness, hearing loss, oscillopsia, pulsatile tinnitus, tinnitus, and vertigo. Among these symptoms, pulsatile tinnitus (8/10), autophony (7/10),

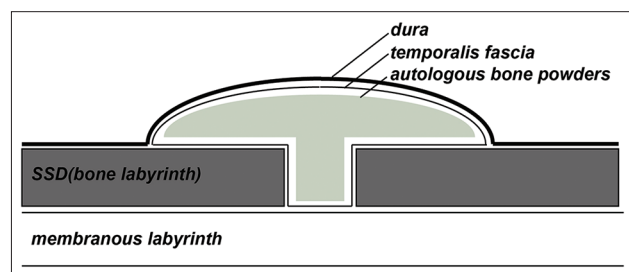


Figure 1: The sketch of the dumping structure for resurfacing superior semicircular canal dehiscence.

and vertigo (6/10) were the most frequent, followed by hearing loss (5/10) and disequilibrium (5/10) [Table 1]. In addition, the Tullio phenomenon and Hennebert sign were found in 6 patients. Moreover, an air-bone gap of 10 dB or greater was found in 80% (8/10) of patients by PTA. Normal tympanometry was found in 17 ears, except 3 ears with type Ad by tympanometry (including the left ear in patient No. 1 and two ears in patient No. 5). In addition, VEMP test outcomes were found in nine patient medical records (not found in the record of patient No. 8). There was a significant difference in the VEMP threshold between the affected ears (12 ears) and normal ears (6 ears) ($P = 0.005 < 0.05$, Mann–Whitney *U*-test), but not in VEMP amplitude ($P = 0.454 > 0.05$, Mann–Whitney *U*-test), indicating that the VEMP threshold in affected ears was lower than that in normal ears, but the VEMP amplitude between them was not significantly different. A similar situation was found in the VEMP threshold ($P = 0.042 < 0.05$, Mann–Whitney *U*-test) and amplitude ($P = 0.489 > 0.05$, normal distribution and equal variance, *t*-test) of patients with unilateral SSCD.

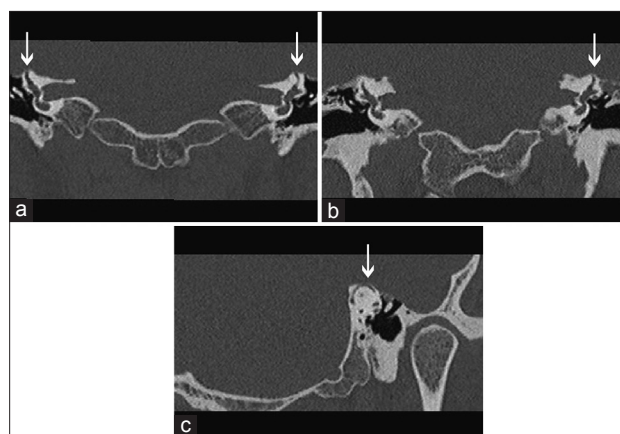


Figure 2: High-resolution computed tomography images of 2 patients with superior semicircular canal dehiscence (SSCD). One with bilateral SSCD (arrows on a) and the other one with left SSCD (arrows on b and c).

Patient number	Operation side	Duration of follow-up (months)	Residual symptoms	Tullio	Hennebert sign	PTA changes* (dB)
1	Left	56	Nil	–	–	–10
2	Left	49	Nil	–	–	–10
3	Left	50	Autophony, pulsatile tinnitus, tinnitus, vertigo (worsen)	+	+	5
4	Left	48	Nil	–	–	0
5	Right	21	Mild disequilibrium	+	–	0
6	Right	27	Mild disequilibrium	–	–	0
7	Right	21	Mild disequilibrium	–	–	–7
8	Right	48	Nil	–	–	–24
9	Right	9	Hearing loss	–	–	–5
10	Left	9	Autophony	–	–	0

*PTA changes: The change of average PTA of 250, 500, 1000, 2000, 4000 Hz between postoperative PTA and preoperative PTA. +: Positive findings; –: Negative findings; PTA: Pure tone audiometry.

Unilateral surgery was performed in all of the patients, including 3 patients with bilateral SSCD. In patients with bilateral SSCD, surgery was performed on the side with more severe symptoms which showing lower threshold and greater amplitude in VEMP outcomes; for example, surgery was performed on the left ear in patient No. 3 and the right ear in patient No. 7, but the left ear in patient No. 1 was excluded because of trauma in that ear. After surgery, all of the patients received regular follow-up for 9–56 months [Table 2]. Most of the patients showed complete resolution (4/10) or partial resolution (5/10), except for 1 patient with aggravated bilateral SSCD (patient No. 3; Table 2). In the 5 patients with partial resolution, residual symptoms included mild disequilibrium (3/5), autophony (1/5), and hearing loss (1/5). At the same time, the Tullio phenomenon and Hennebert sign disappeared in most of the patients except patients No. 3 (both existed) and No. 4 (the Tullio phenomenon existed).

In addition, there were 5 patients with hearing improvement [Figure 3]. Furthermore, no one had serious complications due to the surgery such as sensorineural hearing loss, facial paralysis, cerebrospinal fluid leakage, and intracranial hypertension.

DISCUSSION

In the present study, 10 patients underwent the unilateral transmastoid approach for resurfacing the canal defect using the temporalis fascia and autologous bone powders. In addition, most (9/10) of them had complete or partial resolution and avoided pulsatile tinnitus, autophony, vertigo, hearing loss, and severe disequilibrium [Figure 4]. Furthermore, hearing improved in 5 patients after surgery, and none had serious complications. Therefore, the transmastoid approach was proven to be effective and safe for patients with SSCD.

The transmastoid approach for resurfacing the canal defect was applied based on its lower invasiveness and risk of infection compared to the middle cranial fossa approach, and its higher stability and endurance compared to the transcanal approach.^[16] In previous studies, the temporalis fascia, tragal cartilage, tragal perichondrium, cortical bone graft, and silicone elastomer were used to resurface the canal defect with most satisfactory outcomes.^[14,17-19] Here, we first applied a dumpling structure made using autologous bone powder to fill in the middle of the temporalis fascia. In addition, the bone powders were shaped with a medical adhesive to fit the area surrounding the bone dehiscence. This structure had several advantages such as better flexibility than tragal cartilage to prevent shifting, better anti-resorption than tragal perichondrium, and better biocompatibility than silicone elastomer and hydroxyapatite cement.

All of the patients with unilateral SSCD (7/10) had satisfactory outcomes because all or most of the symptoms

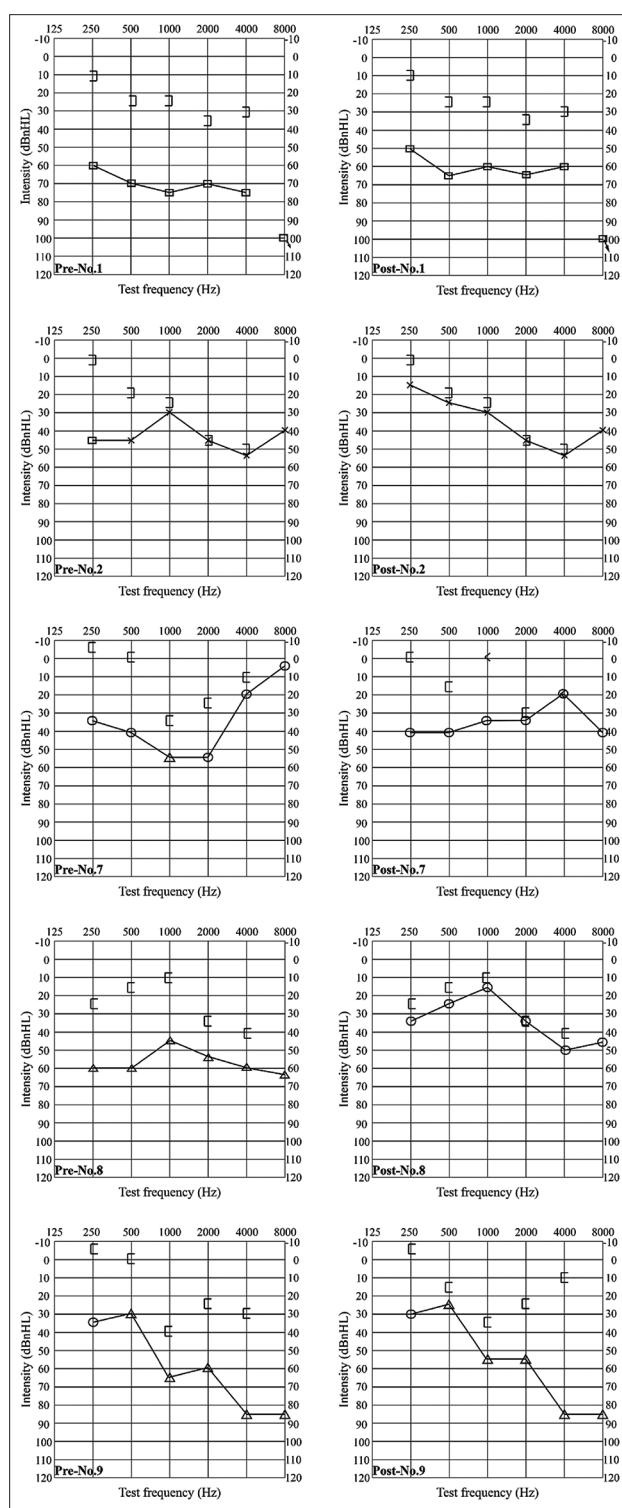


Figure 3: Preoperative and postoperative pure tone audiograms of 5 patients with improved hearing. They are patient No. 1, No. 2, No. 7, No. 8 and No. 9, as labeled.

disappeared after surgery. One patient (patient No. 3) with bilateral SSCD had worsened symptoms after surgery, including autophony, vertigo, pulsatile tinnitus, and tinnitus, but the two other patients with the same condition had good outcomes (patient No. 1 had complete disappearance of

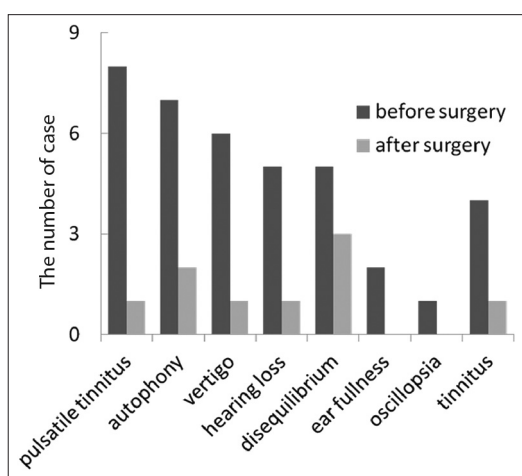


Figure 4: Preoperative and postoperative symptoms.

symptoms, patient No. 7 had partial disappearance except hearing loss which possibly caused by injury of the inner ear from head trauma). We presumed that the outcomes in patient No. 3 may have been related to the effect of the contralateral SSCD, as well as possible shifting of the dumpling structure or its incorrect application; however, the precise reason remains unknown. Therefore, these results revealed that the surgery was effective for patients with unilateral SSCD while some interfering factors may reduce the effect for those with bilateral SSCD.

The VEMP threshold in the affected ear was lower than that in the normal ear in either all of the patients or those with unilateral SSCD based on statistics, which were in accordance with those from previous studies.^[7] However, the VEMP amplitude did not seem to be statistically greater in the affected ear than in the normal ear, possibly affected by muscle tension, head position, age and sample size, although a low VEMP threshold likely indicated SSCD.

The symptoms of SSCD can be classified into vestibular symptoms and hearing function disorders. The former includes vertigo, disequilibrium, oscillopsia, nystagmus, the Tullio phenomenon, and the Hennebert sign; the latter comprises autophony, hearing loss, pulsatile tinnitus, tinnitus, and ear fullness.^[2,3] In our study, there were 8 patients with both vestibular symptoms and hearing function disorders, excluding 2 patients with only hearing function disorders. Regarding the incidence of symptoms, pulsatile tinnitus (8/10) occurred the most frequently in this group, followed by autophony (7/10), and vertigo (6/10). These results are not in accordance with those from previous studies,^[20] and to some extent, demonstrates the various manifestations of SSCD.

One limitation of this study is that we did not know the precise reasons underlying the aggravated symptoms that occurred in 1 patient after resurfacing of the canal defect, because the patient refused further examination. In addition, this retrospective study was only performed in one hospital,

which limits the level of evidence. Therefore, a multi-center study on the effect of this surgical technique should be considered in the future.

In conclusion, there are two main manifestations of SSCD, vestibular symptoms and hearing function disorders, but the symptoms are variable. VEMP and computed tomography may help in diagnosing this syndrome. The transmastoid approach for resurfacing the canal defect using the dumpling structure was proven to be effective and safe for patients with unilateral SSCD. However, further studies are needed in those with bilateral SSCD.

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