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Second-Side Surgery in Superior Canal Dehiscence Syndrome

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Abstract

Objective—Bilateral superior canal (SC) dehiscence syndrome poses a challenge because bilateral SC dehiscence (SCD) plugging might be expected to result in oscillopsia and disability. Our aims were as follows: 1) to evaluate which symptoms prompted patients with bilateral SCD syndrome (SCDS) to seek second-side surgery, and 2) to determine the prevalence of disabling imbalance and oscillopsia after bilateral SC plugging.

Study Design—Prospective observational study.

Setting—Tertiary referral center.

Patients—Five patients with bilateral SCDS based on history, audiometric and physiologic testing, and computed tomographic findings. This includes all of our patients who have had second-side plugging surgery to date.

Intervention(s)—Bilateral sequential middle fossa craniotomy and plugging of SCs.

Main Outcome Measure(s)—Cochleovestibular symptoms, cervical and ocular vestibular-evoked myogenic potential testing, dizziness handicap inventory, short-form 36 Health Survey, dynamic visual acuity testing.

Results—The most common symptoms prompting second-side surgery were sound- and pressure-induced vertigo and autophony. Three of the 5 patients reported that symptoms shifted to the contralateral ear immediately after plugging the first side, whereas in 2 patients, contralateral symptoms developed several years after the first SC plugging. Two of 4 patients experienced ongoing oscillopsia after bilateral SCDS surgery; however, all patients reported relief from their SCD symptoms and were glad that they had pursued bilateral surgery.

Conclusion—In patients with bilateral SCDS, sound- and pressure-induced vertigo most commonly prompted second-side surgery. Despite some degree of oscillopsia after bilateral SCDS surgery, patients were very satisfied with second-side surgery, given their relief from other SCDS symptoms.

Keywords

Bilateral; Superior canal dehiscence; Quality of life

Dehiscence of the superior semicircular canal is associated with a distinct set of vestibular and auditory phenomena, including sound- and pressure-evoked nystagmus, conductive hyperacusis, and autophony (1–6). Characteristic deficits observed on physiologic testing include an air-bone gap on pure-tone audiometry and heightened responses on vestibular-evoked myogenic potential (VEMP) testing (2,7). Varying combinations of these symptoms and signs along with computed tomographic confirmation of superior canal (SC) dehiscence constitute SC dehiscence (SCD) syndrome. Dehiscence of the bone overlying the involved SC can be confirmed at the time of surgery, and repair of that dehiscence resolves the symptoms in most cases (8). Dehiscence of the SC is thought to cause the associated symptoms and signs by creating a “third mobile window,” allowing abnormal flow of endolymph in the canal after provocative stimuli (9–11).

Temporal bone histopathologic studies as well as radiographic investigations demonstrate a 20% to 50% occurrence of bilateral dehiscences of the superior semi-circular canals, possibly owing to a congenital or developmental process (12, 13). We demonstrated in previous work that SC plugging surgery for SCD syndrome (SCDS) does not typically produce permanent global dysfunction of the operated labyrinth. Rather, it leads to an isolated deficit in the involved canal (14, 15). However, plugging both SCs would be expected to not only cause loss of the vestibuloocular reflex (VOR) for rapid downward head movements in the respective planes of the affected canals but throughout the entire range of approximately 90 degrees spanned by these canals. This would include higher frequency pitch downward head movements that occur during routine ambulation and running (16). Thus, bilateral SC plugging might be expected to cause vertical oscillopsia with associated visual impairment and gait instability and potentially more significant disability compared with the preoperative state (17).

We report here a series of 5 patients with bilateral SCDS who elected to pursue sequential plugging of both SC dehiscences. We evaluated which symptoms prompted patients with bilateral SCDS to seek second-side surgery and the degree of disability associated with those symptoms. We also determined the frequency of disabling imbalance and oscillopsia after bilateral SC plugging in this small cohort.

METHODS

Study Patients

This study was a prospective observational study. A diagnosis of SCD was made if there were symptoms of vertigo provoked by loud sounds or pressure changes, or autophony; evidence of dehiscence on temporal bone computed tomographic scans (obtained with 0.5-mm collimation and reconstructions in the plane of the SC and orthogonal to it) (12); and signs on physiologic testing suggestive of SCD. These signs included conductive hyperacusis on audiometry, eye movements evoked by sound or pressure stimuli, or

heightened VEMP responses in the affected ear. In cervical VEMP testing, relaxation potentials are recorded from a tonically contracted ipsilateral sternocleidomastoid muscle in response to increasing amplitudes of auditory stimulation (18), whereas in ocular VEMP testing, excitation potentials are recorded from the contralateral inferior oblique muscle in response to loud pure tones or midline bone-conducted vibrational stimuli (19). Lower thresholds for eliciting cervical VEMP responses (7,20) and higher amplitudes of ocular VEMP responses have been observed in SCDS (21). Patients were diagnosed as having bilateral SCDS if symptoms, signs, and radiographic evidence on multislice computed tomography were present bilaterally (22). A subset of the patients diagnosed with bilateral SCDS elected to undergo second-side surgery to relieve bilateral debilitating symptoms; these patients were followed prospectively. This study qualified for exemption from an institutional review board protocol based on US Department of Health and Human Services criteria 45 CFR 46.101 (b4). The Johns Hopkins Medicine institutional review board made the determination that the study qualified for this exemption.

Surgical Technique

The surgical techniques for plugging the dehiscent SC have been described previously (8). Briefly, a middle cranial fossa microsurgical approach is taken, with intraoperative administration of mannitol 0.5 g/kg before initiation of the craniotomy. Image guidance is used to definitively localize the dehiscence. Small strips of fascia are then directed into the open lumina of the canal, followed by chips of bone, to completely obliterate the bony lumen on either side of the dehiscence. Care is taken not to disrupt the membranous canal; rather, it is compressed by the plugs. We have observed that SC plugging more consistently leads to resolution of symptoms compared with canal resurfacing (8). Plugging has therefore been the preferred procedure since 2002, and our analysis is limited to these cases. Bone cement is applied to the middle fossa floor, and a fascia graft is laid over the repair and sealed in place with fibrin glue. Care is taken to prevent application of suction to the dehiscence site, which could remove excessive perilymph or damage the delicate membranous canal. The auditory brainstem response, facial nerve, and somatosensory evoked potentials are monitored during the surgical procedures. Postoperatively, all patients receive dexamethasone 6 mg 3 times daily, which is tapered off over 5 days or 2 weeks after the procedure, the longer course being used if there is evidence of sensorineural hearing loss or balance function loss outside the confines of the plugged SC.

Clinical Assessment

Our clinical assessment of this small cohort was largely qualitative. We evaluated what symptoms drove patients to seek second-side surgery, and in a subset of patients, we assessed the severity and functional impact of these symptoms using the Jacobson Dizziness Handicap Inventory (DHI) (23) and the Short-Form 36 health-related quality of life survey (SF-36) (24). The four main questions we posed to the patients postoperatively were as follows: 1) Do you experience symptoms of oscillopsia (visual impairment with head motion, gait instability, and chronic disequilibrium)? 2) Do you have any new activity limitations secondary to new deficits? 3) Have you experienced relief of your persistent second-side SCDS symptoms? 4) Are you glad you had the second-side surgery? Please rate this on a scale of 0 to 10 (0 = very happy, 10 = very unhappy).

Passive dynamic visual acuity (DVA) testing was performed to quantify pitch plane and vertical canal function; this measure has been shown to correspond well with canal-specific VOR gains obtained from search coil testing (25). Details of this testing procedure have been published previously (25); briefly, static visual acuity is measured first by presenting the optotype “E” on a screen and progressively decreasing the optotype size by a visual acuity change of 0.1 LogMAR until the participant can no longer resolve the orientation of the optotype. The better one’s visual acuity, the lower one’s LogMAR score, with LogMAR = -0.3, 0, 0.3, 0.7, 1.0, and 1.3 corresponding to Snellen visual acuity of 20/10, 20/20, 20/40, 20/100, 20/200, and 20/400, respectively. Passive (manually imposed) head thrusts are then performed in the planes of the horizontal, superior, and posterior semicircular canals. Optotypes are presented for 85 ms when head movement velocity is between 120 and 180 degrees per second, and the DVA test score is calculated by subtracting the static visual acuity LogMAR score from the DVA LogMAR score. Only Patient 4 underwent DVA testing because our protocol was established during his postoperative period.

RESULTS

We have diagnosed SCD in 238 patients at our institution since its description in 1998. Of these, 117 (49%) chose to have surgery to repair the dehiscence; 31 (26%) of these 117 subjects had a right-sided dehiscence, 40 (34%) had a left-sided dehiscence, and 45 (38%) had bilateral dehiscences. Of the 45 patients with bilateral dehiscences, 5 (11%) elected to pursue second-side surgery. At initial presentation, 4 of the patients had symptoms or signs of bilateral SCDS; 1 patient had only unilateral symptoms. However, all 5 patients had radiographic evidence of bilateral SCD at initial presentation. Bilateral SCD surgery was performed in 5 (4.3%) of the 117 patients who underwent surgical repair of their SCD, and in 5 (2.1%) of the 238 patients diagnosed with SCDS. We recently completed the fifth case and thus present here the case presentations of all 5 patients and postoperative follow-up data from only the first 4 patients. A description of demographic and clinical characteristics of these 5 patients is provided (Table 1). The mean age at presentation was 35 years, and there were 3 male and 2 female subjects. The mean interval between first and second surgery was 22 months.

Case Presentations

Patient 1 underwent his first SCD repair on the right side in October 2002. He noted immediate relief of his right-sided symptoms and experienced only mild left-sided symptoms for several years postoperatively. He returned to clinic in June 2006 reporting a recent progression in his left-sided symptoms, specifically sound- and pressure-induced vertigo. His score on the DHI in April 2007 was 52, consistent with a moderate perception of handicap. He elected to undergo second-side surgery in April 2007.

Patient 1 was most recently contacted in February 2010, 34 months after his second-side surgery. He reported oscillopsia with pitch-plane head movements and when walking on hard surfaces. He did not note any significant activity limitations and reported being able to drive with only mild difficulty on bumpy roads. He no longer experienced sound-induced vertigo or aural fullness. Overall, he stated that he was very glad to have undergone bilateral

SCD repairs. We could not reach him at the time of publication to provide any more information including DHI or SF-36 scores or an objective rating of his overall level of satisfaction.

Patient 2 underwent his first-side surgery on the right side in January 2009. Postoperatively, he noted that his symptoms almost immediately shifted to his left side. At his 6-month postoperative visit, he described severe sound- and Valsalva-induced vertigo, as well as left-sided autophony, pulsatile tinnitus, and aural fullness. He completed the SF-36 health questionnaire at this visit and was found to have physical and mental composite scores of 52.1 and 56.0, respectively, indicating an average self-assessment of his quality of life. His DHI score was 48, consistent with a moderate perception of handicap. At his 10-month visit, he reported several serious falls: one at work, associated with Valsalva-induced vertigo and resulting in a left rotator cuff tear, and a second fall resulting a fracture of his coccyx. Given the significant disability and safety risk associated with his ongoing symptoms, he elected to pursue second-side surgery in January 2010.

Patient 2 was queried 9 months after his second-side surgery. He reported that he occasionally experienced disequilibrium, particularly in the darkness or when looking down to put his pants on in the morning or while up on a ladder, consistent with a reduction in the pitch-plane VOR. He described his balance issues as “a little annoying,” requiring that he be more careful for example when walking down stairs. However, he did not report any associated falls or activity limitations. He noted that his SCD symptoms, including autophony and pulsatile tinnitus, were resolved. Overall, he was glad he had the second-side surgery; he felt himself to be better off with smaller, more predictable balance deficits rather than with disabling auditory symptoms and episodic vertigo. He rated his overall level of satisfaction as a 2/10 (with 0 = very happy, 10 = very unhappy). His DHI score was 14, indicating no handicap, and his SF-36 scores were 51.4 and 62 on the physical and mental composite scores, respectively, demonstrating some improvement.

Patient 3 had her first SCD repair on the left side in August 2009. She noted that her left-sided symptoms improved immediately after surgery; however, she soon began to experience symptoms on her right side. Six months postoperatively, she described significant right-sided autophony, characterized by hearing her own voice, her heartbeat, her eye movements, and her bony joints in her right ear. She scored a 45.2 on the physical component summary and a 55.9 on the mental component summary on the SF-36, consistent with below-average and average self-assessed quality of life scores, respectively. Her score of 62 on the DHI indicated a moderate degree of dizziness handicap, and she perceived her autophony to be an even more debilitating problem. Given her ongoing autophony and its impact on her quality of life, she elected to undergo second-side surgery in July 2010.

Patient 3 was contacted 3 months after her second-side surgery. She described mild oscillopsia with walking and jogging, as well as slight difficulty walking in the dark. She reported that these symptoms did not limit any of her activities. The primary symptom that had prompted her to pursue second-side surgery was autophony in her right ear, which resolved postoperatively. However, she did note the onset of recurrent symptoms localizing to her left ear. She ascribed her increased DHI score of 74 (indicating a severe handicap) and

poorer SF-36 scores of 39.3 and 33.8 on the physical and mental composite scores, respectively (consistent with below-average quality of life) to the symptoms in her first-side ear. Audiometry demonstrating the reappearance of an air-bone gap at low frequencies on the left side supported the recurrence of third mobile window physiology on the original side. Nevertheless, Patient 3 indicated that she was glad she had pursued second-side surgery; her overall satisfaction level rating was 0/10 (0 = very happy, 10 = very unhappy). This patient is considering the option of revision surgery for the left ear.

Patient 4 underwent repair of his right SCD in July 2009. He noted a shift in his symptoms from his right to left ear immediately postoperatively. At a 7-month postoperative visit, he noted persistent pressure-induced vertigo associated with coughing, sneezing and any exertion, and a constant left-sided autophony. He reported that his quality of life was very poor and that he was seeking to go on disability insurance, given his inability to work as a teacher. He elected to pursue second-side surgery in August 2010.

Patient 4 was probed 2 months after his second-side surgery. He reported occasional oscillopsia, for example, while walking in the grocery store aisle. He was taking classes in preparation to resume his teaching career, and although he reported progressive improvement in his functional status, his SF-36 scores of 40.4 and 27.9 on the physical and mental composite scores, respectively, indicated below-average quality of life. He did not report any new activity restrictions since his second-side surgery. He noted resolution of his symptoms of autophony and pulsatile tinnitus, although he reported dizziness postoperatively, as reflected in his DHI score of 60. Interestingly, he underwent passive DVA testing 1 week after his left second-side surgery (25), and his passive DVA scores in all canal planes (including the plugged SCs) were within normal limits, suggesting that he was compensating well for any peripheral loss. Overall, he stated that he was no worse off than before his second-side surgery with some early indications of improvement, and his overall satisfaction level was 3/10 (0 = very happy, 10 = very unhappy).

Patient 5 had her first SCD surgery on the right side in September 2009. She reported complete resolution of her symptoms of Valsalva-induced vertigo, autophony, and pulsatile tinnitus postoperatively and was able to resume her regular activities. In January 2011, 16 months after her initial surgery, she noted a flulike syndrome that precipitated a significant increase in her left-sided SCD symptoms, specifically autophony, pulsatile tinnitus, and sound-induced vertigo. She expressed a desire to be back to normal and symptom-free and, thus, elected to undergo second-side surgery in March 2011.

A summary of the symptoms prompting second-side surgery along with the onset and severity of these symptoms is provided (Table 2).

DISCUSSION

This initial case series provides preliminary insight into the motivations and outcomes associated with second-side surgery in patients with bilateral SCDS. We observed that the most frequent symptoms prompting second-side surgery were pressure- and sound-induced vertigo and autophony. Three of the 5 patients reported that symptoms shifted to the

contralateral ear immediately after plugging the first side. In these patients, repair of the more symptomatic side may have “unmasked” contralateral symptoms. All 3 patients who experienced immediate contralateral symptoms went on to pursue second-side surgery approximately 1 year later. In 2 of the 5 patients, contralateral symptoms developed several years after the first SCD repair, suggesting progression of their contralateral condition over a timeframe of 2 to 5 years. Patients typically reported significant disability associated with their contralateral SCD symptoms before pursuing second-side surgery. One patient reported a history of injurious falls, another patient was on disability leave, and the 3 other patients noted significant impairment in their regular activities and functional status associated with their residual symptoms.

The reduction in vertical VORs did not result in disabling oscillopsia or significant activity limitations in any of the patients after second-side SCD surgery. Indeed, Patient 4 demonstrated very little quantitative loss of VOR gain in the vertical dimension, suggesting excellent central compensation for the reduction in peripheral function. The sequential loss of SC function may permit the development of compensatory reflexes between first- and second-side surgery and mitigate the functional consequences of bilateral SC ablation. This may be particularly true in younger individuals in whom the development of central compensation is more robust (26). Moreover, plugging of a semicircular canal does not result in complete loss of rotational sensitivity in that canal. Physiologic studies have demonstrated that plugging the lumen of the bony semicircular canal creates a situation in which fluid flow from low-frequency head rotations is dampened more than that from high-frequency rotations (15,27,28). This is important in this context because low-frequency rotations, although blocked from stimulating the plugged SC, are unlikely to cause inhibitory silencing of the coplanar contralateral posterior canal (PC). This contralateral PC response can be used to generate a VOR, and central compensation can be expected to increase its gain to nearly compensatory values. Meanwhile, the higher frequencies can still stimulate the plugged SC, although the coplanar PC may be silenced. The net result is that there is still some VOR for rotations in the plane of the plugged SC at all frequencies.

Nevertheless, it must be noted that some oscillopsia did occur in all patients for some period after the second SCD plugging surgery. In 2/4 patients it has been persistent to a degree. However, despite this, all patients reported satisfaction after the second surgery with ratings of 0 to 3 of 10 on the visual analog scale of satisfaction. This suggests that even a degree of oscillopsia is preferable to the preoperative symptoms of bilateral SCDS in properly selected patients. In counseling patients for prospective surgery for the second side in bilateral SCDS, the risk of oscillopsia weighed against the relief of specific SCDS symptoms should be explicitly reviewed.

There were no significant complications associated with second-side surgery, including facial nerve weakness, cerebrospinal fluid leak, speech/language deficits from temporal lobe retraction, or intracranial hemorrhage. One patient did have evidence of a recurrence of her SCD symptoms on the first side after second-side surgery. Since we adopted the SCD plugging and resurfacing technique, our recurrence rates after SCD surgery have been reduced to less than 5%, although these rates are not zero.

All 4 patients reported relief of their SCD symptoms after second-side surgery. Additionally, all patients expressed that they did not regret having pursued bilateral surgery and that the benefits outweighed the risks and drawbacks. We suggest that patients may benefit from bilateral SCD surgery if they are experiencing significant disability associated with their second-side SCD symptoms. The DHI and SF-36 alone, which do not query about SCD symptoms such as autophony, pulsatile tinnitus, or a distorted perception of one's own voice, may be insufficient to capture the severity of symptoms. The autophony index may serve as a supplementary test (29), although some patients find the distortion of their own voice to be distinct from the perception of its intensity and, thus, even find the autophony index an inadequate measure of their distress. We would advise evaluation of each individual's symptoms in addition to the results of the indices. In addition, we would advise waiting at least 4 to 6 months before performing second-side surgery based on previous research demonstrating that transient global vestibular hypofunction normalizes over this period (14, 15). As our experience and understanding of second-side surgery grows, continued observation is needed to ensure that the preoperative symptoms justify the postoperative risks in all cases.

Limitations of this study include the small cohort size and the lack of complete assessment of all patients. Nevertheless, we conclude from these preliminary data that despite some degree of oscillopsia, patients with disabling bilateral SCD symptoms express satisfaction with having pursued sequential bilateral SCD plugging.

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TABLE 1

Demographic and clinical characteristics of patients with second-side superior canal dehiscence surgery (N = 5)

Patient	Age at presentation (yr)	Sex	Months between first and second surgery	Months since second surgery
1	28	Male	55	49
2	40	Male	12	15
3	36	Female	11	9
4	30	Male	13	8
5	40	Female	19	1

TABLE 2

Symptoms, onset, and severity of symptoms that prompted second-side superior canal dehiscence surgery (N = 5)

Patient	Symptoms	Onset	Severity of symptoms
1	Sound- and pressure-induced vertigo	Delayed	Impairment of activities and functional status
2	Sound- and pressure-induced vertigo	Immediate	Falls resulting in fracture and soft tissue injury
	Autophony, pulsatile tinnitus		
3	Autophony, pulsatile tinnitus	Immediate	Impairment of activities and functional status
4	Pressure-induced vertigo	Immediate	Disability leave from work
	Autophony		
5	Sound-induced vertigo	Delayed	Impairment of activities and functional status
	Autophony, pulsatile tinnitus		