Dizziness Handicap After Cartilage Cap Occlusion for Superior Semicircular Canal Dehiscence

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Objective: To evaluate the change in self-reported dizziness handicap after surgical repair using the cartilage cap occlusion technique in cases of superior canal dehiscence (SCD).

Study Design: Repeated measures, retrospective chart review.

Setting: Tertiary referral center.

Patients: Twenty patients over a 2-year period who underwent surgical repair of SCD using the cartilage cap occlusion technique.

Intervention: Therapeutic.

Main Outcome Measure: Preoperative and postoperative Dizziness Handicap Inventory (DHI) questionnaires were completed (median, interquartile range).

Results: Preoperative (48, 28–56) and postoperative (33, 19–50) total scores were not significantly different. Scores for patients with moderate/severe preoperative DHI scores (DHI, >30; n = 14) demonstrated significant change (p = 0.001, Wilcoxon paired sample test), whereas those with mild scores did not (DHI, ≤30; n = 6; p = 0.67).

Conclusion: Change in DHI score is variable. As described by DHI score, patients with higher preoperative handicap may demonstrate significant improvement after surgery, whereas those with mild handicap may not. These results are similar to previous reports and indicate that the cartilage cap occlusion technique may provide an alternative to middle fossa craniotomy approach for surgical management of symptomatic SCD.

Key Words: Adult—Cartilage cap—Dizziness Handicap Inventory—Superior canal dehiscence.


Superior semicircular canal dehiscence (SCD) syndrome is a collection of sound- and/or pressure-induced symptoms occurring because of the thinning or absence of bone overlying the superior semicircular canal (1). Diagnosis of SCD is based on presenting signs and symptoms, as well as auditory and vestibular test results that suggest inner ear end organ hypersensitivity. Imaging studies are used to confirm the presence of SCD in patients presenting with symptoms consistent with this disorder. Primary symptoms associated with SCD include vertigo and oscillopsia induced by loud sounds or pressure changes (1). Since its initial description, additional symptoms have been reported, including chronic imbalance, pulsatile tinnitus, hearing loss, and autophonia. Clinical findings, such as conductive hyperacusis, low threshold/increased amplitude cervical vestibular-evoked myogenic potentials (cVEMPs), and sound-/pressure-induced vertical-torsional nystagmus in the affected plane have been present in cases of confirmed SCD (2–4).

Although auditory symptoms may be present in SCD, vestibular complaints are commonly reported as significantly debilitating to the patient (2). Resurfacing or plugging of the dehiscent canal, typically using a standard middle fossa craniotomy, is reported to alleviate debilitating vestibular symptoms (5–9). Specifically, Crane and colleagues (9) reported significant improvement in self-reported dizziness handicap after surgical plugging, particularly for patients reporting moderate-to-high levels of preoperative dizziness handicap. Although plugging the dehiscent canal provides reduced SCD-related complaints, it also reduces vestibular function in the repaired canal and risks reduced function throughout the labyrinth (approximately 10%; (10)). To reduce this risk, a transmastoid and tegmen mini-craniotomy approach was developed that uses a cartilage cap over the dome of the dehiscent canal (11). This technique is less involved than the standard middle fossa approach, as it uses a mastoidectomy for canal exposure. A cartilage cap is placed over the dehiscence, avoiding manipulation of the membranous labyrinth and reducing the possibility of surgically induced vestibular dysfunction. It can be completed...
as an outpatient procedure, with no expectation of prolonged hospitalization (35% discharged same day, 65% discharged within 23 hours). The majority of patients treated using this technique have reported improved or resolved dizziness postoperatively (11).

The self-perceived effect of intervention provides an important description of surgical success. Previous work described subjective dizziness improvement in patients treated using the cartilage cap technique but did not use a specific measure to describe the change in dizziness after treatment (11). The purpose of this study was to evaluate the change in self-reported dizziness handicap, as described by the Dizziness Handicap Inventory (DHI) (12), in patients after SCD repair using the cartilage cap occlusion technique and to compare these results to previously reported DHI improvements after surgical plugging using a standard middle fossa craniotomy (9).

MATERIALS AND METHODS

This study was conducted with the approval and oversight of the Mayo Clinic institutional review board (IRB 11-000351). Thirty-five consecutive patients diagnosed with SCD and treated using the cartilage cap occlusion technique (11) between July 2009 and December 2010 were included. All patients reported dizziness as their chief complaint. Patient diagnosis was confirmed using high-resolution computed tomography (CT) with 0.5-mm collimation and reconstruction perpendicular to the superior semicircular canal in accordance with SCD imaging protocol. Objective measures included auditory signs (e.g., conductive hyperacusis) and vestibular test results (e.g., cVEMP amplitude and threshold, positional nystagmus, Tullio phenomenon, Hennebert phenomenon). Surgical candidates were those with high-resolution CT positive for SCD, objective measures, and significant vestibular symptoms.

The surgical procedure has been previously described in detail (11). Briefly, cartilage is harvested from the tragus or concha, and a standard mastoidectomy is performed. After identification of the superior semicircular canal, a small area of tegmen lateral to the superior semicircular canal is removed. The dura is elevated to create a pocket, and the previously harvested cartilage is placed to create a cap over the dome of the superior semicircular canal and the dehiscence. The dehiscence is not generally visualized with this technique.

Preoperative Evaluation

All patients underwent routine history and physical evaluation, as well as audiometric and vestibular testing. Audiometric testing included air- and bone-conducted thresholds, acoustic reflex testing, and tympanometry. Standard vestibular testing included oculomotor testing, videonystagmography, rotational chair, computed dynamic posturography, testing for Tullio and Hennebert phenomenon, and cVEMP (500 Hz toneburst stimuli; 5.1 Hz rate, Blackman gating; 4-ms duration) using our established clinical protocol. Initial cVEMP intensity was 95 dB nHL (120 dB pSPL) and was reduced in 10-dB increments to establish threshold.

Dizziness Handicap Inventory

Self-reported dizziness handicap was quantified using the DHI. The DHI is a 25-item questionnaire used to express the effect of dizziness in everyday life (12). Each item has 3 possible responses, with “yes” scoring 4 points, “sometimes” scoring 2 points, and “no” scoring zero points. DHI total scores range from 0 to 100, with higher scores representing increased self-reported dizziness handicap. Only total score was considered for these analyses, as the construct validity of the historically used subscales has been questioned (13). For these analyses, DHI total scores were categorized as mild (<30 points) or moderate/severe (>30 points) (9,14). Each patient completed a written DHI before preoperative vestibular evaluation. A follow-up DHI was mailed to each patient at least 4 months (range, 4–21 mo) after surgery. All follow-up questionnaires were mailed at one time during the study. Patients who did not return the DHI were called twice to follow up. Scores were described as improved if the total score was reduced by at least 18 points (12).

Statistical Analysis

R statistical software (version 2.12.1) was used to perform nonparametric statistical tests. Patient demographics and DHI scores were reported using median and interquartile range (IQR). Comparisons of continuous variables were made using Wilcoxon paired sample or 2-sample tests. Categorical variables were compared using Fisher’s exact test. Bonferroni correction was used to reduce the risk of familywise error. A significance level of 0.05 was used.

RESULTS

Four patients were excluded because they did not complete a preoperative DHI. Of the remaining patients, 20 returned the written follow-up DHI after surgery (64.5% response rate). The study group included 14 female and 6 male subjects ranging in age from 36 to 80 years (median, 48 yr). All surgeries were unilateral (12 right, 8 left), although 6 patients had evidence of bilateral SCD on CT.

Dizziness Handicap Inventory

For the total group (n = 20), median preoperative DHI score was 48 (IQR, 28–56). Median postoperative DHI score was 33 (19–50). The median change between preoperative and postoperative DHI score (−13, −24 to 2.5) was nonsignificant (p = 0.08, Wilcoxon paired sample test; Fig. 1). Analysis of unilateral SCD patients only did not improve the relationship (p = 0.13). The duration between surgery and obtaining the follow-up DHI did not significantly predict postoperative DHI score (p = 0.29, rs = −.25, Spearman’s rho).

Increased preoperative score was associated with reduced postoperative score (i.e., improvement in DHI score postoperatively; p = 0.02, rs = −0.50; Fig. 2). More specifically, patients with moderate/severe preoperative DHI scores (>30 points, n = 14) demonstrated significant change in total score (p < 0.001, Wilcoxon paired sample test), whereas patients reporting mild preoperative dizziness handicap (<30 points, n = 6) did not (p = 0.67; Fig. 3).

Eight patients demonstrated a significant reduction in score (≥18 points); the remaining 12 reported either no change (n = 8) or increased (n = 4) postoperative DHI score. Of those 8 patients with improved DHI scores, one
had mild self-reported handicap preoperatively (DHI score = 22). The remaining improved patients had preoperative scores greater than 30 points (range, 44–86). For patients demonstrating no change (<±18 total points), 2 patients reported mild preoperative handicap (DHI score = 12, 16). The remaining 6 had scores that ranged from 46 to 92.

Four patients reported worse DHI scores postoperatively. Three patients reported mild preoperative DHI scores (range, 0–30), and one was considered moderate/severe (DHI score = 48). All 4 patients self-reported resolution of preoperative SCD-related symptoms (e.g., chronic imbalance, vertigo induced by loud sounds/pressure changes) at postoperative evaluations. Two of these patients were diagnosed with bilateral SCD, one of whom received surgical repair of the contralateral SCD after completion of this study because of increased SCD-related symptoms. Three patients with mild preoperative DHI scores reported postoperative benign paroxysmal positional vertigo, which was successfully treated with positioning maneuvers. Additional factors may have contributed to worsening dizziness for the fourth patient, including bradycardia, bilaterally detached retinas, and slight caloric weakness (canal paresis = 24%).

**Preoperative Symptoms**

All patients reported dizziness preoperatively, with chronic disequilibrium present in 70% (n = 14; Table 1). The majority of patients (n = 13) demonstrated abnormal sensory organization test results (computerized dynamic posturography). Additional vestibular testing (oculomotor testing, videonystagmography, rotational testing) was nonsignificant between the improved and unimproved groups (p > 0.05, Fisher’s exact test).

CVEMP results were compared for individual patients with unilateral SCD diagnosis only (n = 14). For the surgical side, responses were present for all improved patients. Three absent responses were noted for the nonsurgical side (2 improved, 1 unimproved; age range, 50–63). One unimproved patient demonstrated bilaterally absent cVEMPs (age, 80 yr). Median (IQR) cVEMP amplitude was not significantly different between surgical (152.99 μV, 89.93–260.6) and nonsurgical (184.51 μV, 136.75–251.20) sides (Wilcoxon paired sample test, p > 0.05; Fig. 4). For the surgical side, those who improved (n = 6) demonstrated significantly larger cVEMP amplitude preoperatively (288.12 μV, 245.16–325.56) than those who did not (89.93 μV, 82.26–126.69; p = 0.02, Wilcoxon 2-sample test). No amplitude difference was found between the nonsurgical sides of either group (p = 0.91). Thresholds and latencies were not significantly different between sides. All thresholds fell within the reference range (≥75 dB nHL) for our clinical protocol.

Preoperative auditory complaints, including subjective hearing loss (n = 12), tinnitus (n = 10), aural fullness...
(n = 9), and autophony (n = 6) were commonly encountered in the total group. Preoperative auditory symptoms were reported similarly in patients who reported DHI improvement and in those who did not (p > 0.05, Fisher’s exact test; Table 1). Postoperative auditory complaints were not collected for these analyses.

**DISCUSSION**

SCD syndrome is characterized by auditory and vestibular complaints associated with inner ear end organ hypersensitivity. These complaints may be alleviated with surgical intervention. Traditionally, surgical management of SCD has involved a middle fossa craniotomy and plugging the dehiscent canal, leading to reduced function within the affected canal (10). The cartilage cap occlusion technique used with these patients does not involve plugging or manipulating the membranous labyrinth, which should preserve the function of the canal (11).

In this dataset, preoperative score did not significantly predict the amount of change in postoperative DHI score, which may relate to the small datasets used for the current and previous comparisons. However, the trend in overall score improvement and the significant improvement in scores for those with moderate/severe preoperative dizziness were in agreement with previous work (9). More specifically, our patients with higher preoperative DHI total score demonstrated significant decreases in score postoperatively. Although patients with mild dizziness handicap reported significantly debilitating symptoms, it is possible that additional symptoms (e.g., conductive hyperacusis, anxiety/depression) added to the significant debilitation. These contributions may not be demonstrated by the DHI (15,27). Further review of additional complaints may provide insight on possible significant improvements in patients with mild preoperative dizziness handicap.

Historically, cVEMPs have been used most often to describe patients with SCD (e.g., 9,16,17). However, cVEMPs are highly dependent on the state of the vestibular end organ and the level of muscle contraction used to record the inhibition of muscle firing (18). CVEMPs demonstrate wide amplitude and threshold variability in normal and SCD patients (17). A portion of these inconsistencies may be explained by the variability noted in aging patients. Within our dataset, 1 patient (age = 80 yr) demonstrated bilaterally absent cVEMPs and 3 (ages = 50, 51, and 63 yr) were absent unilaterally. These patients were at risk for reduced or absent responses because of age (19,20) and may not indicate underlying vestibular pathology or add to SCD diagnosis.

For patients with present responses, neither threshold nor amplitude fell significantly outside our clinical normative data. This result is in conflict with previously reported cases, which have demonstrated high amplitudes and low thresholds in SCD (21). However, we must consider that the range of presenting thresholds and amplitudes is large and may not successfully differentiate between healthy patients and those with SCD, especially in patients early in the progression of the disorder or in those with small dehiscenses (17,22). Manzari et al (2012) provided a report illustrating the variability of amplitudes found in patients with documented SCD. These data demonstrated similar amplitude distributions for healthy and SCD-affected sides and that the absence of significant amplitude asymmetry or high amplitude
does not rule out possible SCD. Abnormally low thresholds have also been useful in determining possible SCD cases (5). However, additional confirmed cases have been reported that demonstrate thresholds within the reference range (22). It is possible that protocol differences or the size of the dehiscence may significantly alter our expected cVEMP outcomes (2,22). At this point, the definition of significantly low threshold and large amplitude may not be completely clear because of these variations in individual cases and test protocols.

SCD presents bilaterally in 46% to 60% of patients (17,23). It is unsurprising that significant self-reported dizziness handicap was still evident in patients with bilateral SCD because only unilateral surgical intervention was provided during this study period. However, half of our bilateral cases (n = 3/6) reported significant improvement in DHI score after unilateral repair. It is unclear why these bilateral cases significantly improved when only 1 dehiscent canal was repaired. It is possible that the contralateral side was “anatomic” and treatment of the “symptomatic” SCD provided appropriate symptom relief (11,24). For the remaining 3 unimproved cases, surgical intervention of the contralateral SCD may provide additional symptom relief (15,26). Conversely, given the high presentation of bilateral SCD (17,23), it is possible that imaging missed some cases of bilateral SCD in our unilateral data. Our current ability to appropriately verify SCD diagnosis is limited by imaging technology and may lead to misestimation of SCD (2,17,22,23). These undiagnosed cases would likely influence our ability to predict and document improvement, significantly challenging the surgeon. In the future, refinements in objective tests and improved imaging should alleviate this challenge.

This retrospective analysis was conducted on patients who received surgical intervention for SCD during a 2-year period. Although our response rate was acceptable (65%), the number of subjects does provide a limitation, as it reduces our ability to thoroughly assess available patients. Previous evaluation of this technique found self-reported complete resolution in 78% of patients, with another 14% reporting definite but incomplete improvement in symptoms (11). Because of this variability in self-reported outcome, we must consider that postoperative change was not appropriately captured by the DHI. There seems to be a disconnection between patient self-report and our current metric for obtaining self-reported dizziness information. Obtaining consistent metrics allows for providing appropriate postoperative expectations. Although patients consistently report subjective improvement in symptoms after surgical repair when using both the cartilage cap and standard middle fossa techniques (9,11,25), quantifying this improvement has rarely been conducted.

This study demonstrated that the cartilage cap occlusion technique can lead to reduced self-reported dizziness handicap, particularly in patients with moderate/severe DHI scores. Our DHI score changes are similar to those following surgical repair using the standard middle fossa approach (9), indicating that a less involved surgical option is available for SCD repair. In the future, a more sensitive test battery, including testing for self-reported handicap as well as anxiety/depression measures, may need to be established to better quantify the dizziness handicap experienced by SCD patients.

CONCLUSION

Patients with higher self-reported dizziness handicap were likely to have significant reduction in dizziness postoperatively. While this does not necessarily exclude patients from surgical repair, patients with mild preoperative dizziness handicap may not receive significant reduction in vestibular symptoms as described by the DHI. Investigation of additional symptoms or improved dizziness measurement techniques may assist in predicting postoperative outcomes. The cartilage cap occlusion technique for SCD repair reduced DHI total score similarly to a standard middle fossa approach, providing a less involved surgical option that provides similar outcomes.

Acknowledgment: The authors thank the James Russell and Martha Crawford Endowed Clinical Research Fellowship in Otolaryngology and the Mayo Clinic Florida Clinical Research Internship Study Program for the support.

REFERENCES


