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Original Article

Round Window Reinforcement for Semicircular Canal Dehiscence Syndrome

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BACKGROUND: To evaluate the clinical outcomes and safety profile of round window reinforcement (RWR) as a minimally invasive surgical treatment for patients with semicircular canal dehiscence syndrome (SCDS).

METHODS: This retrospective case series analyzed 7 patients (mean age: 59 years) diagnosed with SCDS who underwent transcanal RWR between June 2024 and June 2025 at the Kopfzentrum Bielefeld. Inclusion criteria followed the Bárány Society consensus diagnostic standards. Clinical symptoms, audiometric findings, and vestibular test results—including Dizziness Handicap Inventory (DHI) scores—were assessed pre- and postoperatively. In 2 patients, endolymphatic hydrops was diagnosed via delayed contrast-enhanced magnetic resonance imaging and monitored postoperatively.

RESULTS: All patients completed follow-up (mean: 35 months). Improvement in auditory symptoms was observed in 5 of 7 patients (71.4%), including tinnitus relief in 83.3% and hyperacusis relief in 75%. Vertigo improved in 50% of symptomatic cases. No postoperative deterioration in symptoms, DHI score, or hearing was observed. Audiometric outcomes showed a non-significant mean change in air-bone gap (±2.5 dB). No intra- or postoperative complications occurred. In patients with concomitant hydrops, auditory improvement was noted, though vertigo persisted.

CONCLUSION: Round window reinforcement appears to be a safe and effective therapeutic option for selected patients with SCDS, particularly those presenting predominantly auditory symptoms or contraindications to more invasive procedures. Further prospective studies are needed to validate these findings and define the role of RWR in the broader surgical management of third window syndromes.

KEYWORDS: Auditory symptoms, endolymphatic hydrops, round window reinforcement, superior semicircular canal dehiscence, third window syndrome, transcanal surgery, vertigo

INTRODUCTION

Canal dehiscence (SCD) syndrome was first described by Lloyd B. Minor in 1998, marking a pivotal advancement in the understanding of vestibular disorders.[1] This clinical entity is defined by a pathological defect in the bony roof of the superior semicircular canal, which establishes an abnormal connection—or so-called "third window"—between the inner ear and the middle cranial fossa. This anatomical anomaly disrupts the normal mechanics of inner ear fluid dynamics and results in a spectrum of vestibular and auditory symptoms.

Patients with SCD typically present with vestibular complaints such as vertigo, nystagmus, and oscillopsia that are provoked either by loud acoustic stimuli (a phenomenon known as Tullio's phenomenon) or by pressure fluctuations in the external auditory canal (Hennebert's sign) or middle ear (e.g., Valsalva maneuvers). In addition, auditory manifestations, including autophony, hypersensitivity to bone-conducted sound (hyperacusis), pulsatile tinnitus, and varying degrees of conductive or sensorineural hearing loss (SNHL), are frequently reported.[1]

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These clinical features can be attributed to the presence of the osseous dehiscence, which alters the inner ear's pressure transmission pathways. Specifically, the acoustic energy normally transmitted from the stapes footplate through the oval window is partially diverted toward the site of the dehiscence—this "third window"—thereby diminishing energy propagation along the cochlear basilar membrane while abnormally stimulating the vestibular end organs.[2]

To address this aberrant physiology, several surgical interventions have been introduced over the years. The earliest technique, also pioneered by Minor, involves resurfacing and/or occlusion (plugging) of the dehiscent superior semicircular canal via a middle cranial fossa craniotomy.[1] As a less invasive alternative, the same procedure may also be carried out through a transmastoid approach, offering reduced intracranial risk and operative time.[3,4] However, both approaches carry a measurable risk of complications: postoperative benign paroxysmal positional vertigo occurs in approximately 25% of cases, and a similar proportion of patients may experience high-frequency SNHL as a sequela of surgery.[5,6]

In an effort to minimize these risks, a novel surgical strategy was proposed by Silverstein in 2014.[7] This method focuses on reinforcing the round window membrane rather than directly addressing the dehiscence. By strengthening the round window, the aim is to neutralize the biomechanical effect of the "third window," thereby restoring more physiological inner ear fluid dynamics and eliminating aberrant vestibular and auditory stimuli.

MAIN POINTS

- Round window reinforcement (RWR) is a safe and minimally invasive alternative:
- The study demonstrates that RWR can be performed without major or minor complications, offering a low-risk option for treating semicircular canal dehiscence syndrome, especially in patients with surgical contraindications.
- Auditory symptom relief is more predictable than vestibular improvement:
- Postoperative outcomes showed marked improvement in tinnitus (83.3%) and hyperacusis (75%), while only 50% of patients with vertigo experienced relief, aligning with existing literature that RWR better addresses auditory symptoms than vestibular complaints.
- No postoperative deterioration observed:
- None of the 7 patients in this case series experienced worsening of symptoms, hearing thresholds, or Dizziness Handicap Inventory scores following RWR, suggesting a strong safety profile and therapeutic potential of the technique.
- Potential benefit for patients with coexisting endolymphatic hydrops:
- In 2 patients with magnetic resonance imaging–confirmed endolymphatic hydrops, auditory symptoms improved postoperatively, though vertigo persisted. This supports considering RWR in select complex cases where dual pathology exists.
- Round window reinforcement may serve as a first-line option before canal plugging:
- Given its simplicity, favorable safety profile, and effectiveness in reducing auditory symptoms, RWR could be considered as an initial intervention before resorting to more invasive surgical options like canal plugging or resurfacing.

The present study aims to assess the clinical and audiological outcomes following round window reinforcement (RWR) in patients diagnosed with canal dehiscence syndrome (CDS). Through this analysis, it was sought to evaluate the therapeutic efficacy and safety profile of this less invasive surgical option in comparison with more traditional canal plugging procedures.

METHODS

Between June 2024 and June 2025, a total of 7 patients diagnosed with superior semicircular canal dehiscence syndrome (SCDS) underwent RWR at the Kopfzentrum Bielefeld. The cohort consisted of 5 male and 2 female patients, with a mean age of 59 years (range: 49-74 years). Notably, in 2 of these cases, preoperative magnetic resonance imaging (MRI) revealed additional evidence of endolymphatic hydrops. For these patients, a contrast-enhanced MRI using intravenous gadolinium was performed 4 hours post-infusion, both before and after surgical intervention, in order to evaluate changes associated with hydrops. This study was approved by the Ethics Committee of Kopfzentrum Bielefeld(approval number: #001-2025, February 2, 2024). Written informed consent was obtained from the patients for publication of this case report and accompanying images. s

All patients included in the study met the diagnostic criteria for CDS as outlined in the consensus document from the Committee for the Classification of Vestibular Disorders of the Bárány Society.[8] According to these internationally recognized criteria, a diagnosis of CDS requires fulfillment of the following 3 categories:

A. Clinical symptoms: At least 1 symptom indicative of third mobile window physiology must be present. These include:
    1. Hyperacusis to bone-conducted sounds
    2. Vertigo and/or oscillopsia induced by sound stimuli (Tullio phenomenon)
    3. Vertigo and/or oscillopsia induced by pressure changes (Hennebert sign or Valsalva-induced)
    4. Pulsatile tinnitus
B. Physiological signs or tests: At least 1 objective test must demonstrate evidence of abnormal pressure transmission via a third window. Accepted tests include:
    1. Eye movements aligned with the plane of the affected superior semicircular canal elicited by sound or pressure stimulation.
    2. Abnormally low bone conduction thresholds in low frequencies on pure-tone audiometry.
    3. Enhanced vestibular evoked myogenic potentials (VEMPs), either with low cervical thresholds or elevated ocular amplitudes.
C. Imaging findings: A high-resolution computed tomography (CT) scan with multiplanar reconstruction must demonstrate a dehiscence of a semicircular canal (Figure 1).

Only patients who satisfied at least 1 criterion in each of these 3 categories (clinical symptoms, physiologic testing, and imaging confirmation) were included in the study population.

For all 7 patients, both audiometric outcomes and subjective symptom control were assessed preoperatively and postoperatively. Symptom severity and impact were evaluated using the DHI scoring

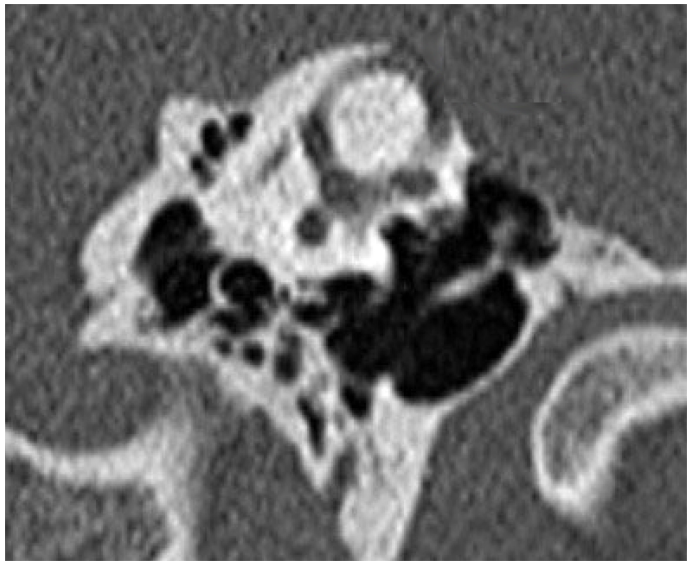

Figure 1. High-resolution computed tomography scan showing a left superior semicircular canal dehiscence.

system. In the 2 patients with MRI-confirmed hydrops, follow-up gadolinium-enhanced MRI using the identical 4-hour delayed protocol was repeated after surgery to assess potential anatomical and fluid dynamic changes.

Surgical Technique

All patients underwent transcanal RWR under general anesthesia. The procedure began with local infiltration of an anesthetic into the external auditory canal. Two vertical canal incisions were made at the 6 o'clock and 12 o'clock positions, followed by elevation of a standard tympanomeatal flap.

Careful attention was paid to preserve the chorda tympani nerve whenever feasible. In cases where greater exposure of the middle ear was necessary, the posterior bony wall of the external auditory canal was gently curetted to improve visualization of critical structures, including the ossicular chain, the round window niche, the chorda tympani, the facial nerve, and the hypotympanum.

Once adequate exposure was achieved, the mucosa covering the round window niche was meticulously removed using a fine micro pick to optimize graft adherence and integration. A small, autologous soft tissue graft—most commonly harvested from periauricular fascia—was then carefully positioned over the round window membrane. In selected cases, perichondrium was used as an alternative grafting material.

The tympanomeatal flap was re-approximated to its anatomical position, and the tympanic membrane as well as the external auditory canal were covered with multiple protective layers of silicone sheeting. The canal was then filled with resorbable gelfoam to support the flap and ensure stable positioning of the graft during the healing process for a week.

RESULTS

This retrospective case series includes 7 patients diagnosed with superior SCDS, who underwent RWR at the Kopfzentrum Bielefeld. Of the 7 patients, 5 were male and 2 were female. The mean age at the time of surgery was 59 years, with patient ages ranging from 49 to 74 years.

The mean follow-up duration for the last clinical examination was 35 months (range: 3-78 months). Two patients in the cohort demonstrated radiological signs of concomitant endolymphatic hydrops on MRI.

With respect to presenting symptoms, the most common preoperative complaint was vertigo, reported by 6 out of 7 patients (85.7%). This was followed by tinnitus (6/7, 85.7%) and hyperacusis (4/7, 57.1%). Following RWR surgery:

- Three out of 6 patients with preoperative vertigo (50%) experienced a noticeable improvement.
- Five out of 6 patients with tinnitus (83.3%) reported subjective amelioration of their symptoms.
- Three of 4 patients with hyperacusis (75%) noted symptomatic relief.

Importantly, none of the patients experienced a worsening of their symptoms postoperatively, even in cases where full resolution was not achieved.

No major postoperative complications occurred in this series. In particular, there were no cases of facial nerve injury, SNHL, or intracranial complications. Minor complications were also not observed.

The mean time to the most recent audiological evaluation post-surgery was 26 months (range: 3 to 60 months). Audiological outcomes indicated improvement in air conduction thresholds and reduction in air-bone gap (ABG) in 4 patients, with a mean ABG decrease of 2.5 dB (range: 1.5-5 dB). Conversely, 3 patients exhibited mild deterioration in air conduction postoperatively, with a mean increase in PTA (Pure ton audiogram) air conduction of 2.5 dB (range: 1.25-3.75 dB). Importantly, no patient experienced a change exceeding 5 dB in either direction, and the overall pre- to postoperative difference in hearing thresholds was not statistically significant.

Regarding the 2 patients with coexisting endolymphatic hydrops, both reported improvement in hyperacusis and tinnitus following surgery. However, vertigo symptoms persisted in both cases, which was corroborated by postoperative DHI scores. Notably, one of these patients demonstrated normalization of cervical vestibular evoked myogenic potential (cVEMP) testing postoperatively compared to a previously pathological result. Follow-up MRI performed 12 months after surgery revealed no significant changes in the degree or extent of hydrops in either patient.

The DHI survey was completed at a mean of 35 months following surgery (range: 3 to 78 months). The average preoperative DHI score was 38. Postoperative assessments demonstrated improved scores in 3 patients, while the remaining 4 patients showed no change. No patient reported a worsening in DHI score after the intervention. The mean postoperative DHI score across the cohort was 36.

Due to the retrospective nature of the study, complete data sets were not available for all patients. Nevertheless, based on available records

and subjective patient reports, 5 of 7 patients experienced improvement in auditory symptoms, and 3 of 6 patients with preoperative vertigo reported clinical benefit. One patient showed objective resolution of cVEMP abnormalities postoperatively. Notably, none of the patients experienced a deterioration in their condition, expressed a desire for procedural reversal, or required further surgical intervention, either at the center or elsewhere.

DISCUSSION

Canal dehiscence syndrome remains a challenging and often underdiagnosed condition within neurotology. Despite increasing recognition over the past 2 decades, it is still frequently misinterpreted due to its overlapping symptomatology with other vestibular and auditory disorders. Moreover, universally accepted diagnostic criteria have only recently been established by the Bárány Society, and implementation remains inconsistent across clinical practices.

High-resolution CT imaging is essential for diagnosing CDS, as it provides definitive anatomical visualization of the bony dehiscence. However, CT is not routinely ordered for patients presenting with vertigo, leading to underdiagnosis or misdiagnosis. In this series, 2 patients demonstrated concurrent SCD (superior canal dehiscence) and endolymphatic hydrops—a dual pathology that further complicates the clinical picture and has been only rarely described in the literature. The presence of SCDS should be systematically considered in cases of medically refractory hydrops.[9]

Magnetic resonance imaging has emerged as a valuable adjunctive tool in the evaluation of patients with SCD syndrome, especially in those being considered for revision surgery. MRI provides functional and fluid dynamic insights that complement anatomical information from CT. Specifically, a 4-hour post-gadolinium delayed MRI can be useful for detecting endolymphatic hydrops. Additionally, vestibular function testing plays a crucial role in the preoperative assessment. Caloric testing evaluates the residual function of the superior vestibular nerve, while cVEMPs primarily assess inferior vestibular nerve function. In patients with bilateral SSCD (superior semicircular dehiscence), it is particularly important to determine the functional reserve of the operated ear prior to considering surgical intervention on the contralateral side.[10]

The co-occurrence of CDS and endolymphatic hydrops has been reported in a 2020 case series by Johanis et al,[11] who described 3 patients exhibiting persistent or recurrent symptoms following successful surgical repair of CDS. This diagnostic overlap highlights a critical clinical challenge, as symptoms may be attributed to either or both underlying conditions. For patients presenting with a history of vertigo, the internal auditory canal (IAC) MRI remains a standard imaging modality, primarily used to rule out vestibular schwannoma.[12] A combined approach utilizing both CT and inner ear MRI is advocated in all patients with unexplained vestibular or auditory symptoms, particularly when the initial diagnostic work-up is inconclusive. In such cases, MRI of the IAC should be strongly considered.

A variety of surgical techniques have been developed to address CDS, including transmastoid and middle cranial fossa approaches for resurfacing, capping, or canal plugging. While effective, these procedures carry inherent risks. Middle cranial fossa surgery involves craniotomy and temporal lobe retraction, which may result in SNHL, especially in revision cases or in patients with a history of stapedectomy.[13] Additionally, canal occlusion via either approach carries a small but significant risk of inducing global vestibular hypofunction and further hearing deterioration.[14]

In response to these concerns, Silverstein proposed the RWR technique as a minimally invasive alternative.[7] This approach involves reinforcing the round window membrane to reduce abnormal fluid shifts caused by the third window effect, without the need for direct intervention on the superior canal. The RWR technique is simpler, can be performed under local anesthesia, and has not been associated with major complications. Nevertheless, its clinical outcomes—especially in terms of vestibular symptom resolution—are variable and less predictable than those achieved through canal plugging.

These results are consistent with existing literature, which suggests that RWR tends to yield better control of auditory symptoms (e.g., tinnitus, hyperacusis) than vestibular complaints such as vertigo.[15] In selected cases, however, vertigo may also resolve, and normalization of cVEMPs can occur postoperatively.[16] Despite conflicting evidence and some authors questioning the utility of this approach, it is believed that RWR remains a valuable first-line option—particularly in patients with bilateral disease, significant comorbidities, or contraindications to general anesthesia.

Importantly, failure of RWR does not preclude subsequent definitive treatment. In such cases, transmastoid or middle fossa canal resurfacing or plugging may still be offered. Currently, most data on RWR are limited to case reports and small series. Limitations of this study include its retrospective design, small sample size, and reliance on subjective outcome measures, as there is no validated questionnaire specific to SCD syndromes. Nevertheless, the absence of any postoperative deterioration in the series is noteworthy.

CONCLUSION

In conclusion, further prospective studies with standardized diagnostic and outcome metrics are warranted to clarify the role of RWR within the broader therapeutic landscape for CD syndromes. The findings support its use as a safe, low-risk option for selected patients, with particular benefit for those experiencing predominantly auditory symptoms.

Data Availability Statement: Datasets generated during the current study are available from the corresponding author upon reasonable request.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Kopfzentrum Bielefeld (Approval no: #001-2025, Date: February 6, 2024).

Informed Consent: Written informed consent was obtained from the patients who agreed to take part in the study.

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