

# Surgical exposure of the internal auditory canal through the retrosigmoid approach with semicircular canals anatomical preservation

Avaliação da exposição do fundo do conduto auditivo interno através do acesso retrosigmóide-transmeatal

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## ABSTRACT

**Objective:** Evaluate the feasibility of an adequate exposure with anatomical preservation of labyrinth structures through retrosigmoid transmeatal approach (RSA) in surgeries for resection of acoustic neuromas/vestibular schwannomas (VS). **Method:** Thirty patients underwent surgical resection and were preoperatively evaluated with fine slice high definition CT scans and 3D-MRI volumetric reconstructions. Extension of internal auditory canal (IAC) opening during surgery was measured using 3 mm right-angle calibrated hook and neuronavigation parameters. Postoperatively, the extension of IAC opening and integrity of the labyrinth were confirmed through preoperatively images procedures. **Results:** The preoperative length of IACs varied between 7.8 and 12.0 mm (mean 9.3 mm, SD 0.98, 95%CI 8.9 to 9.6, and median 9.0 mm). Postoperative images demonstrated adequate opening of the IAC and semicircular channels integrity. **Conclusion:** A complete drilling of the posterior wall of IAC through the RSA is feasible and allows direct visualization of the IAC-fundus without damaging the semicircular canals.

**Keywords:** acoustic neuroma, retrosigmoid approach, internal auditory canal, hearing preservation, microsurgery.

## RESUMO

**Objetivo:** Avaliar a possibilidade de exposição adequada preservando anatomia das estruturas labirínticas pelo acesso retrosigmóide-transmeatal (RSA) nas ressecções de schwannomas do vestibular (VS). **Método:** Trinta pacientes foram submetidos à ressecção cirúrgica e avaliados no pré-operatório com tomografias de alta definição e reconstruções de ressonância magnética 3D. A extensão da abertura do conduto auditivo interno (CAI) foi medida e confirmada com parâmetros de neuronavegação. No pós-operatório, a extensão da abertura e a integridade do labirinto foram confirmadas por imagens de tomografia computadorizada. **Resultados:** A extensão do CAI no pré-operatório apresentou variação de 7,8-12 mm (média 9,3 mm, DP 0,98, IC95% de 8,9-9,6 e mediana 9 mm). Imagens pós-operatórias demonstraram abertura adequada do IAC e integridade dos canais semicirculares. **Conclusão:** A abertura completa da parede posterior do CAI pelo RSA é possível e permite a visualização direta do fundo do conduto sem prejudicar os canais semicirculares.

**Palavras-chave:** neurinoma do acústico, acesso retrosigmóide, meato acústico interno, preservação auditiva, microcirurgia.

Development of better imaging techniques has allowed diagnosis of small vestibular schwannoma (VS) and has changed the indications and objectives of surgical treatment of these tumors<sup>1,2,3</sup>. Complete removal and preservation of cochlear nerve function became a goal to be achieved in patients presenting preoperatively with functional hearing. Usually VS extend within the internal auditory canal (IAC) and may reach its fundus. Adequate exposure of this region is necessary to achieve total resection and preserve the cochlear and facial nerves<sup>1,2</sup>. Choice of surgical approach is

important to preserve the labyrinth and hearing<sup>1,4</sup>. Damage of the semicircular canals as well as of the vestibule and endolymphatic sac during opening of the IAC has been implicated as one of the causes of hearing loss after the retrosigmoid transmeatal approach (RSA).

The labyrinthine block is located laterally to the IAC and to avoid injury of these structures, some neurosurgeons do not open the IAC until its fundus<sup>4,5</sup>. If this portion of the IAC is not adequately exposed, an incomplete tumor resection may be performed and tumor recurrence may occur<sup>1,6,7</sup>.

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**Conflict of interest:** There is no conflict of interest to declare.

Received 16 June 2014; Received in final form 09 December 2014; Accepted 29 December 2014.

Knowledge of IAC microsurgical anatomy is very important to achieve functional preservation of VII and VIII cranial nerves in VS surgery<sup>8,9,10</sup>. Despite of advances in microsurgical techniques and intraoperative monitoring, the rates of hearing preservation after VS surgery in recent series has not significantly changed<sup>10,11,12,13</sup>.

The best surgical approach to obtain adequate exposure of the IAC and achieve total removal of VS is still controversial. Ear, nose throat (ENT) surgeons use mainly the translabyrinthine approach to resect larger tumors and the middle fossa approach for small VS. Some authors state that these two approaches are the only capable to provide adequate exposure of IAC-fundus. Neurosurgeons preferentially remove VS of all sizes through the RSA. Total tumor removal with anatomical and functional preservation of the cochlear nerve through the RSA has been reported by many authors<sup>1,3,6,11,14</sup>.

This prospective clinical study was carried out to evaluate the extension of IAC exposure through the RSA with anatomical preservation of the semicircular canals in surgeries of VS.

## METHOD

From January 2008 to May 2010, 71 patients harboring VS underwent surgical resection through the RSA in the dorsal (mastoid) position by the senior neurosurgeon. To evaluate the extension of IAC exposure through the RSA and the anatomical preservation of the semicircular canals, irrespective the pre or postoperative hearing status, 30 consecutive patients were prospectively studied. Before starting data collection permission from the Ethics Committee in Research of the Neurological Institute of Curitiba, Brazil was obtained (Protocol 030/08). The participating patients received a consent form as requested by the National Health Council, Decree no. 93.933 describing the details and research purposes. The study included patients of both sex, regardless of age, with diagnosis of VS irrespective the size of the lesion.

### Preoperative imaging evaluation (Stage 1)

The day before surgery the patients were submitted to fine slice (0.6 mm) CT-scan with volumetric reconstruction of the skull and IAC. All examinations were performed by the same radiologist. All measurements of IAC length (from the entrance until its fundus) was performed by the same neurosurgeon and confirmed by the radiologist (Figures 1 and 2). For navigation guidance fusion of CT-scan images with preoperative MRI were performed according to the following protocol: gradient echo in T1 (minimum YOU, TR 350, NEX 4,00, matrix 256x224, FOV 24, thickness 2.0mm, GAP 0.3), before and after endovenous administration of paramagnetic contrast and 3D CISS (FIESTA) T2-weighted images (minimum YOU, TR 4, NEX 2,00, matrix 256x256, FOV 24,

thickness 0.8 mm, GAP 0) for the evaluation of the extension of tumor invasion of the IAC (Figure 3). The images were recorded in a CD-ROM in DICOM and after preoperative planning in the workstation exported to navigation (BrainLab<sup>®</sup>) for intraoperative guidance.

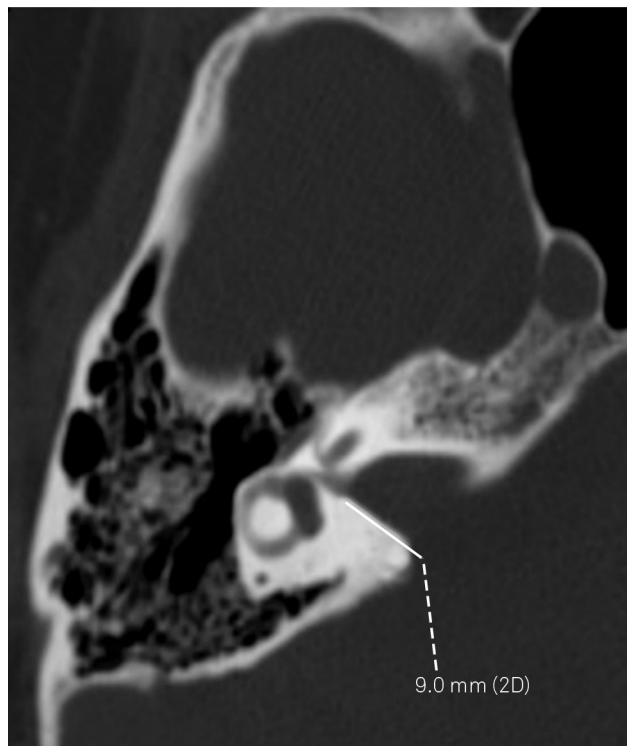


Figure 1. Axial CT scan demonstrating the length of the IAC measured from the edge of the posterior wall until its fundus.

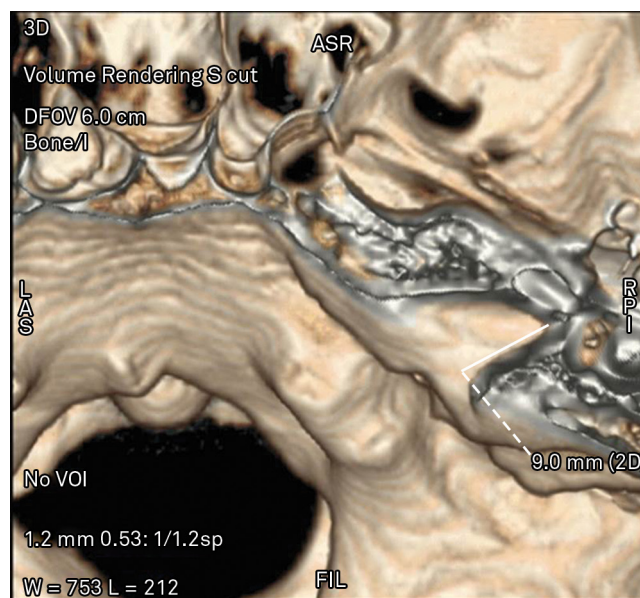


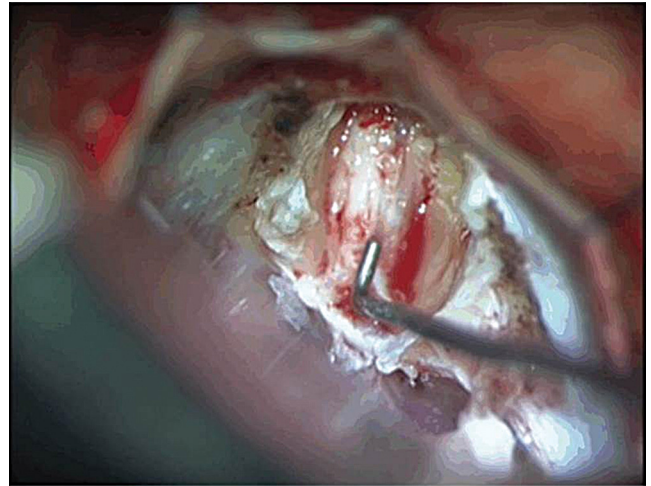
Figure 2. 3D CT reconstruction of the IAC demonstrating the measured length of the IAC. Superior view.



**Figure 3.** Heavy T2 weighed images (FIESTA) of the cerebellopontine angle. Axial slice demonstrating the intracanalicular portion of a VS (arrow) as well as the labyrinthine block in the depth of the IAC (red circle).

### Intraoperative measurements (Stage 2)

Surgery was carried out in dorsal position with the head rotated to the opposite site with light flexion of the chin and facial nerve and cochlear nerve monitoring. After registration of navigation parameters the transverse and sigmoid sinuses were drawn over the skin. MRI-guided navigation accurately identifies the position of the transverse and sigmoid sinus, reducing the rates of venous injury during the retrosigmoid craniotomy<sup>15</sup>. The cerebellomedullary cistern was drained and the cerebellopontine angle exposed through the retrosigmoid approach. In larger tumors the extracanalicular portion was initially resected, to expose the posterior IAC wall. The dura mater over the posterior IAC wall was coagulated and incised in a circular shape. A pedicle dural flap was dissected from the posterior IAC bony wall and rotated down over the jugular foramen. The IAC was drilled with high speed cutting drills, followed by diamond burrs of different sizes, under constant irrigation. The drilling was performed in a medial to lateral direction, towards the fundus of the IAC. The extension of IAC drilling was measured using a 3 mm calibrated right-angle hook (Figure 4). Further confirmation of IAC drilling length was checked with neuronavigation parameters (Figure 5). These data were recorded. Total removal of intracanalicular portion of tumor was accomplished.



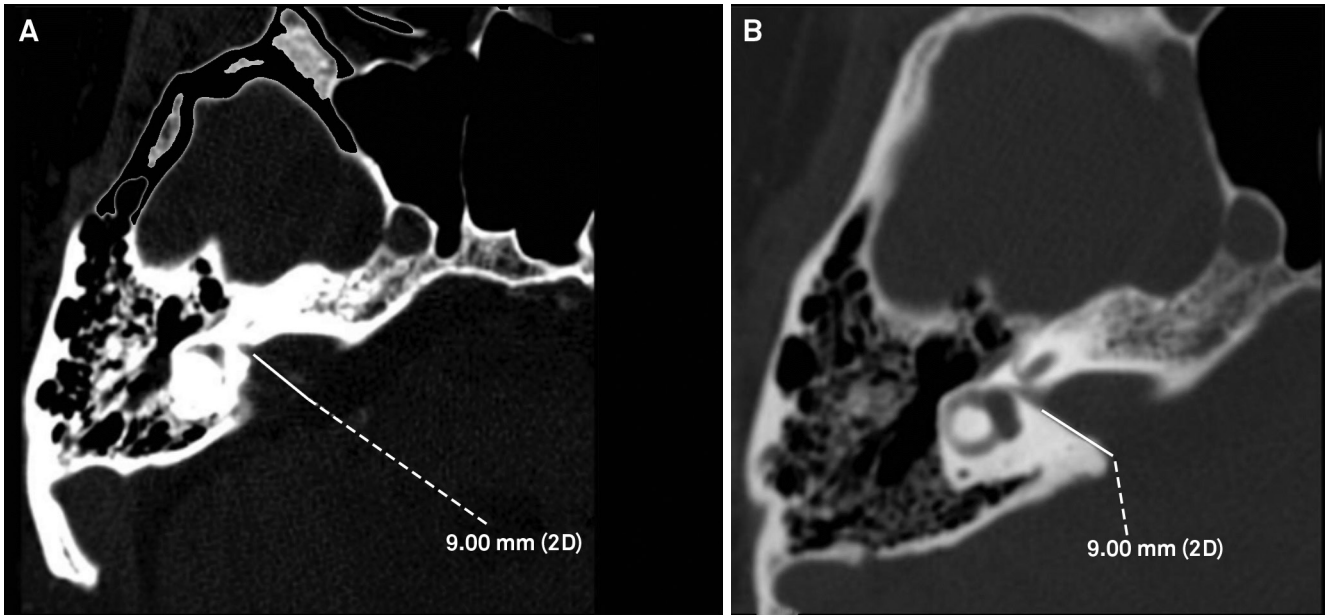
**Figure 4.** The extension of IAC drilling was measured using a 3 mm calibrated right-angle hook.



**Figure 5.** Length of IAC drilling checked with neuronavigation parameters.

### Postoperative imaging evaluation (Stage 3)

Postoperatively ( first 3 days after surgery) all patients were submitted to imaging evaluation with CT and MRI following the same preoperative protocol. The extension of IAC opening and integrity of the labyrinth structures were evaluated at the workstation and 3D reconstructions were performed. In Table the pre- and intraoperative IAC measures are demonstrated. The postoperative image findings were compared with the preoperative and the intraoperative measurements to check the extension of IAC opening and integrity of semicircular canals (Figure 6).



**Figure 6.** Postoperative image findings (A) were compared with the preoperative (B) showing complete opening of IAC and integrity of semicircular canals.

**Table.** List of the 30 cases included in the study demonstrated the accordance between pre- and intraoperative measurements.

Case	Stage 1 (mm)	Stage 2 (mm)
1	9	9
2	9.8	10
3	10	10
4	9.5	9.5
5	8.7	9
6	9	9
7	8	8
8	8.2	8.5
9	10	10
10	9.8	10
11	8.6	9
12	8.5	8.5
13	9.3	9.5
14	12	12
15	12	12
16	9	9
17	9.1	9.5
18	7.8	8
19	8.2	8.5
20	10.2	11
21	8.6	9
22	10.2	10.5
23	10	10
24	9	10
25	9	9
26	8.8	9
27	9	9
28	9.2	9.5
29	8.9	9
30	9	9

## RESULTS

The average age of the patients was 52.1 years, being 11 men (36.7%) and 19 women (63.3%). The vestibular schwannomas operated in this study were: 6 intrameatal tumors (T1), 9 small intra-extrameatal tumors (T2), 13 medium-sized tumors (T3) and 2 tumors with brainstem compression or even dislocation (T4). The preoperative images (Stage 1) demonstrated that the size of IAC varied between 7.8 and 12.0 mm (Mean: 9.3 mm, SD: 0.98, 95%CI: 8.9 to 9.6, and Median: 9.0 mm). Adequate exposition of the IAC and its fundus, as measured in preoperative images, was assured with the intraoperative measurements (Table) and neuronavigation confirmation (Stage 2) in all cases. There was no violation of the labyrinthine block as demonstrated by 3D reconstruction of postoperative images (Stage 3).

## DISCUSSION

There are considerable discussions in the surgical literature regarding the best approach for surgical resection of VS. One of the main factors which influence the choice of the approach is the status of preoperative hearing. The retrosigmoid and the middle fossa are the two most commonly used attempting to preserve hearing. The middle fossa approach has been mainly used for small tumors but a variable fraction of the exposure of the fundus of the IAC may remain not visible due to the transverse ridge. A study has shown that in approximately 25% of the cases the lower portion of the fundus of the IAC remains hidden by the transverse crest requiring some degree of blind dissection to resect VS involving the fundus<sup>16</sup>.

The RSA has the advantage of providing adequate surgical exposure for all tumor sizes with direct control of the vessels and nerves at the cerebellopontine angle and early identification of the intracanalicular portion of facial and vestibulo-cochlear nerves. Preservation of hearing is possible using this approach. Some authors (mainly ENT surgeons) claim as drawback of this approach the impossibility of complete exposure of the fundus of the IAC without damaging the semicircular canals<sup>4,17,18,19</sup>. Injury of the labyrinth structures during posterior IAC wall drilling may cause deafness even with preservation of cochlear nerve. Residual tumor and tumor recurrence are most frequent in the lateral portion and at the fundus of the IAC<sup>20,21</sup>. Direct visualization of this IAC segment is important for total tumor removal and nerves preservation. There are no precise anatomical landmarks allowing identification of the labyrinth structures in the temporal bone. Some neurosurgeons choose not to open the IAC completely to avoid possible hearing loss due damage to the semicircular canals, even with the possibility of leaving residual tumor<sup>21,22</sup>.

Some anatomical and radiological studies suggested the impossibility of exposing the fundus of the IAC without violating the semicircular canals, the vestibule or the endolymphatic sac<sup>23,24</sup>. A study recommends leaving about 32% of the lateral portion of the IAC without manipulation to avoid compromising the labyrinth structures<sup>25</sup>. The endolymphatic duct is also located near to the IAC-fundus and damage to this structure may cause in long-term hearing deterioration<sup>25,26</sup>. Anatomical variations may be induced by the tumor itself<sup>22</sup>.

Anatomic and clinical studies have demonstrated the possibility of exposure of the fundus of IAC through the RSA approach with preservation of the labyrinth<sup>27,28</sup>. Kartush et al. in an anatomical study with 32 specimens, using a surgical microscope and mimicking the surgical position, have showed that it was possible to obtain a direct view of the transverse crest and the vestibular nerves in all areas of the exposure, without compromising the bony labyrinth<sup>28</sup>. In order to obtain such results, the drilling of the posterior wall of the IAC did not extend laterally to the transverse crest. This study was conducted in anatomic fixed specimens and the reliability and real correlation with the viewing angles of the posterior wall of the IAC during surgery may be questionable. Usually there is more cerebellar retraction in approaches using anatomic specimens than in real surgery.

Mazzoni et al. have proposed a modification in the RSA to achieve complete exposure of IAC-fundus without damaging the labyrinth structures<sup>29</sup>. These authors performed a wide

retrosigmoid craniotomy, removal of the whole portion of the perimeatal petrous bone up to the blue line of the labyrinth, not exposing the quadrant of the superior vestibular nerve allowing tumor dissection under a direct visual control. No patients in this series presented either hearing loss or tumor recurrence at three years of follow-up<sup>29</sup>. It was, however, a retrospective study in which no postoperative exam was used in order to demonstrate the opening of the full length of the IAC as well as the integrity of the labyrinthine structures.

Recent studies have shown the use of endoscopy and navigation in VS surgery through the RSA to preserve labyrinth integrity<sup>21,30</sup>. Drilling of the IAC was performed with aid of CT based navigation images and the lateral portion of the IAC was opened with endoscope. It was observed that the use of endoscopy and navigation through RSA approach maximized the exposure of the IAC-fundus without injury to the labyrinth<sup>21,30</sup>.

In our series 30 patients with VS operated through the RSA in dorsal position were prospectively studied to determine the extension of IAC drilling and the integrity of the semi-circular canals. In Table the pre- and intraoperative data are demonstrated. Neuronavigator was used only to demonstrate the range of the ICA-fundus in stage 3 and it has proved to be very useful. Opening of the entire IAC with anatomical preservation of the semi-circular canals was possible in all cases. Although all patients in this study remained with preserved hearing after surgery, we do not evaluated then with audiometry, as this will be done in a subsequent study. The main objective was to demonstrate that the complete opening of the ICA was feasible without the destruction of the labyrinthine block, leading to deafness.

According to our experience some factors were decisive to achieve better exposure and visualization of the IAC-fundus. The positioning of patient (dorsal position with light flexion and rotation of the head to the opposite side), wider craniotomy and opening of the cerebello-medullary cistern increased the angle of view of the posterior and lateral wall of the IAC. Using this positioning there was no cerebellar retraction and small tumors may be operated on without any retractor. Drilling of the posterior IAC-wall should not exceed the limit of the transverse crest.

In conclusion, this prospective study has demonstrated that complete drilling of the posterior wall of IAC through the RSA is feasible and allows direct visualization of the IAC-fundus without damaging the semicircular canals. Radical removal of the intracanalicular portion of VS reaching the IAC-fundus can be performed without blind dissection.

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