



## Retrosigmoid endoscopic keyhole for vestibular schwannomas: systematic review and meta-analysis

*Keyhole* endoscópico retrosigmoideo para schwannomas vestibulares: revisión sistemática y metaanálisis

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### ABSTRACT

**Introduction:** The development of endoscopy for vestibular schwannomas in recent decades offers a panoramic view of the structures of this location that is superior to microscopic vision.

**Objective:** To specify role of the retrosigmoid endoscopic keyhole in vestibular schwannomas.

**Method:** The search was developed in Medline. The following terms in English with Boolean operators were used: "vestibular schwannoma" OR "acoustic neurinoma" AND "keyhole approach" OR "endoscopic resection" OR "endoscopy". Spanish and English language restriction was used. Editorial articles, letters to the editor, books, single case presentations, reviews, meta-analyses, and those with

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poor method were excluded; also articles on anatomical specimens. The Major package of the Jamovi software was used to perform a single-arm meta-analysis of total resection and "acceptable" post-surgical facial function, and estimate the overall effect.  $I^2$  greater than 75% was taken as high heterogeneity.

**Results:** Eight articles were chosen for the study. In the analysis of total resection, it is estimated at 0.84 for a p-value less than 0.01. It was similar in the case of preservation of "acceptable" facial function, with 0.77. In a subgroup analysis, those series where the diameters of the tumor lesion were greater than 3 cm showed less preservation of facial function. The anatomical preservation of the facial nerve was less than 90% in two series.

**Conclusions:** The retrosigmoid endoscopic keyhole is an effective and safe technique in vestibular schwannomas. Studies in this regard reveal relative success, with acceptable rates of anatomical and functional preservation of the facial nerve.

**Keywords:** endoscopy; retrosigmoid craniotomy; vestibular schwannoma.

## RESUMEN

**Introducción:** El desarrollo de la endoscopia para los schwannomas vestibulares en las últimas décadas ofrece una visión panorámica de las estructuras de esta localización, superior a la visión microscópica.

**Objetivo:** Especificar el papel del *keyhole* endoscópico retrosigmoideo en los schwannomas vestibulares.

**Método:** La búsqueda se desarrolló en Medline. Se utilizaron los siguientes términos en inglés con operadores booleanos: "*vestibular schwannoma*" OR "*acoustic neurinoma*" AND "*keyhole approach*" OR "*endoscopic resection*" OR "*endoscopy*". Se utilizó restricción de idioma español e inglés. Se excluyeron artículos editoriales, cartas al editor, libros, presentaciones de casos únicos, reseñas, metanálisis y aquellos con método incorrecto; también artículos con especímenes anatómicos. Se utilizó el paquete Major del software Jamovi para realizar un metanálisis de un solo brazo, de la resección total y la función facial posquirúrgica "aceptable", y estimar el efecto general. Se consideró heterogeneidad alta un  $I^2$  superior al 75 %.

**Resultados:** Se eligieron ocho artículos para el estudio. En el análisis, la resección total se estimó en 0,84 para un valor de p inferior a 0,01. Fue similar en el caso de la preservación de la función facial



"aceptable", con 0,77. En un análisis de subgrupos, aquellas series donde los diámetros de la lesión tumoral eran mayores a 3 cm mostraron una menor preservación de la función facial. La preservación anatómica del nervio facial fue inferior al 90 % en dos series.

**Conclusiones:** El *keyhole* endoscópico retrosigmoideo es una técnica efectiva y segura en schwannomas vestibulares. Los estudios al respecto revelan un éxito relativo, con tasas aceptables de preservación anatómica y funcional del nervio facial.

**Palabras clave:** craneotomía retrosigmoidea; endoscopia; schwannoma vestibular.

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## INTRODUCTION

Vestibular schwannomas, also known as neuromas or acoustic neuromas, are benign lesions resulting from the exaggerated proliferation of Schwann cells of the eighth cranial nerve between the central and peripheral myelin sheath. They are responsible for 6-10% of primary intracranial tumors, and at 71-90% of tumors of the cerebellopontine angle. They are frequent in the fourth and fifth decade of life and about two times more frequent in women than in men.<sup>(1)</sup> There are two different types of presentation: sporadic and hereditary (frequently bilateral in these cases and associated with type 2 neurofibromatosis).<sup>(2)</sup>

Many patients can remain asymptomatic for a long period of time. Direct compression of the tumor on nearby neurovascular structures generally causes related symptoms and signs. Symptoms include progressive hearing loss, as well as vertigo, tinnitus, cerebellar and cranial nerve dysfunction, and secondary obstructive hydrocephalus. The site of origin, the vector of growth, and the size of the tumor are closely related to this entire clinical spectrum.<sup>(3)</sup>

In recent years, the development of imaging techniques, together with intraoperative neurophysiology, have made it possible to focus the objectives of surgery for this lesion on functional preservation beyond tumor resection and survival.<sup>(4)</sup>

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The vast majority of neurosurgeons are familiar with retrosigmoid craniectomies for cerebellopontine angle lesions, especially vestibular schwannomas.<sup>(1)</sup> However, postoperative headache, cerebrospinal fluid (CSF) leaks, and complications related to wound, are relatively frequent in this procedure, which have been minimized with a minimally invasive approach.<sup>(1,3)</sup>

The development of endoscopy in recent decades offers a panoramic view of the structures of the cerebellopontine angle that is superior to microscopic vision.<sup>(5)</sup> This has led to the use of a keyhole in tumor lesions in the region, using the optical advantage endoscopy through a narrow anatomic corridor.<sup>(6)</sup> However, some authors have highlighted a significant decrease in the necessary maneuverability in large-diameter lesions, since the corridor would be occupied by surgical tools and the optical lens (in cases of use of the four-hand technique, this can be enhanced difficulty).<sup>(7)</sup>

However, the use of a two-dimensional endoscopic image can be difficult for surgeons who are familiar with microscopic three-dimensional vision. Facial preservation and tumor resection, two main goals of surgery, can be hampered by both factors.<sup>(8)</sup>

With this purpose, it was developed a systematic search of the medical literature to identify and include articles, following the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) Statement Guidelines<sup>(9)</sup> (Complementary File) with the objective to specify role of the retrosigmoid endoscopic keyhole in vestibular schwannomas.

## METHODS

The search was developed in Pubmed/Medline. In addition, gray literature sources were used: Google Scholar and the MedRxiv preprint server (last update on August 7, 2023). Also, the reference lists of the articles were reviewed.

The following terms in English with Boolean operators were used: “vestibular schwannoma” OR “acoustic neurinoma” AND “keyhole approach” OR “endoscopic resection” OR “endoscopy”.

Language restriction was used for the initial review of articles, to Spanish and English. Two researchers independently scanned the titles and abstracts, identifying relevant articles. Editorial articles, letters to the editor, books, single case presentations, reviews, meta-analyses, and those with poor method were

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excluded; also articles on anatomical specimens.

After identification of studies that met the inclusion criteria, two authors manually reviewed the full text of the selected articles.

The following information was collected from each article: first author, year of publication, sample, use of endoscopy (full, in the case of exclusive use of the endoscopic technique during surgery, and assisted in the case of combined microsurgical and endoscopic use), average diameter of the tumor lesion (in millimeters), degree of resection, anatomical preservation and post-surgical facial function, and the follow-up period.

All researchers independently assessed the quality of the studies using The Grades of Recommendations, Assessment, Development and Evaluation (GRADE) to carry out certification of the evidence and classify the type of study.<sup>(10)</sup>

A total of 8 articles were included. A database was created with the results of studies of our variables of interest (Complementary File). The quantitative data of the reports of total resection and "acceptable" post-surgical facial function, usually expressed as percentage values, were converted to absolute numbers, according to the sample value, to calculate the incidence of the event. The Major package of the Jamovi software was used to perform a single-arm meta-analysis of these two variables and estimate the overall effect.  $I^2$  greater than 75% was taken as high heterogeneity.

The search results are shown in the PRISMA diagram (Complementary File). The initial search found 17,711 articles in Medline and Google Scholar, of which 4848 with full text available. Elimination of duplicates excluded 3165 articles, and the remaining 1683 were reviewed. Those articles that did not meet the selection criteria according to the explicit information in the title or abstract were excluded, reviewing a total of 42 full-text articles. Two articles were included from the analysis of the references of the included articles. After additional review, 8 articles were chosen for the study.

## RESULTS

The articles included a total of 717 patients. Six articles reported the exclusive use of endoscopy in the resection and the remaining two used a combined technique. There was great variability in the reports of

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resection reports, especially in the evaluation tools. Some authors were based on the anatomical estimate, at the end of the surgical act, and others used volume mathematical techniques in postoperative images. The same situation was presented by facial preservation, where two of the reports included House-Brackman grade III within the "acceptable" category while the rest only reported grade I-II as such. Only one of the studies included a control group in its design, although they did not apply inferential statistics. The rest of the studies were case series, corresponding to a level III of evidence. In the analysis of total resection, it is estimated at 0.84 (standard deviation: 0.73-0.95) for a p-value less than 0.01 (Fig. 1). It was similar in the case of preservation of "acceptable" facial function, with 0.77 (standard deviation: 0.64-0.90) (Fig. 2). But taking into account the  $I^2$  values of 95.98 and 88.39, the studies showed high heterogeneity. In a subgroup analysis, those series where the diameters of the tumor lesion were greater than 3 cm showed less preservation of facial function. The anatomical preservation of the facial nerve was less than 90% in only two series.

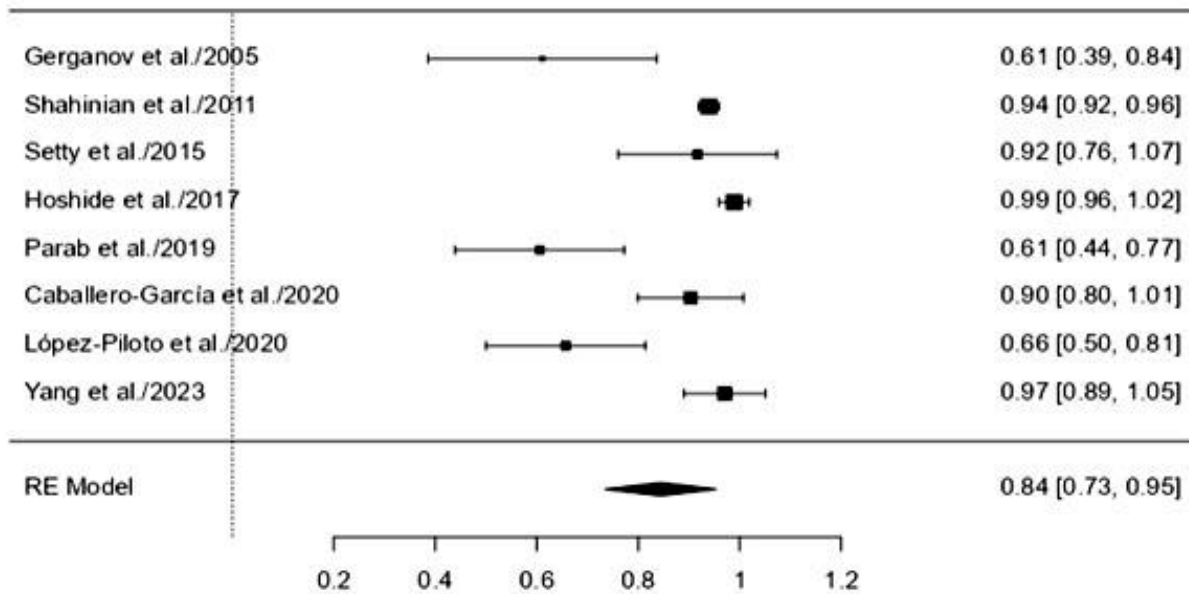


Fig. 1 - Forest plot. Analysis of the degree of total resection in the selected studies.



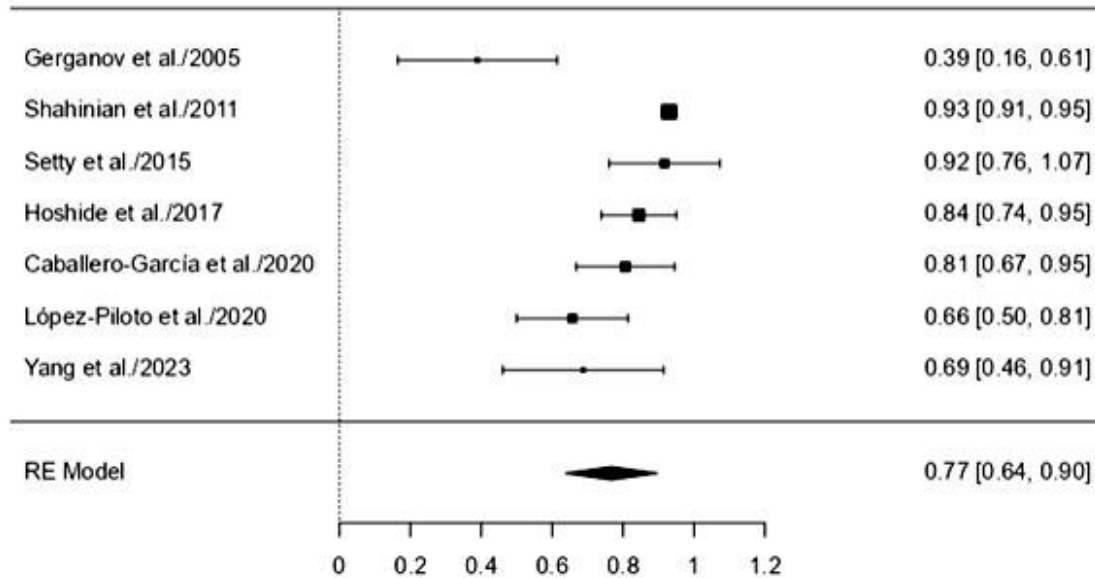


Fig. 2 - Forest plot. Analysis of "acceptable" post-surgical facial function in the selected studies.

## DISCUSSION

Retrosigmoid craniectomy is a classic technique frequently used to treat cerebellopontine angle lesions, particularly vestibular schwannomas. Most of the time, this craniectomy is performed in a sitting position, which involves the use of cranial fixation systems and a wide incision. The operating microscope and brain retractors are used to perform the surgery. The retrosigmoid approach, which is a modification of the suboccipital craniectomy, was first described in 1992.<sup>(17)</sup>

The view of the surgical field undergoes a progressive concentric reduction during the microscopic technique, which is often limited by the edges of the craniectomy. Without these restrictions, endoscopy offers a superior viewing angle. The term "keyhole" does not refer to the dimensions of the craniotomy, but to the creation of an optimized surgical window.<sup>(18)</sup>

The use of a retrosigmoid foramen initially demonstrated clear advantages in approaches to lesions without great risk of bleeding and minimal dissection (trigeminal neuralgia, hemifacial spasm, etc.), where a magnified panoramic view of the vascular structures and their anatomical relationships is achieved without requiring a significant arachnoid dissection and eliminating the use of static cerebellar



retraction.<sup>(19)</sup> Some researchers initially proposed that in cases of tumor lesions, the additional use of endoscopic lenses improved the visualization of the limits of the surgical field and of areas whose microscopic vision is obstructed by other interposed structures.<sup>(11)</sup> This initial experience was enlarged with subsequent series.<sup>(12,13)</sup>

Endoscopy can achieve the same goals as microscopy, with additional advantages such as a smaller incision, a smaller craniectomy (2-2.5 cm), and without the use of static brain retraction. Some groups have used the supine semi-oblique position to facilitate endoscopic surgery and surgeon comfort by minimizing necessary cranial exposure. Similar results have been obtained, which means that cranial fixation systems are not necessary in this position.<sup>(14)</sup> However, other researchers have used the classical positions, or even the sitting position, without this representing an inconvenience for endoscopic maneuverability.<sup>(20)</sup>

One of the great advantages of endoscopy in the cerebellopontine angle is the capacity for dynamic magnification, which depends on the skill of the assistant and its perfect harmony with the surgeon's needs. The use of Holter for fixed lens support eliminates this advantage. Although some authors argue that the constant movement of the lens can damage adjacent structures,<sup>(21)</sup> others have related it to the low training of the assistant, which can be solved with proper familiarization as part of the learning curve.<sup>(15)</sup>

An obvious advantage is the surgical time. Craniectomy times with conventional methods range from 45 to 60 minutes until dural opening (manual technique with Hudson's trephine). Some investigators have shown that the use of an endoscopic hole with a smaller incision and less muscle manipulation has cut exposure times in half.<sup>(14)</sup>

The general vision is that the lesion diameter should not affect the selection of the approach, despite the fact that some authors recommend the selection of small, relatively avascular and solid vestibular schwannomas in the initial phases of the learning curve. This graduated scheme of assimilation of experience and training, which is part of the mastery of the endoscope in transsphenoidal approaches, helps new surgeons to train, leaving the most technically demanding lesions for an advanced stage of the learning curve. Beyond the VS, any lesion in this region can be operated on both microscopically and endoscopically.<sup>(14)</sup>





In this regard, reports on the degree of resection vary between studies. *López-Piloto et al.*<sup>(16)</sup> defines the degree of resection by tomographic study at 24 hours, compared with preoperative volumes. It is noteworthy that these researchers do not expose tumor dimensions nor the mathematical method to estimate the volume of the lesion. Authors normally report these parameters using the maximum diameter in axial slices.<sup>(8,12)</sup> *Hoshide et al.*<sup>(13)</sup> also reported this variable as residual volumes in post-surgical imaging studies; their patients only showed VS greater than 3.0 cm, achieving a near total resection in the 45 cases of the series.

The retrosigmoid endoscopic keyhole has its own complications. Some investigators have observed that cranial nerve paresis is more frequent.<sup>(7)</sup> The use of aspiration, dynamic retraction, and surgical dissection under direct vision is more complex and delicate. The use of constant saline irrigation can mitigate this thermal injury.<sup>(15)</sup> On the other hand, the structures close to the tip of the endoscopic lens are not visible, an element to be taken into consideration at all times, to avoid injuries to the cerebellar cortex. Coordinated and extremely careful movements by the assistant and the surgeon will prevent these injuries.<sup>(14)</sup>

In a subgroup analysis, it is observed that in the series with average diameters greater than 30 mm, there was a decrease in facial functionality after the surgical intervention. This indicates that the use of endoscopy is not absolutely related to tumor volume. It has been widely shown that microscopic resection series influence surgical results due to the dimensions of tumor lesions.<sup>(22)</sup>

The rise of magnetic resonance imaging (MRI) as a diagnostic tool in recent years has allowed early diagnosis of these lesions. Unfortunately, this picture is not homogeneous in all regions, making accessibility difficult in developing countries, where Hannover IV stage lesions (large) continue to prevail.<sup>(15,16)</sup> The appearance of hemorrhages, hydrocephalus, trunk compression brain and cranial nerves is more common in lesions that are greater than 3 cm in diameter. However, the main objectives of surgery continue to be the preservation of the facial nerve and tumor resection, although in recent years the latter has been displaced by the concept of "tumor control" in some circles of researchers who defend the hybrid variant or multimodal treatment (surgery followed by radiotherapy).<sup>(4)</sup>

*Shahinian et al.*<sup>(7)</sup> despite the use of electrophysiological monitoring, published a high rate of facial nerve preservation, anatomical and functional, with complete tumor resection, especially in patients with large-



diameter lesions. This author evaluated facial function one year after the intervention, which may be advantageous in reporting residual true function after rehabilitation, by minimizing the effect of surgical manipulation. However, the other series do not indicate the end date of this variable and include it with the term "post-surgical", which makes it difficult to carry out analyzes between reports.

The vast majority of VS arise from the vestibular portion of the eighth cranial nerve. *Samii et al.*<sup>(22)</sup> in his series of 1000 VS cases, only 1.1% of the cerebellopontine angle tumors corresponded to acoustic neuromas *per se*. Therefore, many investigators advise against resection of intact, visible cochlear nerve in the interest of gross-total resection.

Despite the fact that many authors defend the position that a complete resection and hearing preservation are diametrically opposed objectives, *Shahinian et al.*<sup>(7)</sup> demonstrated a 57% hearing preservation, which they related to the best endoscopic visualization. But it is necessary to highlight that most of the cases in his series had small lesions (less than 4 cm) and were minimally symptomatic, which is directly related to better surgical results.<sup>(22)</sup>

In the series by *Shahinian et al.*,<sup>(7)</sup> only 6 % of patients with functional hearing function had a cochlear nerve infiltrated or destroyed by compression during subtotal resection. In these cases, the authors recommend weighing the decision between the benefit of a complete resection and the risk of losing functional hearing function.

The incidence of complications related to the approach, such as epidural hematomas, CSF leaks, infections, postoperative headache, etc., may decrease with a smaller craniotomy. Injuries to the cerebellum and brainstem (haemorrhage, motor problems, or death) have been the most feared complications of the retrosigmoid approach since its inception. In most cases, dynamic retraction reduces complications with a minimally invasive approach. Any endoscopic technique requires careful hemostasis.<sup>(15)</sup>

The development of hydrocephalus after surgery can be due to a variety of factors, and its management is usually simple. It is rare to do a permanent ventricular derivation. Endoscopic third ventriculostomy may be an attractive treatment for symptomatic hydrocephalus when resources are limited.<sup>(23)</sup>

One of the great advantages of endoscopic use, complete or assisted, is the anatomical identification of the facial nerve. *Gerganov et al.*<sup>(11)</sup> in their initial series reported it in 78 %, but in subsequent series it



occurs in almost all cases. This has allowed the incorporation of the assisted modality in the final phase of microscopic resection, a widely accepted variant in neurosurgical community.<sup>(24,25,26,27,28,29,30,31,32,33,34,35)</sup>

Among the limitations of our study is the high heterogeneity of the published series, which makes inferential analysis difficult. On the other hand, there is no consensus on the ideal moment for the evaluation of post-surgical facial functionality. The inclusion of House-Brackman grade III within an "acceptable" facial function makes comparison between studies difficult. Finally, it is necessary to take into account that the previous experience of the surgical team in neuroendoscopic procedures is vital, and no mention is made of it in any series, which could represent an obstacle in the implementation of this technique in other scenarios.

The retrosigmoid endoscopic keyhole is an effective and safe technique in vestibular schwannomas. Studies in this regard reveal relative success, with acceptable rates of anatomical and functional preservation of the facial nerve. A larger number of cases in prospective cohorts is needed to issue clear recommendations.

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