


A Laboratory Investigation on a Tailored Skin and Muscle Flap Variant for the Retrosigmoid Approach

Salvatore Chibbaro¹ Helene Cebula¹ Ismail Zaed¹ Arthur Gubian¹ Julien Todeschi¹
 Antonino Scibilia¹ Beniamino Nannavecchia¹ Louise Scheer¹ Maria Teresa Bozzi¹
 Pierre Mahoudeau² Andres Coca¹ Francesco Signorelli³ Idir Djennaoui² Christian Debry²
 Mario Ganau¹

¹Division of Neurosurgery, Strasbourg University Hospital, Strasbourg, France

²Division of ENT, Strasbourg University Hospital, Strasbourg, France

³Division of Neurosurgery, Bari University Hospital, Bari France

Address for correspondence Ismail Zaed, MD, Department of Neurosurgery, Strasbourg University Hospital, Strasbourg 67000, France (e-mail: Ismailzaed1@gmail.com).

J Neurol Surg B Skull Base 2022;83(suppl S2):e438–e442.

Abstract

Introduction An anatomical study was conducted to test a modified C-shaped flap designed for patients undergoing a keyhole approach and/or minicraniotomy for retrosigmoid approach (KRSA).

Materials and Methods Ten heads specimens were used. The surgical technique investigated was based on a 4-cm C-shaped skin incision with medial convexity (placed 8 cm laterally to the external occipital protuberance, with the lower edge terminating 1.5 to 2 cm above the mastoid tip), which followed by careful subperiosteal dissection and completed by reflecting and securing the skin flap layer anteriorly and the muscle flaps superiorly and inferiorly by stitches. Anatomical findings, including depth of surgical corridor till to the cerebellopontine cistern (CPC) as well as the sparing of neurovascular structures, were evaluated in every specimen.

Results Twenty surgical approaches to CPC were conducted, resulting in a short working distance to the target (32 mm) without any need for a self-retaining retractor. In every specimen, the integrity of occipital muscles and cutaneous nerves was maintained, and a solid multilayer closure was always achieved. These data suggest that landmarks-based design of this C-shaped incision could be helpful in avoiding damages to the soft tissues encountered during KRSA.

Conclusion This modified approach provides a wide surgical corridor to access the CPC while ensuring the minimal invasiveness of the standard S-shaped incision. Compared with the latter, it preserves better the integrity of the surrounding soft tissues and appears less likely to cause any iatrogenic injury to occipital muscles and cutaneous nerves.

Keywords

- ▶ retrosigmoid approach
- ▶ C-shaped skin incision
- ▶ muscle flap
- ▶ functional pain outcome

Introduction

Keyhole surgical approaches are rapidly gaining popularity given the reduced operating times for opening and closing, the reduced morbidity, and excellent results. The

keyhole retrosigmoid craniotomy is one such approach that, when done well, aims to reduce operating time and postoperative morbidity. It can also provide outstanding access to the entire ventrolateral brainstem and

received

February 12, 2020

accepted after revision

April 23, 2021

published online

May 31, 2021

© 2021, Thieme. All rights reserved.
 Georg Thieme Verlag KG,
 Rüdigerstraße 14,
 70469 Stuttgart, Germany

DOI <https://doi.org/10.1055/s-0041-1730890>.
 ISSN 2193-6331.

cerebellopontine angle (CPA), with reduced approach-related morbidity. A keyhole approach to the CPA reduces the unnecessary exposure of neural elements. There is a misconception that the keyhole approach is synonymous with a smaller craniotomy, which is untrue. A keyhole approach is optimized surgical access to pathological entities.

Several variations of the keyhole retrosigmoid approach (KRSA) are currently used to approach lesions adjacent to the cerebellopontine cistern (CPC), including skull base tumors, neurovascular conflicts, and arachnoid cysts.

Since the iatrogenic damage to the soft tissues encountered during KRSA has been suspected to bear a negative influence on functional outcomes, especially in terms of cranial nerves palsy, postoperative pain, and discomfort around the skin incision, we designed the present anatomical study to test a variation of the standard straight/lazy S-shaped incision.

Materials and Methods

An anatomical study was performed at the skull base anatomy laboratory of the ENT Department of the University of Strasbourg during a period of 2 months. Ten dry latex-injected cadaver heads specimens (six males and four females, seven Caucasian, and three African) were used to the test of a variation of the skin and muscle flap designed for KRSA. During the dissection, this modified approach was performed on both sides of each specimen; no other surgical

approaches to the posterior fossa or presigmoid region were simulated in those heads. The study was granted official approval by the Neurosurgery and ENT Department at the University of Strasbourg. The technical description of the operative approach tested is provided as follows.

The heads were always immobilized in Mayfield 3-pin holder to simulate a park-bench or lateral approach, positioned gently flexed (20 degrees on the anteroposterior plane), and rotated contralaterally (15 degrees away from the side approached). Furthermore, cartesian coordinates were drawn on every head to facilitate all calculations. The longitudinal axis (y-axis) was the vertical line running along the midline from the nasion until the tip of the spinous process of C2, whereas the horizontal axis (x-axis) was the line connecting the most anterosuperior points of both external auditory canals. The following landmarks were also considered before drawing the skin incision: the external occipital protuberance (EOP), mastoid tip, and pinna of the ear.^{1,2}

This modified skin incision has a length of approximately 40 mm and is characterized by a medial convexity. It was usually placed 80 mm laterally to the EOP, and 25 mm medially to the mastoid groove and the pinna. The lower edge of this C-shaped skin incision terminated 15 mm above the mastoid tip (► Fig. 1). Following a careful subperiosteal dissection, a musculocutaneous flap was reflected superiorly and inferiorly and retracted with retaining stitches (► Fig. 2). No self-retaining retractors were needed in any of the procedures simulated during this study. The surface of

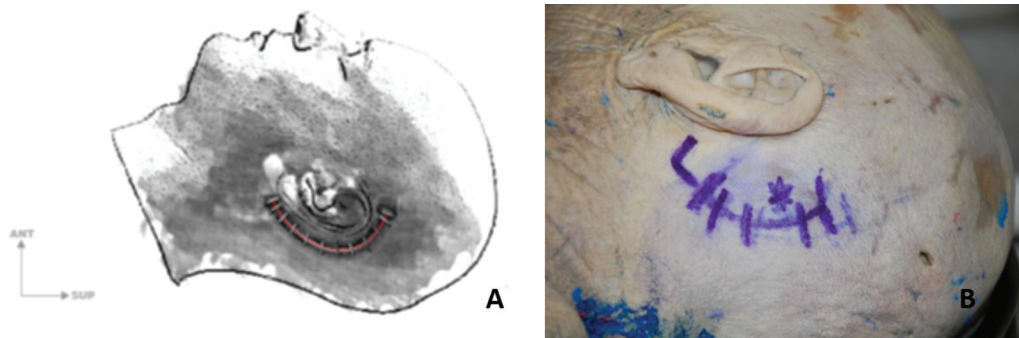


Fig. 1 The C-shaped retroauricular skin incision (approximately 40 mm), as seen on a schematic drawing (A), and on an anatomical piece from our cadaveric study (B).

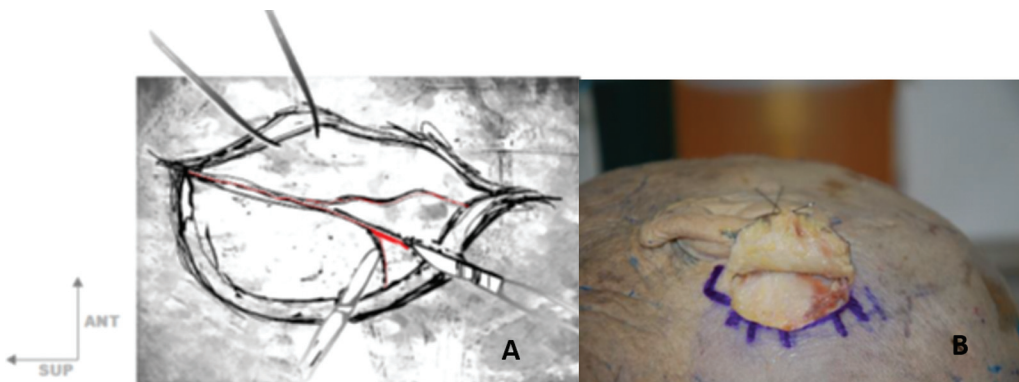


Fig. 2 The musculocutaneous flap retracted with retaining stitches as seen on a schematic drawing (A) and on one of the specimens from our anatomical study (B).

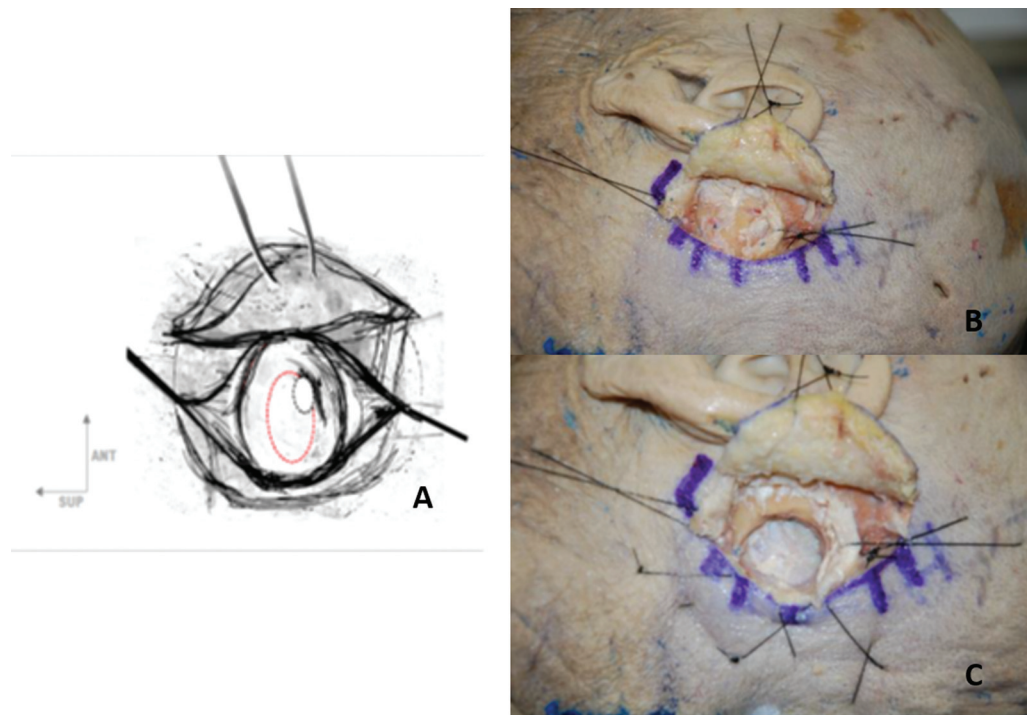


Fig. 3 The retrosigmoid circular keyhole burr hole (~16 mm) as seen on a schematic drawing (A), and reproduced in one of our anatomical specimens (B, C).

bone exposed with this musculocutaneous flap simulated a trapezoid with a pair of parallel sides (B and b). Therefore, its area was calculated as follows: $A = 0.5 \times (B + b) \times d$.

After exposure of the bone surface, a burr hole was performed with a pneumatic drill just below the confluence of the transverse-sigmoid sinuses and expanded with either a craniotome blade or a Kerrison punch to create a circular keyhole (diameter 16 mm) or a mini-craniotomy (diameter 25 mm) and make the most of the height (d) of the trapezoid area exposed (►Fig. 3).

The exposure of the underlying dura mater was followed by a curvilinear opening keeping the base of dural attachment opposite to the sinus junction. Once completed the dissection and exploration of the vascular structures and cranial nerves in the CPC, careful measurements were taken to check the depth of the surgical corridor created. The depth (h) was calculated as the distance between the dural surface and the porus acusticus of the internal acoustic meatus. This parameter along with the radius of the keyhole or mini-craniotomy (r) served to calculate the dimension of the working channel assuming that it would simulate the volume of a cone (with its base at the level of the skull and the apex down into the cistern) as per the formula: $V = (\pi \times r^2 \times h) / 3$. At the end of each approach, the dural flap was cautiously closed in a water-tight fashion, and the musculocutaneous flap closure was obtained in a multi-layer fashion (►Fig. 4).³

To confirm that the occipital artery, lesser occipital nerve (LON), and greater auricular nerve (GAN) were at a safe distance from this modified C-shaped incision, their course was traced through additional dissections. The occipital artery was identified below the trapezius and semispinalis capitis muscle; the LON and GAN were traced from their

emergence from the cervical plexus and followed between the posterior edge of the sternocleidomastoid muscle and the deep cutaneous fascia behind the auricula. Vertical and horizontal distances from the x- and y-axes were measured in 1-mm increments and compared with data from the literature.

Results

The C-shaped incision is always allowed to identify the asterion, which is known to be the typical landmark for the transverse and sigmoid sinuses junction, although this relation has been previously shown to vary in almost 20 to 40% of patients. The main neural structures that may be put in danger when performing the skin incision for a KRSA are the LON and the GAN.

The LON, providing sensorial innervation of the occipital, mastoid, and temporal regions, was found to run approximately 7 cm lateral to the EOP (median = 7.0 cm; average = 6.985 cm; range = 6.4–7.5 cm) and approximately 3 cm medial to the mastoid process tip (median = 3.0 cm; average = 2.995; range = 2.7–3.3 cm), as previously described in the literature.^{4–9} The GAN, providing sensorial innervation to the auricle and parotid areas, may give a mastoid branch running approximately 9 cm lateral to the EOP (median = 9.0 cm; average = 8.955; range = 8.1–9.4 cm), while the principal trunk may be placed approximately 1 cm above to the mastoid tip (median = 1.0 cm; average = 1.03; range = 0.6–1.6 cm). In the 20 procedures performed on the specimens studied only in three cases posterior anastomosing branches with the LON, confirming an anatomical aspect already demonstrated by others.⁶ Thanks to this musculocutaneous

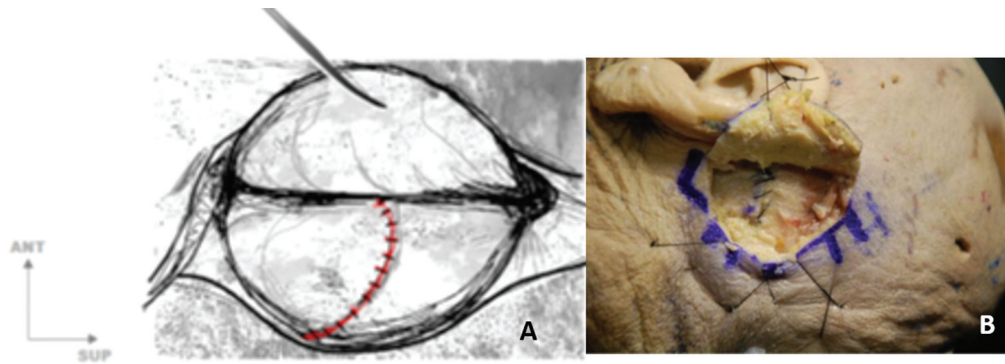


Fig. 4 Closure per layers of the surgical wound, note the accurate suturing of the musculocutaneous flap as seen on a schematic drawing (A), and after the cadaveric dissection performed for the purposes of this anatomical study (B).

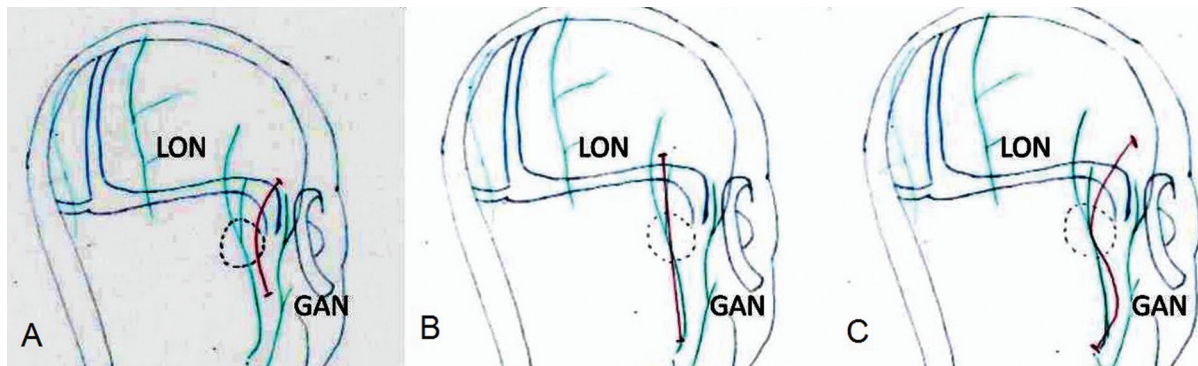


Fig. 5 Schematic drawings showing the course of the lesser occipital nerve and the greater auricular nerve with regards to the C-shaped (A), the conventional straight (B), and the lazy S-shaped (C) incisions, respectively.

flap and subperiosteal dissection the occipital artery, LON, and GAN were spared during all approaches.

The mean area exposed with this musculocutaneous flap was 5.31 cm² (range = 4.52–7.07 cm²); the mean depth of the surgical corridor created resulted to be 34 mm (range = 31–37 mm). The mean volume of the working channel resulted to be 6.02 cm³ (range = 4.67–8.72 cm³). Of note, neither incidental tumors nor anatomical variants were noticed during any of those approaches.

Discussion

The KRSA is very popular to expose the CPC and its contents including cranial nerves VII to VIII, the antero-inferior cerebellar artery, the foramen of Luschka, and the flocculus of the cerebellum. It also allows to reach the prepontine cistern and the pons, exposing the V and lower (IX, X, XI cranial nerves), and to give access to the vertebral artery, the superior, and posterior-inferior cerebellar arteries. Hence, the indications for KRSA are very wide and include neuro-oncology, neuro-vascular, and neuro-functional procedures, such as resection of acoustic neurinomas, cerebellar epidermoids and dermoids, petrosal and petroclival meningiomas, and chordomas of the lower clivus; clipping or trapping of aneurysms of superior, antero-inferior, and posterior-inferior cerebellar arteries as well as of the fourth segment of the vertebral artery; and finally treatment of neurovascular conflicts responsible for trigeminal neuralgia, hemifacial spasm, and glossopharyngeal neuralgia.

In this anatomical study, we investigated the feasibility of designing a musculocutaneous flap variant meant to retain all the advantages of the KRSA while preserving the integrity of the occipital muscle and the cutaneous nerves (LON and GAN). The rationale for doing so is to optimize the functional outcome and to reduce postoperative pain of patients operated through this approach.^{4,5} The preservation of those soft tissues in fact is known to significantly reduce the incidence of occipital/retroauricular pain and neck discomfort,⁶ which can become a chronic postoperative complaint in those patients.⁷ In several reports, those surgical sequelae have been correlated to intraoperative injuries to LON and GAN during the skin incision,⁸ as well as their entrapment in or adherence to postoperative scar tissues.⁹

The standard straight skin incision^{10,11} and its variations, such as the lazy S-shaped one,^{3,12} require an extensive dissection of the posterior neck muscles, increasing the risk of vascular and nerve damage^{13,14} and the occurrence of postoperative muscle fibrosis¹⁵ and in rare cases of postoperative neuromas (–Fig. 5).³ A review of the literature allows to identify some landmark papers revolving around the proposal for additional variation to the skin flaps for KRSA.^{11,12,16–21} focused on the relationship between the skin incision/muscle dissection and postoperative outcome. For instance, Cohen-Gadol et al¹⁶ described a curvilinear U-shaped skin incision with a superior convexity and an upper point at the junction of the sigmoid and the transverse sinuses. However, also their musculocutaneous flap could pose the LON and the mastoid

branch of the GAN at risk of damage.²¹ More recently, Tomasello et al²¹ introduced a 5-cm hockey stick-shaped skin incision, whose most medial aspect was 7 cm lateral to the EOP, and formed by a superior and inferior limb placed slightly superior to the superior nuchal line and 2 cm superior to the mastoid tip, respectively. Their skin incision reaching the muscle fascia was meant to preserve the LON and GAN from iatrogenic injuries and in their clinical series this resulted in 0% cases of postoperative sensory disturbances or pain. In a recent case-control study comparing the standard straight/lazy S-shaped incision with a C-shaped musculocutaneous flap, we demonstrated that the latter provides a significantly better postoperative functional pain outcome and a higher satisfaction rate after surgery, while allowing for a satisfactory working channel in any pathology of the cerebellopontine angle, such as acoustic schwannomas and neurovascular conflicts.²² Of note, this optimization of the functional outcome was associated to a significantly lower incidence of other postoperative complications such as CSF leak and wound infections.²²

Conclusion

This anatomical study confirmed that the modified C-shaped skin incision and muscle flap allows for a tailored and reproducible keyhole approach to the CPA. This simple and elegant skin flap permits to obtain a wide surgical corridor with a relatively short working distance to the CPC. The advantages of respecting the soft tissues (muscular and neurovascular structures) and, therefore, reducing the risk of atrophy of the occipital muscles and injury of the LON and GAN are relevant for translation into the clinical setting. This new laboratory study demonstrates that we can safely push forward the boundaries of this minimally invasive approach, hence expanding its applicability to most neoplastic and functional pathologies of the CPA. Further clinical experience is certainly warranted to validate our findings while confirming the reduced occipital/retro-auricular pain or neck discomfort, and the optimized functional outcome.

Authors' Contributions

All the authors have contributed to the writing of this manuscript, and have read and approved the final version of this manuscript.

Funding

None.

Conflict of Interest

None declared.

References

- 1 Tubbs RS, Loukas M, Shoja MM, Bellew MP, Cohen-Gadol AA. Surface landmarks for the junction between the transverse and sigmoid sinuses: application of the "strategic" burr hole for suboccipital craniotomy. *Neurosurgery* 2009;65(6, Suppl):37-41, discussion 41
- 2 Yamashita T, Lee JH, Tobias S, Kim C-H, Chang JH, Kwon J-T. Surgical procedure "simplified retrosigmoid approach" for C-P angle lesions. *J Clin Neurosci* 2004;11(02):168-171
- 3 Kemp WJ, Cohen-Gadol AA. A review of skin incisions and scalp flaps for the retromastoid approach and description of an alternative technique. *Surg Neurol Int* 2011;2:143
- 4 Jackson CG, McGrew BM, Forest JA, et al. Comparison of postoperative headache after retrosigmoid approach: vestibular nerve section versus vestibular schwannoma resection. *Am J Otol* 2000;21(03):412-416
- 5 Mosek AC, Dodick DW, Ebersold MJ, Swanson JW. Headache after resection of acoustic neuroma. *Headache* 1999;39(02):89-94
- 6 Lee M, Brown M, Chepla K, et al. An anatomical study of the lesser occipital nerve and its potential compression points: implications for surgical treatment of migraine headaches. *Plast Reconstr Surg* 2013;132(06):1551-1556
- 7 Schessel DA, Rowed DW, Nedzelski JM, Feghali JG. Postoperative pain following excision of acoustic neuroma by the suboccipital approach: observations on possible cause and potential amelioration. *Am J Otol* 1993;14(05):491-494
- 8 Tubbs RS, Salter EG, Wellons JC, Blount JP, Oakes WJ. Landmarks for the identification of the cutaneous nerves of the occiput and nuchal regions. *Clin Anat* 2007;20(03):235-238
- 9 Schaller B, Baumann A. Headache after removal of vestibular schwannoma via the retrosigmoid approach: a long-term follow-up-study. *Otolaryngol Head Neck Surg* 2003;128(03):387-395
- 10 Jannetta PJ, McLaughlin MR, Casey KF. Technique of microvascular decompression. Technical note. *Neurosurg Focus* 2005;18(05):E5
- 11 McLaughlin MR, Jannetta PJ, Clyde BL, Subach BR, Comey CH, Resnick DK. Microvascular decompression of cranial nerves: lessons learned after 4400 operations. *J Neurosurg* 1999;90(01):1-8
- 12 Bond AE, Zada G, Gonzalez AA, Hansen C, Giannotta SL. Operative strategies for minimizing hearing loss and other major complications associated with microvascular decompression for trigeminal neuralgia. *World Neurosurg* 2010;74(01):172-177
- 13 Catalano PJ, Jacobowitz O, Post KD. Prevention of headache after retrosigmoid removal of acoustic tumors. *Am J Otol* 1996;17(06):904-908
- 14 Kemp WJ III, Tubbs RS, Cohen-Gadol AA. The innervation of the scalp: a comprehensive review including anatomy, pathology, and neurosurgical correlates. *Surg Neurol Int* 2011;2:178
- 15 Della Pepa GM, Montano N, Lucantoni C, Alexandre AM, Papacci F, Meglio M. Craniotomy repair with the retrosigmoid approach: the impact on quality of life of meticulous reconstruction of anatomical layers. *Acta Neurochir (Wien)* 2011;153(11):2255-2258
- 16 Cohen-Gadol AA. Microvascular decompression surgery for trigeminal neuralgia and hemifacial spasm: nuances of the technique based on experiences with 100 patients and review of the literature. *Clin Neurol Neurosurg* 2011;113(10):844-853
- 17 Fukuhara T, Silverman DA, Hughes GB, et al. Vestibular nerve sectioning for intractable vertigo: efficacy of simplified retrosigmoid approach. *Otol Neurotol* 2002;23(01):67-72
- 18 Garzon-Muvdi T, Jackson C, See AP, Woodworth GF, Tamargo RJ. Preservation of the greater occipital nerve during suboccipital craniectomy results in a paradoxical increase in postoperative headaches. *Neurosurgery* 2015;76(04):435-440, discussion 440
- 19 Huang X, Xu M, Xu J, et al. Complications and management of large intracranial vestibular schwannomas via the retrosigmoid approach. *World Neurosurg* 2017;99:326-335
- 20 Silverman DA, Hughes GB, Kinney SE, Lee JH. Technical modifications of suboccipital craniectomy for prevention of postoperative headache. *Skull Base* 2004;14(02):77-84
- 21 Tomasello F, Esposito F, Abbritti RV, et al. Microvascular decompression for trigeminal neuralgia: technical refinement for complication avoidance. *World Neurosurg* 2016;94:26-31
- 22 Chibbaro S, Cebula H, Scibilia A, et al. Retrosigmoid approach: investigating the role of a c-shaped skin incision and muscle flaps in improving functional outcome and reducing postoperative pain. *World Neurosurg* 2018;111:e340-e347