



Original Article

Minimally Invasive Endoscopic Retrosigmoid Approach to the Cerebellopontine Angle Using a Novel Surgical Instrument: A Cadaveric Study

Mitat Arıcıgil , Hamdi Arbağ , Mehmet Akif Dündar , Suhayb Kuria Aziz ,
Mehmet Tuğrul Yılmaz

Department of Otorhinolaryngology, Head and Neck Surgery, Necmettin Erbakan University School of Medicine, Konya, Turkey (MA, HA, MAD, SKA)
Department of Anatomy, Necmettin Erbakan University School of Medicine, Konya, Turkey (MTY)

ORCID IDs of the authors: M.A. 0000-0001-7004-1367; H.A. 0000-0001-6146-8801; M.A.D. 0000-0001-9004-8400; S.K.A. 0000-0002-4230-9255; M.T.Y. 0000-0001-5744-0902

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OBJECTIVES: In this study, we aimed to describe how endoscopes show the neural and vascular structures at the cerebellopontine angle (CPA) through a minimal craniotomy in a well-described anatomic point in the retrosigmoid region and at the same time, evaluate the endoscopic anatomic exposure and maneuverability. We planned to use the new surgical instrument (endoscope cannula), which we designed on fresh frozen cadavers to simulate a real surgical procedure.

MATERIALS and METHODS: The surgical procedure was planned to be performed on 20 sides of 10 fresh cadaver heads. The distance between the asterion and mastoid process was determined, and the midpoint was then marked. From this midpoint, a craniotomy 2 cm in size was posteriorly made. The endoscope cannula together with 0° or 30° endoscopes was inserted to capture the panoramic views of the neurovascular structures in CPA. Endoscopic anatomic exposure and maneuverability were evaluated using 0° and 30° endoscopes with/without the endoscope cannula.

RESULTS: The surgeon could easily use both hands during the surgical simulation, and maneuverability was seen to increase in CPA with the use of the endoscope cannula.

CONCLUSION: The surgeon can work actively with both hands when the endoscopes and the endoscope cannula are used together. We believe that owing to this, the surgeon's maneuverability would increase and a more effective minimally invasive endoscopic retrosigmoid surgery would ensue.

KEYWORDS: Cerebellopontine angle, endoscopic retrosigmoid approach, minimally invasive

INTRODUCTION

The cerebellopontine angle (CPA) is an anatomic region that contains important neural and vascular structures such as cranial nerves, blood vessels, and parts of the central nervous system. The classic retrosigmoid approach is the basic technique used to access CPA ^[1]. Pathologies such as vestibular schwannomas and neurovascular disturbances of V and VII cranial nerves are mostly managed surgically in this region ^[2-4].

In addition to the traditional surgical methods, endoscopes are now being used in the treatment of CPA pathologies, either alone or in conjunction with a microscope ^[5,6]. Endoscopes can show images that taken closer to CPA with greater magnification. Angled endoscopes can show anatomic structures that are hidden around the corners and allow us to see the relationship between these structures ^[7]. The use of endoscopes has also paved the way for minimally invasive surgery. Smaller craniotomies and reduced retraction of the cerebella decrease the number of possible complications so that patients can resume their daily lives sooner ^[8].

The aim of the present study is to describe how endoscopes can show the neural and vascular structures in CPA through a minimal craniotomy in a well-described anatomic point in the retrosigmoid region and at the same time evaluate the surgical exposure and maneuverability. To evaluate the surgical exposure and maneuverability at the surgical field in a real surgery simulation, we

Corresponding Address: Mitat Arıcıgil E-mail: maricigil79@gmail.com

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planned to use a new surgical equipment (endoscope cannula) that we designed. At the same time, we thought of evaluating the contribution of endoscope cannula in improving the surgical exposure and maneuverability in this surgical procedure.

MATERIAL and METHODS

The present study was conducted in the cadaver dissection laboratory of the Anatomy Department. The study was approved by the local ethics committee before being conducted. The surgical procedure was planned to be performed on 20 sides of 10 fresh cadaver heads. The distances between the Henle spine and the asterion and also between the asterion and the mastoid process were measured (Figure 1). The reason for measuring between these anatomic structures was to determine the appropriate craniotomy site without violating important anatomic structures such as the sigmoid sinus. Surgical simulation was conducted using a drill system (Bien Air, Le Noirmont, Switzerland), rigid endoscopes (Karl Storz, Tuttlingen, Germany; 2.7 mm in diameter, 14 cm in length, and 0° and 30° endoscopes), and cannula designed by us (endoscope cannula). This cannula could be used to retract the cerebellum and also give surgeons a chance to use both their hands. As a result, a fixed image would be obtained from any point (Figure 2). Endoscopes were exchanged with ease without violating any neural tissue. The prototype of this cannula, which we have called the endoscope cannula, was made from copper and aluminum.

Procedures for Endoscopic Minimally Invasive Retrosigmoid Approach

The cadaveric head was positioned with the mastoid area under direct vision. The postauricular incision was made 3–4 cm posterior to the sulcus, starting from the mastoid apex to a little above the superior ear attachment. An inferiorly based musculoperiosteal flap was then elevated at this point. The distance between the asterion and mastoid apex was determined, and the midpoint was marked. From this midpoint, a 2 cm craniotomy was posteriorly made and then an anteriorly based dural flap was elevated.

Evaluation of Exposure and Maneuverability

The arachnoid was opened, and the endoscope cannula was inserted together with 0° or 30° endoscopes to capture panoramic

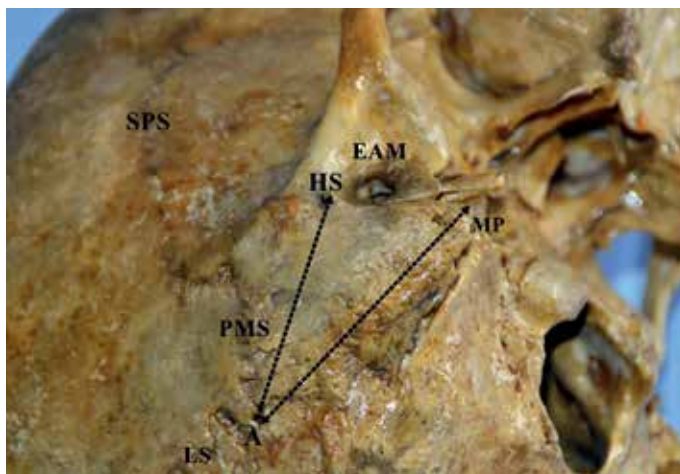


Figure 1. Distance between asterion and mastoid process and distance between asterion and Henle spine shown on a temporal bone. A: asterion, HS: Henle spine, MP: mastoid process, LS: lambdoid suture, PMS: parietomastoid suture, EAM: external auditory meatus, SPS: squamosoparietal suture.

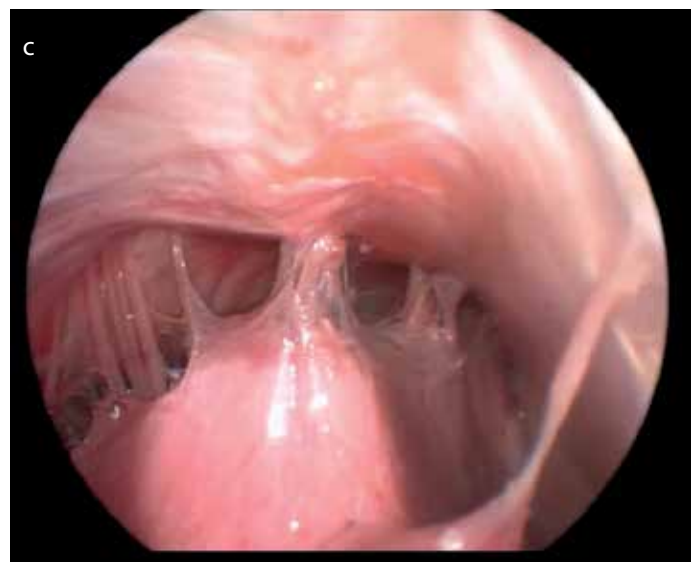
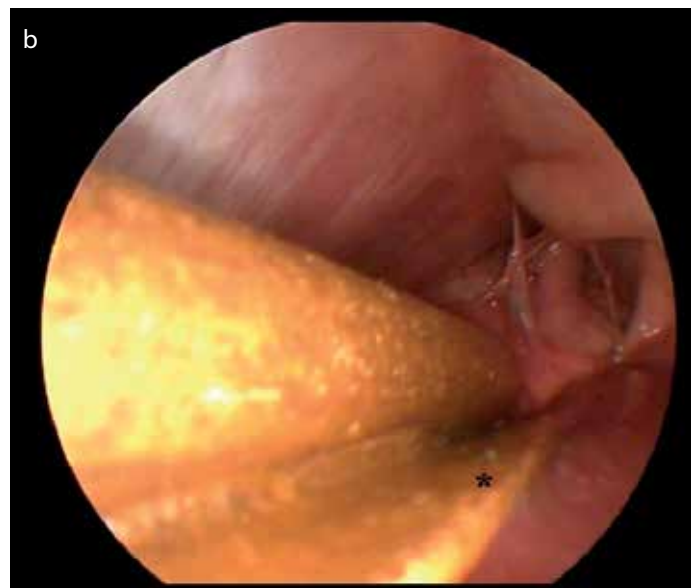


Figure 2. a-c. Photographs of the endoscope cannula (a). Endoscope cannula mounted on the endoscope holder and the endoscope passed through it to capture images of a fixed point (b). Panoramic images of the cerebellopontine angle taken by a 0° endoscope (c). *Cerebellar retractor part.

views of the neurovascular structures. The acousticofacial bundle (vestibulocochlear nerve: CN VIII and facial nerve: CN VII), fundus of the internal acoustic canal, and anterior inferior cerebellar artery (AICA) were observed at the central compartment of CPA (Figure 3). The nervus trigeminus (CN V) was observed at the superior compartment of CPA (Figure 3). The nervus glossopharyngeus (CN IX), nervus vagus (CN X), nervus accessorius (CN XI), and posterior inferior cerebellar artery were viewed at the inferior compartment of CPA (Figure 3). Either the 0° or 30° endoscope was passed into the endoscope cannula, mounted to the endoscope holder, and then inserted into the 2 cm craniotomy window. The retractor part of the endoscope cannula provided a retraction of the cerebellum. Vascular decompression was conducted with vascular neurectomy and drilling of the fundus of the internal acoustic canal (Figure 4). We referred to previous studies while evaluating the exposure and maneuverability (Table 1) [9].

RESULTS

Table 2 shows the distance between the asterion and the Henle spine and the distance between the asterion and the mastoid process. The midpoint between the asterion and the mastoid process

marked the lower edge of the sigmoid sinus in 19 out of the 20 sides (95%), whereas in 1 side (5%), it marked the position of the sigmoid sinus. The midpoint of the distance between the asterion and Henle spine marked the upper edge of the sigmoid sinus on 16 sides (80%). However, this point marked the position of the sigmoid sinus on 4 sides (20%).

During vestibular neurectomy and neurovascular conflict syndrome surgery, the surgeon can comfortably use both hands to drill the fundus with the help of the endoscope cannula, and maneuverability would also increase because the endoscope can be stabilized at any point. At the same time, during the procedure, the endoscope cannula made it easy to exchange endoscopes (0°, 30°, and 45°). Table 3 shows the evaluation of exposure and maneuverability when the endoscopes were used with/without the endoscope cannula.

DISCUSSION

Access to CPA is easily and directly achieved by the retrosigmoid approach. Endoscopes have been introduced with the aim of minimizing cerebellar retraction and by smaller craniotomy. In this

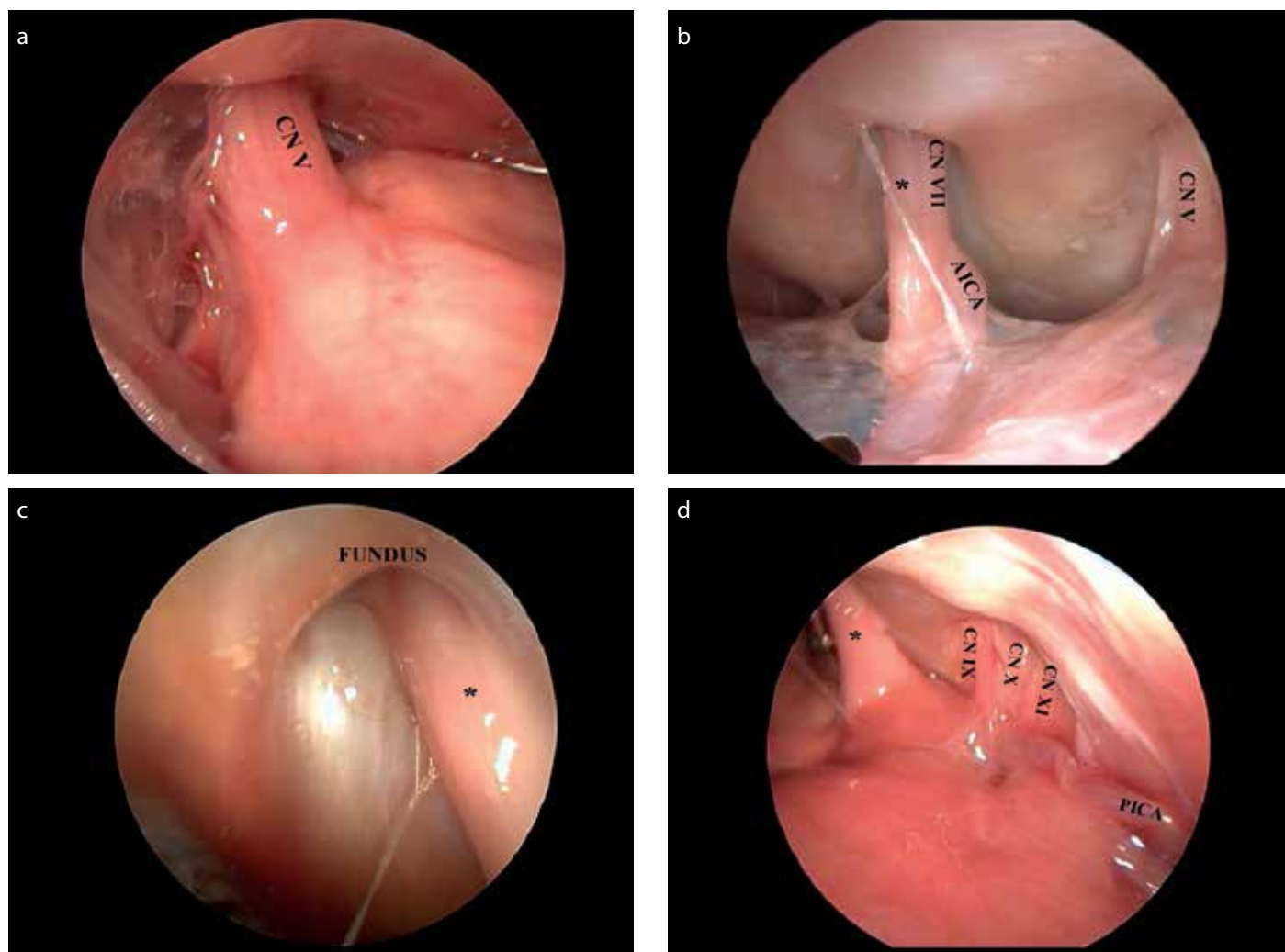


Figure 3. a-d. Superior compartment of the cerebellopontine angle and CN 5 viewed with a 30° endoscope (a). Acousticofacial bundle, anterior inferior cerebellar artery, and CN 5 viewed with a 30° endoscope (b). Acousticofacial bundle and fundus of the internal acoustic canal viewed with a 30° endoscope in the central compartment of the cerebellopontine angle (c). Acousticofacial bundle, CN 9, CN 10, CN 11, and posterior inferior cerebellar artery viewed with a 30° endoscope at the cerebellopontine angle (d). *Acousticofacial bundle.

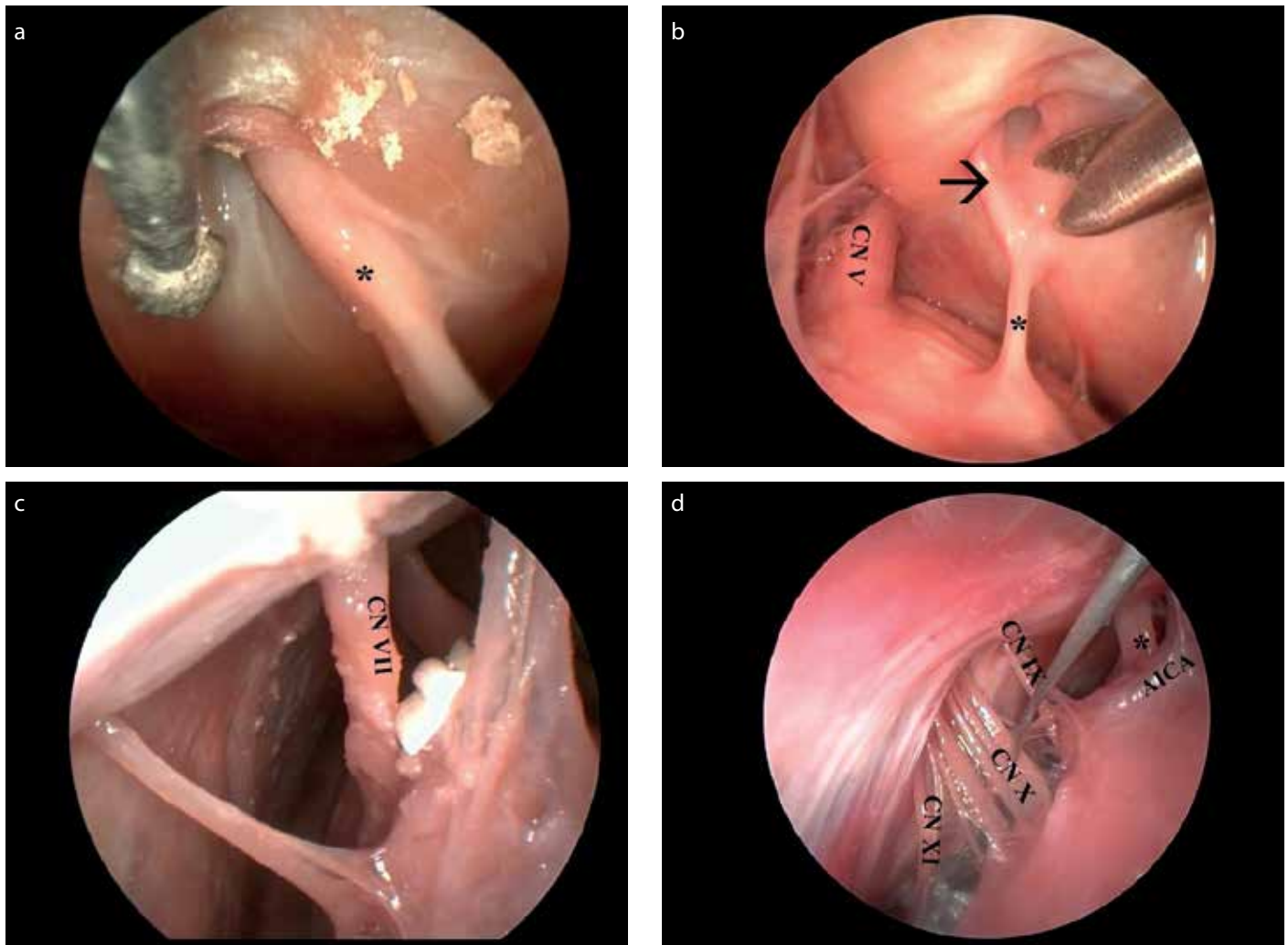


Figure 4. a-d. Evaluation of surgical maneuverability when the 30° endoscope and endoscope cannula are used. Drilling of the fundus of the internal acoustic canal (a). Simulation of the vestibular neurectomy (b). Placement of a Teflon sheet between the facial nerve and anterior inferior cerebellar artery (c). Manipulation of the lower cranial nerves with surgical instruments (d). *Acousticofacial bundle.

Table 1. Exposure and maneuverability score definitions. Surgical maneuvers included vascular decompression, drilling of the fundus of the internal acoustic canal, and vestibular neurectomy

Exposure score	Exposure
0	No exposure
1	Limited exposure
2	Multiangled exposure
3	Circumferential exposure
Maneuverability score	Maneuverability
S1	Surgical maneuvers are not possible
S2	Surgical maneuvers are difficult
S3	Surgical maneuvers are possible
S4	Surgical maneuvers are facilitated

Table 2. Distances between asterion, spine of Henle, and mastoid process (mm).

Marks of the temporal surface	Distances of the marks (mean±SD)
Asterion to the spine of Henle	41.23±1.98 (36.41–45.32)
Asterion to the mastoid process	50.27±2.52 (41.76–55.13)

Table 3. Evaluation of endoscopic anatomic exposure and maneuverability using 0° and 30° endoscopes and endoscope cannula in minimally invasive retrosigmoid approach. This table should be evaluated together with Table 1.

Surgery simulation	Exposure and maneuverability score (0° and 30° endoscopes without endoscope cannula)	Exposure and maneuverability score (0° and 30° endoscopes with endoscope cannula)
Vestibular neurectomy	2, S2	2, S3
Vascular decompression (CN VII-AICA)	2, S2	2, S3
Drilling of the fundus (internal acoustic canal)	2, S2	2, S4

AICA: anterior inferior cerebellar artery.

way, reconstruction is easily obtained, and postoperative prognosis is improved [10]. With the help of angled endoscopes, smaller surgical fields can be accessed making it possible for images of narrow recesses, which are not accessible through a microscope, to be taken [11].

Surgical procedures on CPA have, for some time, been done with the help of microscopes, and endoscopy subsequently became popular in assisting with microscopic techniques. The acousticofacial bundle and fundus of the internal acoustic canal can be seen more clearly with the help of endoscopes through a smaller craniotomy hole than with a microscope. 360° images can be taken without too much retraction of the cerebellum^[12, 13]. An endoscopic approach without a microscope to CPA was first used by Eby et al.^[14] in 2001.

The ability to perform a small craniotomy is one of the most important advantages of this minimally invasive endoscopic surgery. While determining the correct region for craniotomy, some landmarks are taken into consideration to avoid violating major anatomic structures. Generally, with the retrosigmoid approach to CPA, a small craniotomy is performed in the region behind the sigmoid sinus and close to the sinus. Hitotsumatsu et al.^[15] showed that the asterion is at the point where the transverse sinus meets the sigmoid sinus and that the emissary veins are situated at the posterior edge of the sigmoid sinus. The craniotomy should therefore be below the asterion, superiorly to the mastoid, and posteriorly to the mastoid notch. Day et al.^[16] determined that the position of the transverse-sigmoid junction can be placed more accurately anteroposterior to the asterion. The line drawn from the squamosal-parietomastoid suture junction to the mastoid apex is the line that accurately defined the axis of the sigmoid sinus through the mastoid and the front edge of the sigmoid sinus; therefore, the craniotomy should be inferior to the superior nuchal line and posterior to the mastoid. In our study, the midpoint of the asterion-mastoid process marked the posterior edge of the sigmoid sinus on 19 sides (95%). We hypothesize that a 2 cm craniotomy made posteriorly from this midpoint is adequate for a minimally invasive endoscopic approach.

Angled endoscopes provide images of hidden areas of CPA. In a study by Tang et al.^[17], CPA was accessed through a retrosigmoid approach, and the exposures provided by the microscope, 0° and 30° endoscopes, were compared. The authors determined that the 30° endoscope provides better exposure than the 0° endoscope; however, they claimed that the microscopes are more effective with respect to maneuverability. On the other hand, Takemura et al.^[13] reported that the posterior surface of the vascular structures at the central compartment of CPA can be seen clearly using endoscopes. However, they also asserted that it would be better to use a microscope and the endoscopes together. In another study, these authors used a dual port technique to access CPA^[9]. The endoscope was passed via the presigmoid area for visualization, whereas the surgical equipment was passed through the retrosigmoid region. The authors claimed that this would enhance both the surgical maneuverability and exposure. However, the size of the craniotomy was larger in the present study. We used the endoscope cannula designed by us that allowed the surgeon to use both hands, thereby increasing surgical maneuverability. The endoscope cannula was fixed onto the endoscope holder, the endoscope was then passed through it, and the images of the desired regions were taken. Vestibular neurectomy, drilling of the fundus of the internal acoustic canal, and placement of a Teflon sheet between the facial nerve and AICA were done during the surgical simulation (Figure 3). The entire simulation was performed through a 20 mm craniotomy hole. The craniotomy used by Setty et al.^[18, 19] in their study was 14 mm in size and was smaller than the craniotomy used in our study. However, in our study, we tried to apply much less

pressure to have a minimal retraction of the neurovascular structures with the help of the cerebellum retractor incorporated onto the endoscope cannula. Apart from reducing the size of the craniotomy, it is also important to preserve the anatomic structures in minimally invasive surgery. For this reason, much less pressure should be exerted when retracting an important structure, such as the cerebellum, to prevent any possible complications. Therefore, another reason why we used the endoscope cannula was to provide minimal retraction of the cerebellum.

The other issue is the amount of heat emanating from the endoscopes toward the neurovascular structures in case the operation prolongs. In a study by Kozin et al.^[20], endoscopic ear surgery was performed in a model of a human temporal bone, and heat emission from the endoscopes was measured. The endoscopes heated up to 46°C, and they believed that this would cause damage to the cochlear. In our study, the amount of heat emitted from the endoscopes toward the neurovascular structures in CPA was not measured. For this reason, we do not have any data concerning the insulating properties of the endoscope cannula. However, we hypothesize that with improvement of this cannula, it can be insulated with a material that would absorb heat and prevent emanation to the neurovascular structures.

Our study has several limitations. It was performed on fresh frozen cadavers, and as a result, there was no cerebrospinal fluid; therefore, the neural tissues were relatively atrophic. This made it easier for us to reach CPA. In addition, because only the endoscopes and endoscope cannula were used in our study, there was no comparison with microscopic techniques. The endoscope cannula prototype that we designed was made from copper and aluminum. However, for this cannula to be used in actual surgery, it would need to insulate heat from the endoscope and be made from materials that are resistant to corrosive substances.

CONCLUSION

Small craniotomies, minimal retraction, and the use of endoscopes are essential for minimally invasive surgery. The minimally invasive endoscopic retrosigmoid approach allows for smaller craniotomies and less retraction of the cerebellum than conventional techniques. When the endoscopes and the endoscope cannula are used together, the surgeon can work actively with both hands. We believe that because of this, the surgeon's maneuverability would increase and a more effective surgery would ensue.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethic committee of Necmettin Erbakan University Meram Medical Faculty (Decision date: 12.02.2016, Decision number: 2016/448).

Peer-review: Externally peer-reviewed.

Author contributions: Concept – M.A., H.A.; Design – M.A., H.A.; Supervision – M.A., H.A., M.A.D.; Resource – M.A., H.A., M.T.Y.; Materials – M.A., M.A.D., M.T.Y.; Data Collection and/or Processing – M.A., S.K.A.; Analysis and/or Interpretation – M.A., H.A.; Literature Search – M.A., S.K.A.; Writing – M.A., S.K.A.; Critical Reviews – M.A., H.A.

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