C-shaped Incision for Far-Lateral Suboccipital Approach: Anatomical Study and Clinical Correlation

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Abstract

Background The standard incision for far-lateral suboccipital approaches has been the classic “reverse hockey stick.” Although that incision provides ample exposure, concern has been raised that excessive muscle dissection and skin elevation might lead to accumulation of cerebrospinal fluid (CSF) under the flap with increased risk of CSF leak. We hypothesize that the C-shaped incision can minimize the amount of muscle dissection and provide optimal exposure and surgical outcomes.

Objective To describe the anatomical dissection for the C-shaped incision and clinical application of the C-shaped incision for the far-lateral approach.

Methods A retrospective analysis of all the patients operated on at our center using this approach for the treatment of aneurysm of the posterior inferior cerebellar artery (PICA) from 2005 to 2011. Results of clinical and operative outcome are evaluated. Surgical techniques are described in detail. Cadaveric dissections using the C-shaped incision were performed to assess the exposure of the far-lateral suboccipital area.

Results Eleven consecutive patients who had undergone this procedure were selected. All patients underwent clipping of PICA aneurysms. Nine patients (82%) presented with ruptured aneurysms and subarachnoid hemorrhage. All of them underwent suboccipital craniectomy and C1 laminectomy. The dura mater was closed in a watertight fashion in 10 patients (91%). No CSF leak or pseudomeningocele were reported. In nine SAH patients, two (22%) had postoperative dysphagia and required long-term percutaneous endoscopic gastrostomy tube placement. One patient (11%) had chronic respiratory failure and required a tracheostomy. Three patients (33%) developed hydrocephalus and required a ventriculoperitoneal shunt.

Conclusions The C-shaped incision is a valid alternative to the classic reverse hockey-stick incision to gain exposure for far-lateral craniotomies. Knowing the anatomy and dissection techniques can provide an easy and safe route to address anterior lateral cranial-cervical lesions. Our results suggest the C-shaped incision is reliable in preventing CSF leak and the formation of pseudomeningocele.

Keywords

- suboccipital
- far lateral
- pseudomeningocele
- craniectomy
- laminectomy
- aneurysm
- subarachnoid hemorrhage
- dysphagia
- tracheostomy

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Introduction

Adequate exposure and effectiveness in preventing cerebrospinal fluid (CSF) leaks are essential factors for skull base approaches. The far-lateral approach was developed to expose the anterior lateral cranial-cervical junction.^{1–6} Classically, the standard incision for the far-lateral suboccipital approaches has been the “reverse hockey stick” incision where the skin and muscles of the suboccipital area are elevated and reflected inferiorly. Although that incision provides ample exposure, concern has been raised regarding excessive muscle dissection and skin elevation that may lead to the development of pseudomeningocele and/or CSF leaks. This article describes an alternative skin incision to achieve the same exposure of the lateral suboccipital/far-lateral area that we have named the C-shaped incision. We hypothesize that this incision provides the same excellent exposure and minimizes the risk of CSF leak and pseudomeningocele. The step-by-step cadaveric dissection techniques as well as our clinical results in 12 consecutive patients are presented.

Methods

After obtaining Institutional Review Board approval, all patients operated on by the senior author (S.A.) using a C-shaped incision for clipping of a posterior inferior cerebellar artery (PICA) aneurysm from 2005 to 2011 were identified. Cases for both ruptured and unruptured aneurysms are included. Retrospective chart review was performed. In all cases, lateral suboccipital craniectomy was done along with C1 laminectomy and upper condylar resection. Relevant clinical data as well as surgical outcomes were obtained and analyzed. For illustration purposes, the skin incision and muscle dissection was performed on formalin-fixed cadavers, and photographs were taken at each step.

Operative Technique and Results

Patient Positioning

Patient positioning is important not only for the skin incision but for the appropriate dissection of the deep structures. We place the patient in the lateral or park-bench position while keeping the orientation of the head neutral. The neck is flexed laterally to open the angle between the shoulder and the skull base, but no rotation is given to the head. Rotating the head toward the floor results in a rotation of the C1 vertebra and its transverse process that make it more difficult to palpate as well as causing rotation of the rectus capitis lateralis muscle. This rotation causes compression of the jugular vein, coursing on the anterior aspect of the transverse process of C1, which can distort local anatomy and create a greater potential for injury to the vertebral artery, jugular vein, or spinal accessory nerve.

Skin Incision

Placement of the incision is preceded by palpation of bony landmarks of the lateral skull base. The tip of the mastoid, the angle of the jaw, and the transverse process of C1 are palpated

Fig. 1 C-shaped incision is marked. The presumed location of transverse-sigmoid sinus is also marked using the zygomatic arch, inion, and mastoid tip as landmarks.

and marked on the patient's skin. The expected locations of the transverse and sigmoid sinuses are also marked on the patient's skin (► **Fig. 1**). When planning the incision, one has to recognize that the working space for a far-lateral approach is directly posterior to the mastoid tip and the transverse process of C1. Enough space posterior to these two structures (at least 4 cm or ~ 3 finger breadths) is necessary to allow for appropriate visualization and surgical dissection. Starting 4 cm behind the mastoid tip/transverse process of C1, the C-shaped incision is then completed to allow the base of the skin flap to be flush with the line connecting the sigmoid sinus, the mastoid tip, and the transverse process of C1 (► **Fig. 2**).

Muscle Dissection

The orientation of the individual muscles in the suboccipital triangle dictates how these muscles have to be dissected and reflected to obtain maximum exposure with minimal distortion of the normal anatomy. All but two of those muscles have a superior and lateral cranial insertion. The exception is the sternocleidomastoid muscle (SCM) and the superior oblique muscle; all the other muscles run in the general superolateral to inferomedial direction.

In our approach, the SCM is elevated from the periosteum but left attached to the galea and reflected anteriorly with

Fig. 2 C-shaped skin flap is reflected anteriorly.

Fig. 3 The sternocleidomastoid muscle is reflected detached from the insertion and reflected anteriorly with the flap.

the skin flap (►Fig. 3). The splenius capitis is detached from its lateral insertion and reflected inferiorly and medially (►Fig. 4). The next muscle layer, the semispinalis capitis and longissimus capitis, are then exposed and also detached from their lateral insertion and reflected inferiorly and medially (►Fig. 5). The deep muscles of the suboccipital triangle are then exposed. These include the superior oblique, inferior oblique, and rectus capitis major that covers the posterior arch of C1 (►Fig. 6). On the posterior arch of C1, the vertebral artery and surrounding venous plexus on the C1 vertebral artery groove are then palpated and identified (►Fig. 7). At this time, the superior oblique muscle has to be identified and completely resected by detaching it from its cranial insertion and the transverse process of C1. The superior oblique muscle is one of the four muscles that insert on the transverse process of C1; the others are the inferior oblique, the levator scapulae, and the rectus capitis lateralis. Knowledge of these four insertions is important when working near the transverse process of C1 because the dissection in that area carries the risk of injury to the vertebral artery.

In our clinical series we have used both a “layer-by-layer” muscle dissection as well as a in bulk dissection whereby,

Fig. 4 The splenius capitis is detached from its lateral insertion and reflected inferiorly and medially.

Fig. 5 The semispinalis capitis and longissimus capitis are detached laterally and reflected inferiorly and medially. The styloid diaphragm underneath the longissimus muscle is covering the deep muscle layer. Note the occipital artery and vein locate underneath the longissimus muscle.

after the SCM was reflected anteriorly, all the suboccipital muscles down to the suboccipital triangle were reflected inferiorly and posteriorly, leaving only the superior oblique to be dissected and removed separately.

Craniectomy and C1 Laminectomy

Once the occipital squama, the posterior arch of C1, and the dural entry zone of the vertebral artery have been identified, a standard lateral craniectomy is performed and the foramen magnum is opened. The posterior arch of C1 is resected. To obtain good visualization of the lateral medulla, dural entry zone of the vertebral artery, and origin of PICA, we found it important to remove the superior part of the occipital condyle and the adjacent condylar fossa. The extent of the drilling is often dictated by the clival angle of each patient. Patients with a more acute angle require more drilling than others to achieve the same degree of far-lateral exposure. The dura is then opened starting in the cervical spine, crossing the foramen magnum and then curving laterally in the superior aspect of the opening, the same shape as a reverse hockey

Fig. 6 The deep muscles are exposed forming the suboccipital triangle.

Fig. 7 The arch of C1 within the suboccipital triangle is exposed. For illustration purposes, insertions of more superficial muscles are resected.

stick (►Fig. 8). The vertebral artery is not mobilized and the dura is opened posterior (medial) to the artery.

Results

A total of 11 patients were identified. All patients were diagnosed with a PICA aneurysm. Mean age at the time of surgery was 60 years. Mean length of stay was 32 days. Four of 11 (36%) were male; 7 of 11 (64%) were female. Nine patients (82%) presented with subarachnoid hemorrhage and two patients (18%) presented as unruptured. Of the nine patients presented with subarachnoid hemorrhage, two (22%) presented as World Federation of Neurologic Surgeons grade I, three patients (33%) presented as grade II, four patients (44%) presented as grade IV, and one patient (11%) presented as grade V. Dura was closed in a watertight fashion in 10 patients (91%). Complications of patients with subarachnoid hemorrhage are summarized in ►Fig. 9. Two patients (18%) had postoperative dysphagia and required placement of a percutaneous endoscopic gastrostomy tube. One patient (11%) had chronic respiratory failure requiring a tracheostomy. Three patients (33%) developed hydrocephalus and required ventriculoperitoneal shunting. Three patients (11%) experienced vasospasm, requiring treatment in the endovascular suite.

Fig. 8 After suboccipital craniectomy and partial C1 laminectomy is performed, the dura is opened starting in the cervical spine extending through the foramen magnum and then curving laterally.

Postoperative complications

Fig. 9 Summary of complications in subarachnoid hemorrhage patients. PEG, percutaneous endoscopic gastrostomy (tube); VPS, ventriculoperitoneal shunt.

In all 11 cases, no vertebral artery mobilization was necessary and no vertebral artery injuries were reported. No CSF leak, pseudomeningocele, or wound dehiscence/infections occurred. Of nine patients with reliable postoperative clinical examination, no occipital neuralgia, ear numbness, or tongue weakness was reported.

Discussion

Our study presents an alternative skin incision and muscle dissection technique to achieve exposure of the far-lateral region of the skull base. When this incision was used to approach 11 consecutive PICA aneurysms for clipping, good exposure was achieved along with no occurrence of CSF leak or pseudomeningocele.

This incision has been used to gain access to the posterior and lateral craniocervical junction. Both tumors and vascular lesions can be treated through this approach. Heros⁴ and George et al³ described this approach originally in the 1980s, and its variants have been studied and described extensively.^{3,6–13} Lanzino et al⁵ summarized and reviewed this approach in detail. In the classic description,⁴ a “reverse hockey stick” incision is recommended to expose the posterior fossa while at the same time avoiding a laterally placed muscle bulk to interfere with the viewing trajectory. Although such incision is still widely used and provides appropriate exposure, we postulated that a more targeted incision over the lateral aspect of the inferolateral skull base might offer the same degree of exposure while reducing the amount of muscle dissection. Because watertight dural closure in those far-lateral approaches can often be challenging, we hoped that a more conservative muscle dissection would prevent postoperative pseudomeningocele and ideally CSF leak.

In all 11 cases of PICA aneurysm clipping, we did not encounter any difficulties or limitations in exposure, and successful clip ligation of the aneurysm was achieved in all cases with no occurrence of pseudomeningocele or CSF leak. A series very similar to ours was published by D'Ambrosio et al.⁷ Twenty patients with PICA aneurysms treated with the far-lateral approach were reported. In their series, the authors encountered a 15% incidence of CSF leak requiring surgical wound revision, and one patient also had a wound infection. In their description of the technique, the classic reversed hockey incision was used. To decrease the occurrence of CSF

leak, the authors modified their original closing technique and began using free abdominal fat grafts and 48 hours of continuous CSF drainage through a lumbar drain in the final four patients of the series.

In our series, based on a similar patient population treated for PICA aneurysm, we did not encounter any incidence of CSF leak, and no patient required a wound revision. We did not use any fat grafts to augment closure, and we did not insert a lumbar drain postoperatively.

We conclude based on our small series that the use of a C-shaped incision for the far-lateral approach to PICA aneurysm is a step that helps reduce the incidence of CSF leak while still allowing for a successful exposure and clipping of PICA aneurysms.

Conclusion

The C-shaped incision provides adequate exposure for the far-lateral approach. Knowing the anatomy and dissection technique can provide an easy and safe route to address lesions in this area. A C-shaped incision proves to be a good option in preventing CSF leakage and formation of a pseudomeningocele.

Note

The contents of this manuscript have not been presented or published previously.

Disclosure

The authors report no conflict of interest or financial support concerning the materials or methods used in this study or the findings specified in this article. Author contributions to the study and manuscript preparation include the following: conception and design, Agazzi, Lau; acquisition of data, Lau, Olivera, Agazzi, van Loveren; drafting the article, Lau, Reintjes; critically revising the article, Lau, Reintjes; study supervision, Agazzi.

This report was approved by the institutional review board.

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