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Far Lateral Craniotomy Closure Technique for Preservation of Suboccipital Musculature

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Abstract

The far lateral approach is used for accessing pathology at the craniovertebral junction but can be complicated by postoperative suboccipital muscle atrophy. In addition to significant cosmetic deformity, this atrophy can lead to head and neck pain and potentially could contribute to cranio-cervical instability. To address this issue, the senior author began using a single myocutaneous flap without a muscle cuff and securing it directly to the bone using predrilled holes in the bone that resemble a chevron. The method is described and illustrated with an example case. Results from seven consecutive cases are reported since the technique was adopted. Muscle atrophy was measured by calculating area at the level of the occipital condyle and compared with the contralateral side. No significant differences were noted. In conclusion, we have found this to be an excellent closure technique and wanted to present our initial results for consideration by other skull base surgeons.

Keywords

- far lateral
- transcondylar
- muscle atrophy
- modified far lateral
- extreme lateral
- technique

Introduction

The modified far-lateral transcondylar approach is a modification of lateral suboccipital approach involving a suboccipital craniotomy, partial removal of the occipital condyle, mobilizing the vertebral artery, and partial lateral laminectomy of C1 vertebra.[1] This approach provides exposure to structures of ventrolateral craniocervical junction: posterior surface of petrous bone, foramen magnum, jugular foramen, petrosal and suboccipital cerebellum, lower cranial nerves, and vertebrobasilar junction. The far lateral suboccipital craniotomy has gone through an evolutionary process, including many variations in skin incisions and extent of osteotomy.[1–5] We previously reported modifications developed by the senior author (M.W.M.) to reduce risk, while providing adequate exposure to address oncologic pathology arising around the cranio-cervical junction.[6]

Suboccipital muscle atrophy following this approach has not been studied extensively[7,8] but is something that many neurosurgeons have encountered in practice. The traditional teaching for the release of the suboccipital musculature is to incise the muscle just below the superior nuchal line to "leave a cuff" of muscle for reattachment during closure. Retraction of the muscle leaving a hollow in the muscle below the nuchal line, and an apparent lump further down the neck, is what surgeons refer to as postoperative muscle atrophy. This muscle atrophy not only contributes to poor cosmetic outcomes but may also lead to neck pain, abnormal posture, and could potentially contribute to cranio-cervical instability.[9] Here, we describe our experience with a novel technique developed by the senior author to minimize muscular atrophy after far-lateral exposure.

Surgical Technique and Case Example

This study was approved by the authors institutional review board (19–29097) and the subject who provided postoperative photos gave written consent for publication of the pictures.

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Technique

We perform the modified far-lateral approach as previously described.[6] Briefly, the patient is put in a three-quarter prone position. The head is secured in 3-point fixation and turned nearly 160 degrees from vertical with nose pointing toward the floor. An inverted U-shaped incision extending from midline at C2 is opened superiorly to the transverse sinus, laterally to transverse-sigmoid junction, and inferiorly down to the tip of mastoid (►**Fig. 1A**). The suboccipital muscles are elevated with the skin as a single myocutaneous flap with subperiosteal dissection of the ligamentous insertion to the bone at the superior nuchal line. Periosteal elevators and bone chisels are used for this elevation, and we avoid use of the mono-polar electrocautery. The flap is dissected free from C2 lamina inferiorly to 1 cm above the superior nuchal line superiorly and laterally over the mastoid. It is retracted inferiorly and laterally with scalp hooks. Prior to performing the craniotomy, a series of "chevron" holes are made along the superior nuchal line (►**Fig. 1B**). Using the P-CRN drill bit with a straight collar (Anspach, Johnson & Johnson, New Brunswick, New Jersey, United States), a small hole is drilled from above and below the superior nuchal line at a steep tangent to the surface of the bone until they meet in the middle. This creates a channel through which a needle can be passed, allowing an 0 braided absorbable suture (Vicryl, Ethicon, Johnson & Johnson, New Brunswick, New Jersey, United States) to be used to secure the myocutaneous flap to the bone during the closure (►**Fig. 1C, D**). No muscle cuff is

Fig. 1 Far-lateral closure technique with chevron holes. (**A**) Right sided modified far-lateral incision. (**B**) Intraoperative photo showing inferior and lateral retraction of the single layer myocutaneous flap. The superior nuchal line is marked in blue-marking pen, and the chevron hole entry sites are identified by white arrows. (**C**) Intraoperative photo showing path of suture needles through the chevron holes. (**D**) The deep fascia and muscular layer is pulled up to the chevron holes, pulling the myocutaneous flap tight against the occipital bone.

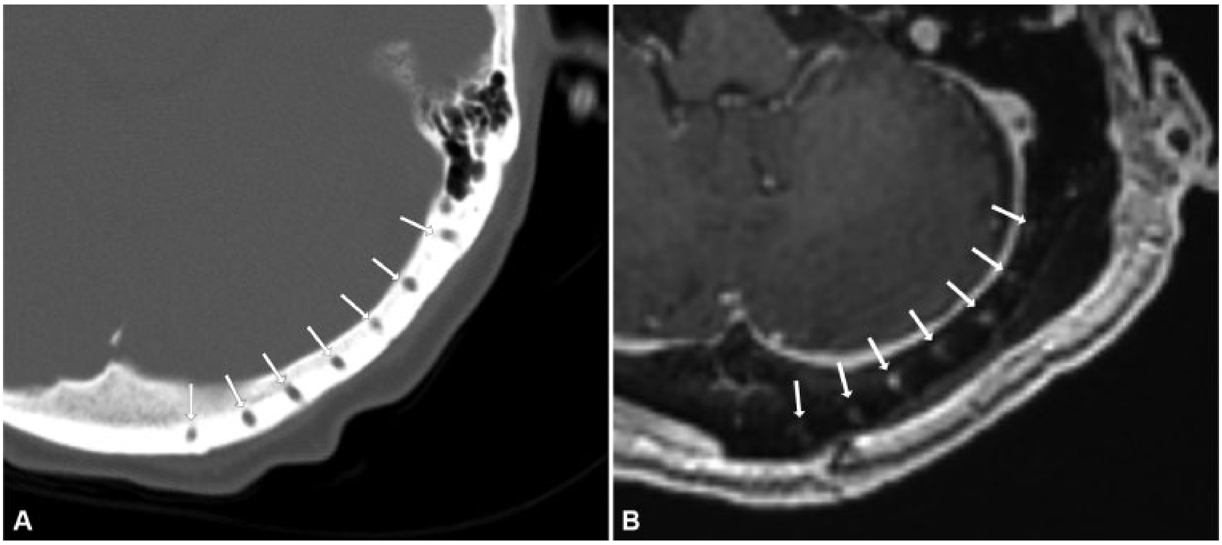

Fig. 2 Postoperative imaging showing the chevron holes. (**A**) Postoperative computed tomography bone window showing path of the chevron holes (white arrows) through the left occipital bone. (**B**) Postoperative T1 postcontrast magnetic resonance imaging showing path of the chevron holes (white arrows) through the left occipital bone.

created. Each hole is about a centimeter apart. The number of holes depends on the extent of the myocutaneous flap. Representative postoperative computed tomography (CT), and magnetic resonance imaging (MRI) reveal the location and position of the chevron holes (►**Fig. 2A, B**).

Following completion of the craniotomy, C1 laminectomy, surgical resection, and dural reconstruction, we reapproximate the muscle group via the fascial band dissected from the bone using 0 braided absorbable suture (Vicryl, Johnson & Johnson, New Brunswick, New Jersey, United States), pulling the fascia and muscular layers tight up against the craniotomy flap, and eliminating dead space by securing the flap to the chevron holes (►**Fig. 1D**). A standard midline muscle and fascial closure is completed with 0 braided absorbable suture (Vicryl, Johnson & Johnson). The subcutaneous tissue and galea are closed with a running 2–0 absorbable stitch (Vicryl, Johnson & Johnson) and the skin with 4–0 monofilament nylon (Novafil, Medtronic, Dublin, Ireland).

Case Example

A female patient presented with progressively worsening symptoms of mild voice hoarseness, dysphagia, gait imbalance, suboccipital headaches, and neck stiffness/pain. MRI revealed a left foramen magnum homogeneously enhancing lesion measuring 2.8×1.8 cm and causing medullary compression (►**Fig. 3A**). The patient was taken to the operating for a left modified far-lateral approach for tumor resection. Gross total resection was achieved, and pathology was grade I meningioma (►**Fig. 3B**). Postoperatively, the patient had some persistent dysphagia and her tongue deviated left. She was able to tolerate a thick nectar diet. Her dysphagia slowly improved. Follow-up clinic visit at 8 weeks demonstrated excellent wound healing and no signs of muscular atrophy (►**Fig. 3C, D**).

Results

We identified seven cases of far lateral craniotomy in past 2 years (2017–2019) where the above technique was used. Patient characteristics are detailed in ►**Table 1**. Muscular atrophy was measured as previously published by Ogiwara et al.[7] Briefly, the suboccipital area was measured on T2-weighted MRI (►**Fig. 4**). Percentage change in muscle bulk was calculated ([contralateral area: ipsilateral area]/contralateral area) multiplied by 100. Areas of pseudomeningocele were subtracted. Outcomes for changes in muscle and soft tissue bulk are reported in ►**Table 1**. Two patients (3 and 4) suffered from pseudomeningocele, one requiring a ventriculoperitoneal shunt placement. Due to the small sample size, statistical significance was not assessed, but our results show preservation of suboccipital muscle bulk in this small cohort.

Discussion

The far-lateral approach is an essential surgical technique in the armamentarium of every skull base surgeon. It provides access to ventrolateral craniocervical junction for a variety of pathologies in this region. Several incisions have been adopted including inverted U-/J-shaped,[1] lazy S[5] and C-shaped.[4] There are very few studies comparing the effect of different incisions on muscular atrophy. A recent paper has demonstrated decreased suboccipital muscular atrophy with a C-shaped incision.[7] In our hands, an inverted U- or J-shaped incision provides excellent exposure, requires minimum muscle dissection by allowing *en bloc* elevation of a myocutaneous flap and preserves neurovascular supply to the muscles. While significant attention is given to preservation of the cranial nerves and patient function, cosmetic and functional complications arising from atrophy of

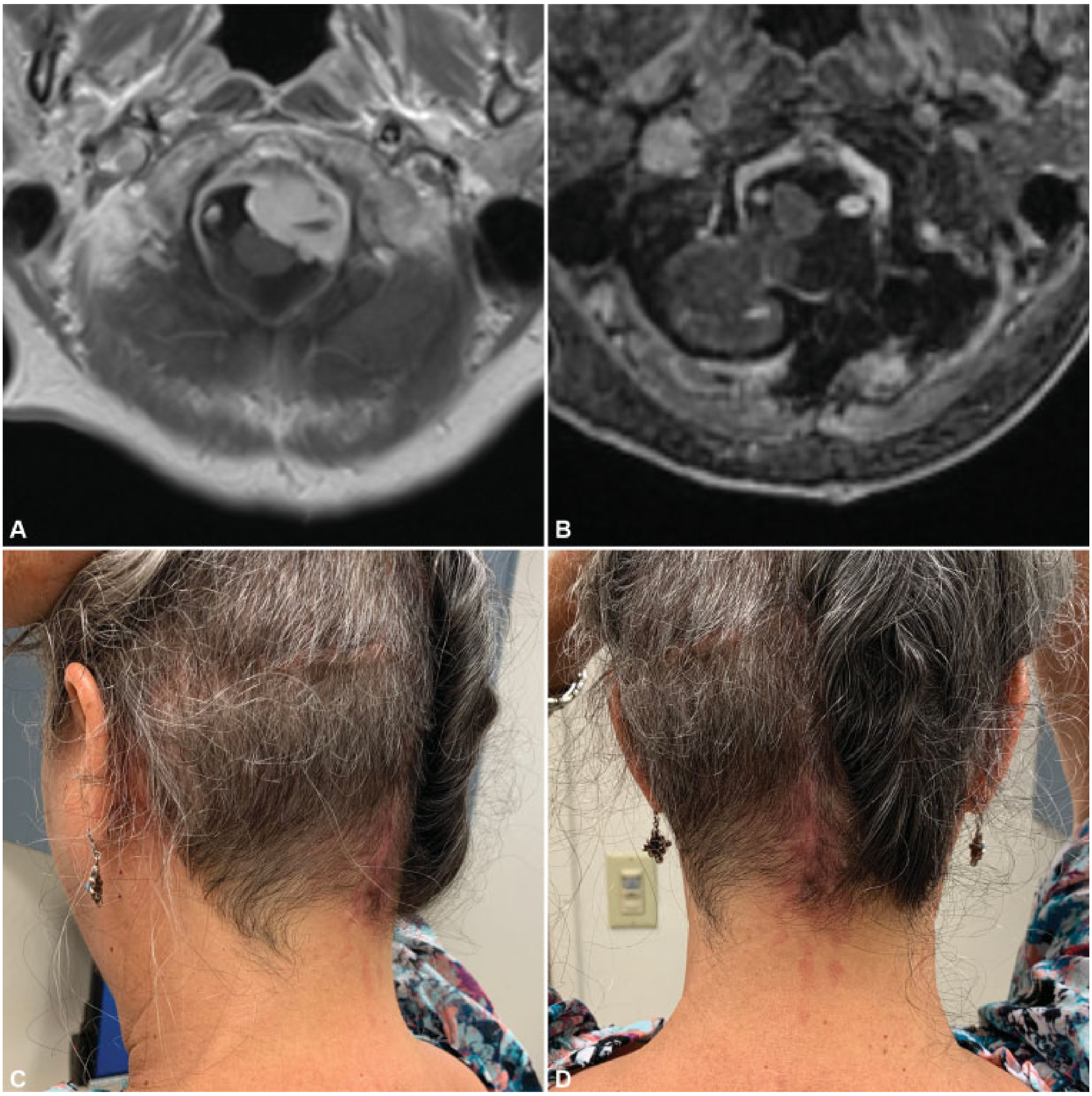

Fig. 3 Case example. (**A**) Preoperative T1 postcontrast MRI showing a left ventro-lateral foramen magnum meningioma causing medullary compression. (**B**) Postoperative T1 postcontrast MRI showing subtotal resection with good medullary decompression and a small residual left on the ventral clivus after a left modified far lateral craniotomy for tumor resection. (**C**) Posterior oblique and (**D**) midline photographs showing preservation of suboccipital muscle bulk at 8 weeks postoperative. MRI, magnetic resonance imaging.

Table 1 Patient cohort

	Age	Sex	Pathology	Complications	Follow-up (mo)	Muscle bulk (% change)
1	81	F	FM MNG, GII	Right CN XI deficit	15	−2.3
2	36	F	VS/MNG, GI	None	7	0.0
3	76	F	FM MNG, GI	Pseudomeningocele requiring VPS	10	−9.9
4	66	F	C1 synovial cyst	Pseudomeningocele	7	−9.2
5	64	M	CAPNON	None	4	−6.7
6	63	F	FM MNG, GI	Mild dysphagia	2	−1.2
7	62	F	Petrous MNG, GI	Small pseudomeningocele	2	−5.4

Abbreviations: −, smaller ipsilateral suboccipital area; CAPNON, calcifying pseudo-neoplasm of the neuroaxis; CN XI, cranial nerve XII; FM, foramen magnum; GI, MNG, meningioma; GII, WHO grade II; VPS, ventriculoperitoneal shunt; GI, WHO grade I.

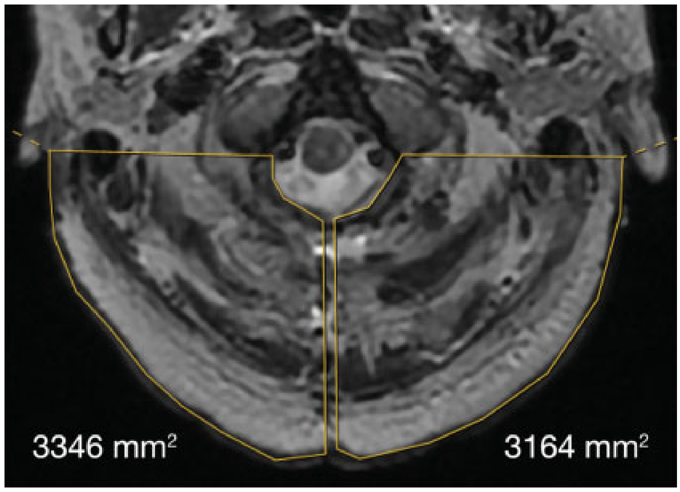

Fig. 4 Measurement of suboccipital muscle bulk. Example measurement from subject 7 who underwent resection of large left petrous face meningioma via a far lateral approach. The area of suboccipital musculature was measured at the level of the occipital condyle/mastoid tip on axial T2 weighted magnetic resonance images. There was a 5.4% loss of muscle and soft tissue bulk compared with the contralateral side.

suboccipital muscle groups can also have consequences for patients, resulting in head and neck pain, and possibly contributing to cranio-cervical instability.[7,8] By not dissecting any of the suboccipital musculature and using a myocutaneous flap without cutting a muscle cuff, we can achieve maximal preservation of the suboccipital muscle bulk and the neurovascular supply to the muscle. Cutting a muscle cuff adds to the devascularization of the muscle group and does not allow a secure method for reattaching the muscle group back to the occipital bone. Use of the chevron holes allows excellent approximation of the myocutaneous flap to the underlying craniotomy utilizing the edge of the fascial insertion of the muscle group to the bone. After disinsertion of the fascial attachment to the bone, the white band of fascia can clearly be seen deep to the galea as the suboccipital muscles are dissected off the bone toward foramen magnum. This band is the landmark for placement of sutures to reapproximate the muscle group.

While we subjectively noted less head and neck pain in these patients, the current study is not sufficiently sized or controlled to evaluate these outcomes. Limitations of the study include the small sample size and relatively short follow-up. Longer term follow up will be needed to see whether muscle atrophy progresses at later time points. Future prospective studies will be needed to carefully assess the impact on postoperative headache and neck pain outcomes.

Conclusion

Chevron holes in the bone at the superior nuchal line allow excellent approximation of the myocutaneous flap and preservation of the suboccipital musculature after far lateral craniotomy and may be considered for use by other neurosurgeons.

Funding
None.

Conflict of Interest
None declared.

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