Clinical Study

Modified skin incision for avoiding the lesser occipital nerve and occipital artery during retrosigmoid craniotomy: potential applications for enhancing operative working distance and angles while minimizing the risk of postoperative neuralgias and intraoperative hemorrhage

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\begin{abstract}
Chronic postoperative neuralgias and headache following retrosigmoid craniotomy can be uncomfortable for the patient. We aimed to better elucidate the regional nerve anatomy in an effort to minimize this postoperative complication. Ten adult cadaveric heads (20 sides) were dissected to observe the relationship between the lesser occipital nerve and a traditional linear versus modified U incision during retrosigmoid craniotomy. Additionally, the relationship between these incisions and the occipital artery were observed. The lesser occipital nerve was found to have two types of course. Type I nerves (60%) remained close to the posterior border of the sternocleidomastoid muscle and some crossed anteriorly over the sternocleidomastoid muscle near the mastoid process. Type II nerves (40%) left the posterior border of the sternocleidomastoid muscle and swung medially (up to 4.5 cm posterior to the posterior border of the sternocleidomastoid muscle) as they ascended over the occiput. The lesser occipital nerve was near a midpoint of a line between the external occipital protuberance and mastoid process. Type II nerves (40%) left the posterior border of the sternocleidomastoid muscle and swung medially (up to 4.5 cm posterior to the posterior border of the sternocleidomastoid muscle) as they ascended over the occiput. The lesser occipital nerve was near a midpoint of a line between the external occipital protuberance and mastoid process in all specimens with the type II nerve configuration. Based on our findings, the inverted U incision would be less likely to injure the type II nerves but would necessarily cross over type I nerves, especially more cranially on the nerve at the apex of the incision. As the more traditional linear incision would most likely transect the type I nerves and more so near their trunk, the U incision may be the overall better choice in avoiding neural and occipital artery injury during retrosigmoid approaches.
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1. Introduction

Retrosigmoid craniotomy is a standard approach used by the neurosurgeon. Some patients have significant headaches following retrosigmoid craniotomy. Such a complication has also been found to affect postoperative quality of life in these patients [1]. Postoperative headache following retrosigmoid craniotomy is a well-known entity and although multifactorial, may be due to occipital nerve transection, entrapment, or neuroma formation.

The lesser occipital nerve is classically described as arising from cervical two (C2) and C3 ventral rami and then courses around the posterior and deep surface of the sternocleidomastoid to ascend parallel with the muscle's posterior border. Occasionally, the nerve may pierce the sternocleidomastoid muscle. Near the cranium, the lesser occipital nerve perforates the deep fascia and passes up into the scalp around the auricle to supply the skin and connect with the great auricular and greater occipital nerves and auricular branch of the facial nerve [2,3]. The nerve also supplies an auricular branch, which supplies sensory innervation to the upper and medial thirds of the auricle. This branch also communicates with the posterior branch of the great auricular nerve.
Compression or stretching of the lesser occipital nerve may result in cervicogenic headaches or occipitoparietal migraines, thus the lack of a definitive nerve blockade site makes it difficult to treat these headaches [1].

The senior author (A. C-G.) has been using the reverse “U” incision (Fig. 1) for retrosigmoid craniotomy as described by Dandy [4] for the past 3 years and has noted a decreased rate of postoperative headaches and more specifically occipital pain among his patients. Therefore, we performed the current cadaveric study to better elucidate the regional anatomy and to compare this incision with the more typical linear incision in regard to regional neurovascular bundles. The advantages of the “U” incision for improving the operative working distance and angles will also be reviewed.

2. Materials and methods

For the present study, 10 adult formalin-fixed cadaveric heads (20 sides) were used. These specimens were derived from five male and five female adult cadavers with an average age at death of 63 years (range 55 to 79 years). In the prone position, the subcutaneous tissues of the posterior head and upper cervical spine, from posterior to the pinna to approximately 2 cm lateral to the midline were dissected. The relationship between the lesser occipital nerve in the region where a standard retrosigmoid craniotomy would be performed was observed. Specifically, the relationship with the lesser occipital nerve to a traditional linear and modified U incision was recorded.

The 7 cm linear incision was localized 0.5 cm posterior and parallel to the mastoid groove and one third above and two thirds below the transverse sinus. The curvilinear incision was determined as follows: A line connecting the inion to the root of zygoma was marked. The junction of this line with extension of the line marking the mastoid groove was noted as the summit of the incision. A wide-based curvilinear “U” incision dependent on this summit was marked (Fig. 1). Relationships between the linear and modified incision and the occipital artery were also observed. All measurements were made with digital calipers (Mitutoyo, Japan). No specimen was found to have prior surgery or gross injury to the areas dissected. Statistical analysis between sides and sex was performed using Statistica for Windows (Dell; Tulsa, OK USA) with significance set at p < 0.05.

3. Results

No pathology was identified in the region of dissection for any specimen. A lesser occipital nerve was identified on all sides. The nerve was not duplicated or triplicated on any side. The lesser occipital nerve was on average 6.8 cm lateral to the external occipital protuberance. However, the nerve was found to have two types of course. Type I nerves (12 sides; 60%) (Fig. 2) remained close (no greater than 1 cm) to the posterior border of the sternocleidomastoid muscle along its entirety, and continued onto the occiput more or less in line with this posterior border even after the muscle attached to the skull but with a small deviation toward the posterior pinna. Some type I nerves crossed anteriorly over the sternocleidomastoid muscle near the mastoid process.

Fig. 1. Schematic drawing of the positioning of a craniotomy for left-sided retrosigmoid approaches. The dotted white line connects the root of the zygoma and the inion and marks the level of the transverse sinus. The vertical blue line is the mastoid groove. The junction of these two lines is the summit of the incision and approximates the junction of the transverse and sigmoid sinuses. [With permission from The Neurosurgical Atlas by Aaron Cohen-Gadol, MD] [30].

Fig. 2. Left-side cadaveric dissection of the lesser occipital nerve. Note that this represents a type I nerve that hugs the posterior border of the sternocleidomastoid muscle along most of its course and in this case courses laterally and crosses the muscle. The locations of the linear and curvilinear incisions are marked. Note that the linear incision transects the nerve while the curvilinear incision cross over the nerve, especially more cranially on the nerve at the apex of the incision.
Type II nerves (8 sides; 40%) (Fig. 3) left the posterior border of the sternocleidomastoid muscle and swung medially (up to 4.5 cm posterior to the posterior border of the sternocleidomastoid muscle) over the nuchal region as they ascended over the occiput.

The lesser occipital nerve was near a midpoint of a line between the external occipital protuberance and mastoid process in all specimens with a type II nerve configuration. However, type I nerves were found at a point about one third of the distance along a line drawn from the mastoid process to the external occipital protuberance. The linear incision placed the type I nerves at greater risk of injury while type II nerves were less likely to be injured via such an incision (Fig. 1).

The inverted U incision was less likely to injure the type II nerves but would necessarily cross over type I nerves, especially more cranially on the nerve at the apex of the incision. On two (10%) right sides, the lesser occipital nerve pierced the sternocleidomastoid muscle prior to the muscle’s attachment onto the skull. On one (5%) left side, the nerve pierced the splenius capitis muscle briefly before continuing to the skin overlying the skull. Each of these nerves that pierced muscles were type I nerves. Although type II lesser occipital nerves tended to be more frequent on left sides, this did not reach statistical significance.

Additionally, the traditional linear incision leads to accumulation of the scalp and underlying muscle under the retractor that increases the working distance of the surgeon toward the cerebellar pontine angle (CP). The curvilinear incision mobilizes the scalp flap inferiorly and avoids this problem (Fig. 4).

Lastly, traditional linear incisions in this area were more likely to transect the main trunk of the occipital artery (Fig. 5). The modified U incision was less likely to transect the artery, especially when the medial limb of the incision was shortened. No statistical differences were seen comparing male or female specimens.

4. Discussion

There are relatively few anatomic landmarks that have been cited in the literature for identifying the lesser occipital nerve [5,6]. Most studies have focused on landmarks for the more medially positioned greater occipital nerve [7]. Dash et al. [8] found that blockage of the lesser occipital nerve was best performed in an area approximately 3 cm in diameter centered at a point 6.5 cm from the midline and 5.3 cm inferior to a line connecting the external auditory canals. Another study found that the main lesser occipital nerve trunk was found on average 7 cm lateral to the external occipital protuberance [9]. Our study found that the main lesser occipital nerve has two types and that type I nerves were closer to the region of the mastoid process in their distribution and were therefore, more likely to be damaged with the traditionally used linear skin incision for retrosigmoid craniotomies. The modified U incision, especially when a shorter medial arm was used, was less likely to transect the main trunk of the lesser occipital nerve and moreover, avoided the main stem of the occipital artery (Fig. 5).

Patients undergoing craniotomy are at risk for chronic headaches [10–20]. Schankin et al. [21] investigated patients with postoperative headaches following craniotomy and classified the types of headaches based on criteria defined by the International Headache Society [22]. These authors identified five different types of headaches and occipital neuralgia was the second most common type making up 16.6% of postoperative headaches sufferers [21]. These postoperative headaches, therefore, might be amenable to surgical decompression of the nerves overlying the occiput, which might be entrapped following craniotomy [23,24]. Moreover, Ducic et al. [1] identified patients with medically recalcitrant postoperative headache where the headache resolved following excision of the injured cutaneous nerve overlying the occiput. These authors concluded that all chronic cases of postoperative headache should be screened for potential occipital nerve injury. In their series, 7 patients with postoperative headache had evidence of occipital nerve injury (neuroma/scar tissue entrapment) and those who underwent occipital nerve excision were found to have an 80% or more decrease in headache.

Unrecognized occipital nerve injuries have been found to be a leading cause of chronic occipital neuralgia in patients who have undergone vestibular schwannoma resection. Treatment of this chronic ipsilateral pain by neuroma excision with implantation of the nerve stump to muscle has been described [25]. However, some examples of midline crossing of the occipital nerves have been reported so that unilateral injury could result in bilateral pain [5]. Additionally, multiple proximal interconnections between the upper cervical nerves can often result in mixed clinical presentations where the treatment options are not clear [26,27]. Interestingly, Schessel et al. [28] modified their incision for cranioplasty in an attempt to avoid occipital nerve injury and found that this had no effect on the incidence and severity of pain. We have used the “U” incision with a wider base for large posterior fossa tumors, including vestibular schwannomas and have noted rare instances of patients suffering from chronic headaches.

4.1. The effect of incision on operative distance and working angles

We initially abandoned the linear incision for these retrosigmoid approaches in favor of the “U” incision due to the difficulties we encountered while using the linear incision. These difficulties...
included accumulation of the scalp and underlying muscle under the retractor that increased the working distance of the surgeon toward the cerebellopontine angle. (b) The curvilinear incision mobilizes the scalp flap inferiorly and avoids this problem (with permission from Clarian/IU Health).

Moreover, this increase in the working distance led to limitation of working angles within the CP cisterns. These limitations were especially problematic among obese patients. Even though our original intent was to use the “U” incision for improving our working distance and angles, we have noticed a decreased rate of postoperative headaches among our patients. However, this conclusion should be confirmed through a randomized trial.

5. Conclusions

The main trunk of the lesser occipital nerve is near the traditional incisions used for retrosigmoid craniotomy. Based on our findings, the inverted U incision would be less likely to injure the type II nerves but would necessarily cross over type I nerves, especially more cranially on the nerve at the apex of the incision. As the more traditional linear incision would also most likely transect the type I nerves, the U incision would be the overall better choice in avoiding superficial neural injury of the main trunk of the lesser occipital nerve and occipital artery during retrosigmoid approaches. These findings support our recent experience with the U incision and patients who seem to experience apparently less postoperative discomfort and improved wound healing.

Conflicts of Interest/Disclosures

The authors declare that they have no financial or other conflicts of interest in relation to this research and its publication.

References


