

Identification of greater occipital nerve landmarks for the treatment of occipital neuralgia

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Important structures involved in the pathogenesis of occipital headache include the aponeurotic attachments of the trapezius and semispinalis capitis muscles to the occipital bone. The greater occipital nerve (GON) can become entrapped as it passes through these aponeuroses, causing symptoms of occipital neuralgia. The aim of this study was to identify topographic landmarks for accurate identification of GON, which might facilitate its anaesthetic blockade. The course and distribution of GON and its relation to the aponeuroses of the trapezius and semispinalis capitis were examined in 100 formalin-fixed adult cadavers. In addition, the relative position of the nerve on a horizontal line between the external occipital protuberance and the mastoid process, as well as between the mastoid processes was measured. The greater occipital nerve was found bilaterally in all specimens. It was located at a mean distance of 3.8 cm (range 1.5–7.5 cm) lateral to a vertical line through the external occipital protuberance and the spinous processes of the cervical vertebrae 2–7. It was also located approximately 41% of the distance along the intermastoid line (medial to a mastoid process) and 22% of the distance between the external occipital protuberance and the mastoid process. The location of GON for anaesthesia or any other neurosurgical procedure has been established as one thumb's breadth lateral to the external occipital protuberance (2 cm laterally) and approximately at the base of the thumb nail (2 cm inferior). This is the first study proposing the use of landmarks in relation to anthropometric measurements. On the basis of these observations we propose a target zone for local anaesthetic injection that is based on easily identifiable landmarks and suggest that injection at this target point could be of benefit in the relief of occipital neuralgia.

Key words: greater occipital nerve, anatomy, occipital neuralgia, nerve block, anaesthesia

INTRODUCTION

Invasive neurosurgical procedures, such as approaches to the foramen magnum, cerebellopontine angle and upper cervical spine, occur in the posterior head and neck [22]. In addition, neurosurgical interventions such as halo and Mayfield pin placement, require an adequate understanding of the cutaneous nerves located in the occipital region in order to prevent severe dysaesthesia [28]. Bogduk [5] suggested the possibility of inducing *anaesthesia dolorosa* by cutting these nerves with incisions over the posterior head and neck. Similarly, Ebraheim et al. [9] identified traumatic neuroma formations as one of the complications that may accompany halo pin placement. Although the surgical anatomy of the greater occipital nerve (GON) has been described [3, 6, 35], its peripheral course varies and thus make it difficult to localise for the diagnosis and therapeutic treatment of occipital neuralgia.

Occipital neuralgia is a common cause of headache and is characterised by paroxysmal stabbing pain [1]. Examination of patients suffering from occipital neuralgia reveals pain and tenderness along the course of GON [1, 14, 27]. In addition, patients usually complain of continuous unilateral pain (bilateral during severe attacks) throughout the occipital and parietal scalp [14, 26]. Furthermore, hyperalgesia, dysaesthesia and paroxysmal vertigo are conditions often associated with occipital neuralgia and are similar to the symptoms that accompany migraine headaches [1, 26]. The diagnosis of occipital neuralgia is made when disease or injury to GON or its roots is believed to be the cause of symptoms [4].

The dorsal ramus of C2 spinal nerve emerges between the posterior arch of the atlas and the lamina of the axis and inferior to the *obliquus capitis inferior* [30], where it divides into a larger medial branch and smaller lateral branches [30]. The medial branch of the ramus provides motor branches to the muscles it traverses and terminates as GON [30], while the lateral branches supply the *splenius capitis*, *longissimus capitis* and *semispinalis capitis* muscles [30].

As suggested by Gawel and Rothbart, this nerve may also receive fibres from C3 dorsal ramus [10]. The greater occipital nerve ascends between the *obliquus capitis inferior* and *semispinalis capitis* and then pierces the latter muscle [12, 30]. After piercing the trapezius aponeurosis, it travels with the occipital artery to supply the integument of

the scalp as far anterior as the vertex of the skull [12, 30].

Possible zones of GON irritation and entrapment include the point at which the nerve emerges from C2 dorsal ramus between the atlas and the axis [14, 31], the point where GON courses between the *obliquus capitis inferior* and *semispinalis capitis* muscles, the point where it pierces the belly of the *semispinalis capitis* muscle and at the point of exit from the tendinous aponeurosis of the trapezius [35].

Entrapment of GON may cause occipital neuralgia and neurolysis of this nerve, particularly with regard to the trapezius aponeurosis, has been performed [7]. However, studies have shown that this procedure does not always eliminate the recurrence of pain [7]. Local anaesthetic nerve block of the GON has been shown to be the most efficient diagnostic and therapeutic tool in treating this disorder [1, 2, 10, 26, 36].

Recent anatomical studies have focused on providing bony landmarks for the identification of the topographic location of the GON in order to specify accurate locations for anaesthetic nerve block injections [1, 26, 36]. In addition, there is great disagreement concerning the location and landmarks of GON, despite the fact that standard anatomical textbooks have extensively described the anatomy of this nerve. A typical example is the identification of the external occipital protuberance as a landmark for identifying the location of GON. However, it is interesting to note that none of the studies performed has taken into account the anthropometric variations of the skull [1, 26, 36].

Therefore the aim of this study was to identify landmarks for the localisation of GON while eliminating the factor of skull size variation in order to provide more efficient points for anaesthesia in the treatment of occipital neuralgia.

MATERIAL AND METHODS

We examined 80 adult human cadavers during the gross anatomy course at Harvard Medical School and 20 cadavers in a similar course at St George's University in Grenada. The age range was between 58 and 86 years with a mean age of 71 years. All cadavers (35 male and 65 female) were fixed in formalin/phenol/alcohol solution. None of the cadavers revealed any evidence of gross pathology, previous surgical procedures or traumatic lesions to the occiput.

Following preliminary examination, images from all the dissected specimens were recorded with a Sony digital camera (model: Sony Cyber-Shot DSC-f717) and studied using a computer-assisted image analysis system (all measurements were carried out with

the Lucia software 5.0 [2000, edition for Windows XP], made by Nikon [Laboratory Imaging Ltd.]. The digital camera was connected to an image processor (Nvidia GeForce 6800 GT) linked to a computer. Digitised images of GON, together with surrounding structures, were stored in the Lucia program (2048 × 1536 pixels). After applying a standard 1 mm scale to all pictures within the program, Lucia was able to use this information to calculate pixel differences between two selected points (ex. origin-termination) on a given nerve, as previously described [23]. The purpose of the software was to allow easy and accurate translation of pixel differences into metric measurements.

The greater occipital nerve was dissected from the periphery to its origin. The topographical relation of GON to the *semispinalis capitis* (piercing each muscle by its trunk stem or as branches) was recorded.

Three reference points were defined for all measurements: a vertical line from the external occipital protuberance to the spinous process of C7 (even if there were some lateral deviation of the spine); the intermastoid line connecting the inferior tips of the mastoid processes; the line connecting the external occipital protuberance to the mastoid process.

Measurements included the diameter of GON (at the exit point from the trapezius aponeurosis) over the occiput and adjacent cranium. In addition, the distance from the exit point of GON to the horizontal line (intermastoid line) and the distance from the point of surfacing of GON to the vertical line were measured.

RESULTS

The greater occipital nerve was present bilaterally in all specimens and was located at a mean distance of 3.8 cm lateral to the vertical line (range 1.5–7.5 cm). It was also located approximately $41 \pm \pm 3\%$ of the distance along the intermastoid line (medial to a mastoid process) (Fig. 1) and $22 \pm 2\%$ of the distance from the external occipital protuberance to the mastoid process (Fig. 2, 3). The greater occipital nerve pierced the *semispinalis capitis* muscle 2 cm (range 1.1–4.2 cm) superior to the intermastoid line. The mean diameter of GON was 3.5 mm (range 1.8–5.1 mm). The nerve divided into medial and lateral branches 4 cm superior to the intermastoid line (range 0–2.5 cm).

The greater occipital nerve was located one thumb's breadth (2 cm) lateral to the external occipital protuberance and approximately at the base

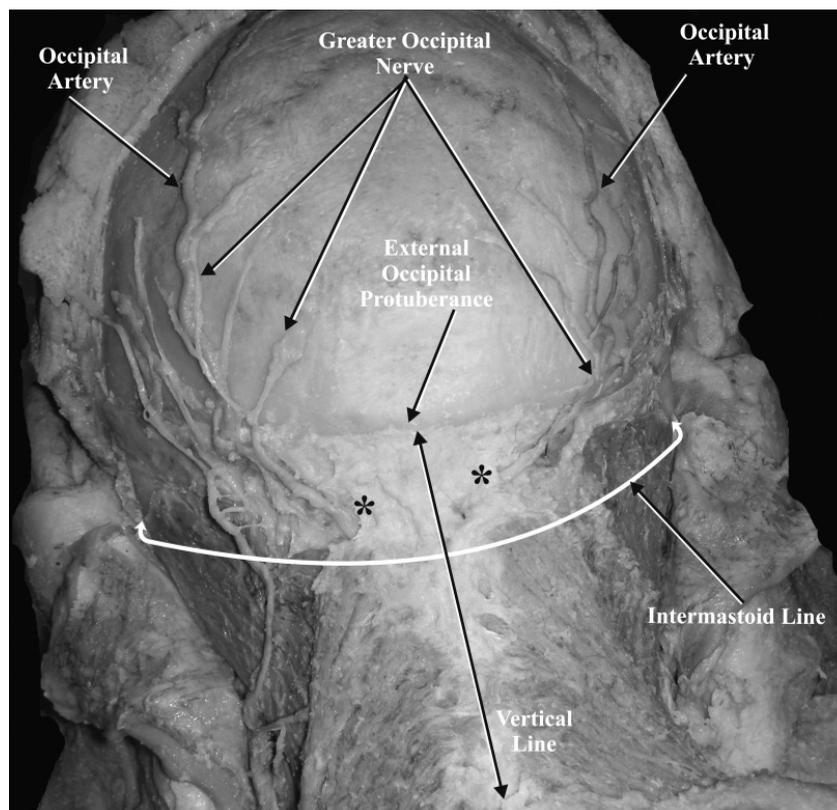


Figure 1. The relationship of the right and left greater occipital nerves (*) at their exit point with the vertical and intermastoid lines.

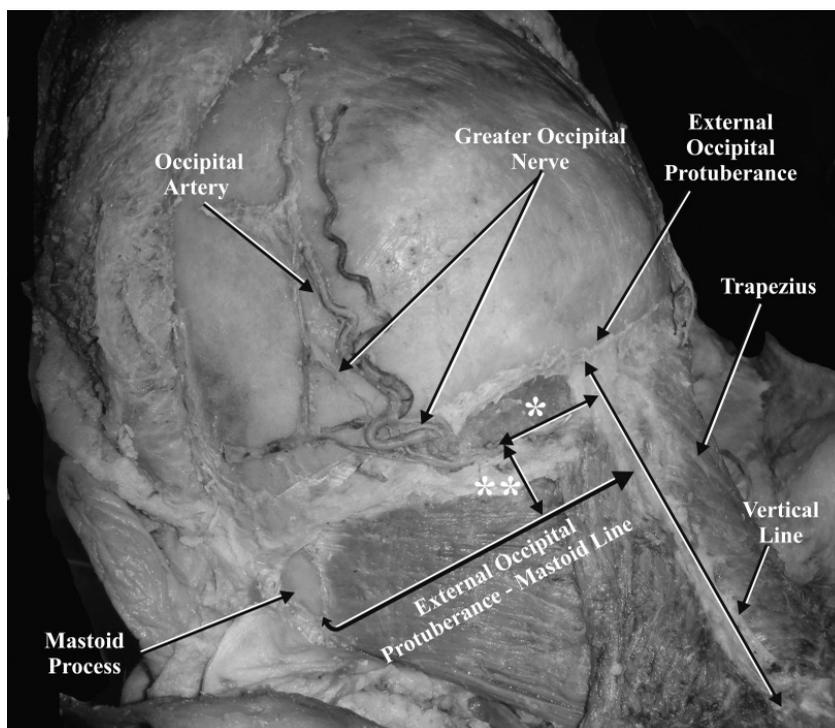


Figure 2. The relationship of the left greater occipital nerve at its exit point with the external occipital protuberance-mastoid line and the vertical line. In addition, the single asterisk (*) reveals the distance of the left greater occipital nerve at its exit point from the trapezius aponeurosis, to the vertical line. The double asterisk (**) reveals the distance of the greater occipital nerve from its exit point to the external occipital protuberance-mastoid line.

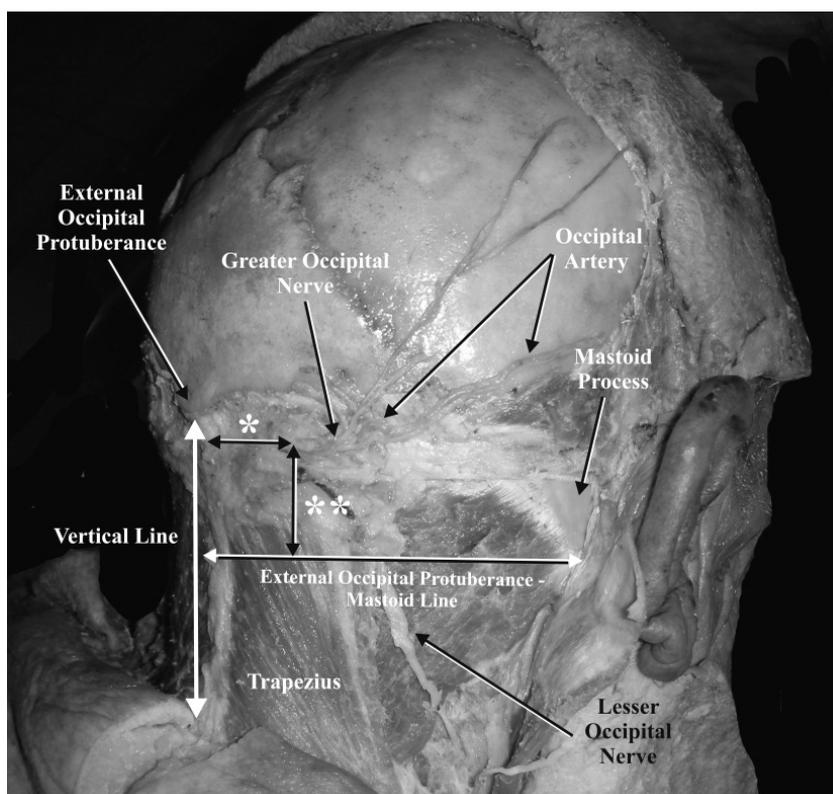


Figure 3. The relationship of the right greater occipital nerve at its exit point with the external occipital protuberance-mastoid line and the vertical line. In addition, the single asterisk (*) reveals the distance of the left greater occipital nerve at its exit point from the trapezius aponeurosis, to the vertical line. The double asterisk (**) reveals the distance of the greater occipital nerve from its exit point to the external occipital protuberance-mastoid line.

of the thumb nail (2 cm inferior to the external occipital protuberance).

No significant differences were found between sides, gender and mastoid processes (Student's *t* test; $p > 0.05$).

DISCUSSION

A diagnostic criterion for occipital neuralgia is the alleviation of occipital pain with local anaesthetic [1]. Long-term therapeutic local anaesthesia for the GON requires the identification of landmarks to determine optimum injection sites. The greater occipital nerve is a winding nerve with looping angles around the nuchal ligament and suboccipital musculature [8, 11, 13, 32, 34]. Its winding course makes it more prone to compression at different points [15, 18–21]. Vulnerable sites along the course of the GON include the point where it rounds the *obliquus capitis inferior* [16, 35], the point where it pierces the belly of the *semispinalis capitis* [4] and the point where it pierces the trapezius aponeurotic band [24, 34].

Vital et al. [35], identified as two risk zones the point at which GON pierces the *semispinalis capitis* muscle and where it pierces the trapezius aponeurotic band. Bogduk's hypothesis was that contraction of the *semispinalis capitis* may be responsible for compressing GON [4, 35]. When perforating the trapezius aponeurotic band, contraction of the trapezius would pull the band inferiorly and away from GON and therefore would not result in entrapment of the nerve [4, 35]. However, where it perforates the trapezius aponeurosis the nerve is still at risk because tendonitis can lead to nerve irritation [4, 35].

Ward [36] proposed locating GON just medial to the palpated occipital artery and directing the injection needle 90° towards the bony endpoint of the occiput for anaesthesia. Ashkenazi and Levin [1] anaesthetised GON by injecting anaesthetic agent 35 mm inferolaterally to the external occipital protuberance. In treating patients suffering from occipital neuralgia Natsis et al. [26] recommended injecting patients 20–25 mm inferior to the external occipital protuberance and approximately 15 mm lateral to the midline. Lastly, Tubbs et al. [33] identified GON 4 cm lateral to the external occipital protuberance and piercing the *semispinalis capitis* muscle approximately 2 cm superior to the intermastoid line.

The medium or long-term success of anaesthesia of GON is uncertain without the identification of optimal injection sites [26]. Recent studies have

designated injection sites for anaesthetising GON without accounting for anthropometric variations of the skull. The recurrence of occipital neuralgia and incomplete impairment of the nociceptive conduction of the GON has given rise to complications from repeated injections, such as Cushing's syndrome [17]. The greater occipital nerve block requires optimisation of injection point locations to ensure efficient anaesthesia. It is possible that ignoring skull anthropometric variations may be one of the factors contributing to the re-occurrence of the debilitating symptoms of occipital neuralgia.

Inspired by incision location when treating appendicitis, we propose adapting the same theory in the treatment of occipital neuralgia. The appendix can be located two thirds of the distance between the umbilicus and the anterior superior iliac spine away from the umbilicus at McBurney's point [29]. Tenderness at this point is a symptom of acute appendicitis [25, 29]. For the treatment of occipital neuralgia, we examined the course and distribution of GON in relationship to the aponeurosis of the trapezius and *semispinalis capitis* muscle. Furthermore, using two bony landmarks, we correlated the position of GON where it penetrates the aponeurotic band with the distances from the external occipital protuberance to the mastoid process and from one mastoid process to the other along the intermastoid line. While considering anthropometric skull variations, we observed that GON emerged from the aponeurosis of the trapezius muscle at 22% of the distance from the external occipital protuberance to the tip of the mastoid process or at 41% of the length of the intermastoid line.

CONCLUSIONS

This is the first study to propose the use of landmarks in relationship to anthropometric measurements in the treatment of occipital neuralgia. It is hoped that this study will provide clinicians, researchers and anatomists with data regarding the variable peripheral course of GON in treating occipital neuralgia. Clinically, extensive knowledge of all possible anatomical variations as well as identifiable landmarks would prove useful for the administration of local anaesthetic nerve block. The application of these data may optimise GON block procedures by taking into account varying skull sizes and thus improving efficiency as well as decreasing the recurrence of occipital neuralgia.

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