Superficial surgical landmarks for the transverse sinus and torcular herophili

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Object. The purpose of this anatomical study is to identify reliable external landmarks that can be used to determine accurately the lower border of the proximal segment of the transverse sinus (TS).

Methods. The authors used 15 formalin-fixed cadaveric specimens for this project. Various anatomical structures were dissected and measurements of the distance between these structures and the proximal TS were obtained.

The data collected in this study demonstrate that the inion is not always a reliable external landmark to use when determining the internal location of the very proximal TS and its drainage into the area of the torcular herophili. In addition, the authors found that the most accurate external landmark to use in reliably estimating the internal placement of the proximal TS is the point of insertion of the musculus semispinalis capitus and not the superior nuchal line. In the present study, this muscle never covered more than 5 mm of the inferior edge of the TS and was found to be a reliable anatomical structure for avoiding the medial segment of the TS.

Conclusions. These findings could aid the surgeon in localizing the TS with various midline approaches to the posterior fossa and the craniocervical junction.

Key Words • transverse sinus • torcular herophili • inion • anatomical study • posterior fossa

EUROSURGEONS must always be aware of the location of intracranial entities such as the TS before beginning a surgical procedure. Traditionally, the inion and SNL have been used to estimate where the very proximal TS/torcular herophili and the medial half of the TS lie, respectively, within the cranium.1–3,11 From our experience, these two bone landmarks are not always adequate in determining exactly where the medial venous sinuses lie. Although bone landmarks may not have developed or may not be readily palpated, muscle insertion is established in utero and is easily palpated and seen intraoperatively. In this study we specifically looked at the spot where the MSC is inserted into the external occiput as a superficial landmark for the intracranial course of the medial TS. Our examination also measured distances between occipital bone landmarks and the proximal TS. Our study has found that, compared with the SNL, the MSC is a more reliable anatomical structure and is easily used for intraoperative identification of the lower border of the medial segment of the TS. Our hope is that these measurements will aid the surgeon with preoperative planning and intraoperative localization.

Materials and Methods

Fifteen formalin-fixed human cadaveric specimens were studied. None of the specimens exhibited any obvious intracranial or craniocervical pathological condition. Also, none of our specimens exhibited any pre- or postfixation of the sinuses at the torcular herophili or the medial segment of the TS.7 The cadavers ranged in age from 61 to 83 years, with a mean age of 74 years. Six female and nine male cadavers were used. On both sides of the cadavers (30 sides), the MSC and its relation to the inferior edge of the proximal TS were studied. An area extending from 4 cm above the inion to the spinous process of the axis was dissected and the overlying skin and fascia were removed. Next, the upper musculus trapezius and musculus splenius capitus were dissected and removed bilaterally. We carefully dissected the upper third of the MSC while paying close attention to its insertion point into the occiput between the superior and inferior nuchal lines. Next, the calvaria was removed in the horizontal plane by using an oscillating bone saw at a level 6 cm above the inion. The brain was removed. All measurements were made using calipers and specimens were observed using × 2.5 loupes magnification. Measurements were first made of the MSC at its insertion site. Next, several holes were drilled into the skull along the apex of the insertion of this muscle. The apex of the MSC was defined as the most cranial fibers of the muscle. The holes were all placed in the horizontal plane. Measurements were made to determine the relationship between the insertion of the uppermost muscle fibers of the MSC and the medial TS. Holes were also drilled in the horizontal plane between the inion and IOP. Measurements were then taken to determine the vertical distance between these two points. We also measured the distance between the inion and the apex of the SNL. The apex of the SNL was defined as the most superior point on the line. Finally, the distance between the apex of the SNL and the apex of the insertion fibers of the MSC was measured.

Results

The results were divided into two main categories: the first group consisted of measurements between bony external landmarks, and the second group contained measurements made between the insertion site of the MSC and various anatomical structures. The insertion site is defined as the most cephalic fibers of the muscle as it at-
taches to the occiput between the SNL and the inferior nuchal line. Our results showed no significant differences between genders.

**Bone Relationships**

The first measurement was made between the apex of the SNL and the midline, that is, the inion (Fig. 1 left, Distance A). This distance ranged from 2.4 to 3.8 mm (mean 2.8 mm, median 2.7 mm). The next measurement in this group was the vertical distance between the inion and the IOP (Fig. 1 right, Distance B). This measurement ranged between 0 and 15 mm (mean 6.4 mm, median 3 mm). In the majority of specimens (73.3%), it was found that the inion was inferior to the IOP. The range for inions found to be inferior to the IOP was from 0.3 to 11 mm (mean 4.3 mm). In two specimens the inion and the IOP were on the same horizontal level (13.3%), and in two specimens the inion was superior to the IOP (13.3%). In the two specimens in which the inion was superior to the IOP, the vertical distance between these two points was 14 and 15 mm, respectively. Note that the inion is actually defined as the central aspect of the external occipital protuberance and thus the two terms are not synonymous.6

**Relationships Between the MSC and Other Anatomical Structures**

We first measured the width of the MSC at the insertion site (Fig. 1 left, Distance C). This width ranged from 3.5 to 5 cm (mean 4.13 cm, median 3.9 cm). The width of the muscle located cranially was equal bilaterally in all specimens. We next measured the distance between the apex of the insertion fibers of the MSC and the corresponding internally located TS (Fig. 1 left, Distance D). The distance for all left sides ranged from 0 to 6 mm (mean 2.6 mm, median 3 mm). In one specimen (6.7%) on the left side, the muscle insertion extended 5 mm superior to the level of the lower border of the TS. The distance for all right sides ranged from 0 to 10 mm (mean 3.5 mm, median 2.5 mm). In three (20%) of our specimens, the insertion fibers of the MSC on the right side were found to be superior to the lower border of the corresponding internally located TS. In the three instances in which the muscle was found to be superior to the lower level of the TS, the distances were 3, 3.5, and 5 mm. We also measured the distance between the apex of the SNL and the apex of the insertion fibers of the MSC (Fig. 1 left, Distance E). The distance was found to be very symmetrical on both sides and ranged from 2.5 to 4 mm (mean 3.1 mm, median 3.3 mm). We found that the right TS was located more inferiorly than the left TS in 53.3% of our specimens. Finally, our study demonstrated and confirmed earlier reports that the majority of the torcular herophili and the very proximal TS were located at the level of the IOP.2,11

**Discussion**

External landmarks are extremely important in localizing intracranial structures. Whenever neurosurgeons enter the posterior fossa, they must always be aware of the normal location of the venous sinuses. Historically, several bone landmarks have been used as external landmarks to the intracranial venous sinuses. Examples would include an area just anterior to the asterion for the internal junction of the transverse and sigmoid sinuses and the SNL for the internal location of the TS.1,2 We have found that, for posterior midline approaches to the posterior fossa, the traditionally used SNL is not always reliable in specifically determining the intracranial course of the proximal TS. The proximal TS is defined as the segment of the sinus closest to its drainage site into the area of the torcular herophili and basically constitutes the medial half of the sinus. We have also found that the previously used external landmark for the torcular herophili, the inion, is not a reliable superficial marker. Again, the inion is not synonymous with the external occipital protuberance, but is defined as
Transverse sinus

the center point on this tubercle. The transverse sulcus separates the pars nuchalis from the pars occipitalis of the occipital squama. This groove is visible by the end of the 1st year of life. If one looks at the course of the transverse sulcus, which is the internal groove housing the TS, and superimposes on it the SNL, it becomes obvious that the two structures are not congruent, especially as one follows the sinus laterally where it begins to arch superiorly. The SNL has a distinct upwardly convex structure, whereas the transverse sulcus, especially medially, is in line with the horizontal plane. With regard to the transverse sulcus, most postmortem studies do not account for the dilation of the sinus during life, whereby it overflows the bony border of the sulcus, in comparison with the SNL. In fact, the SNL is established after a prolonged pull of several cranio cervical muscles, such as the MSC, and has no functional relation to the internally located TS. This is also the case when one considers the inion in which chronic tension from muscle and ligament attachments establishes its prominence. Indeed, the inion also has no functional relation to the internally located torcular herophili and, in the majority of our specimens, was found to be inferior to this point. Therefore, it is important in this population to have other operative landmarks for guidance and to avoid the intracranial venous sinuses. As stated before, the insertion of the MSC into the occiput is established in utero and, therefore, offers itself as an excellent landmark, regardless of age.

One should remember that the TSs are usually not equal in size or level. The right TS is usually larger and placed more inferiorly than the left TS.\textsuperscript{3,4,5,7} Okudera, et al.,\textsuperscript{3} demonstrated that the development of the TS occurs between the 5th and 7th fetal months. They also showed that rapid increases and decreases in the inner diameter of the sinuses during this time often result in irregular margins of the TS.

Consideration must also be given regarding certain pathological states of the posterior fossa. Under normal circumstances, the TS migrates posteriorly during the later part of fetal life to reach their normal adult position on the occipital bone.\textsuperscript{10} In many patients with a Dandy–Walker malformation, the posterior fossa fluid collection, which is established in utero, inhibits the posterior migration of the posterior sinuses and, therefore, they retain their fetal position, which is more cranial than normal.\textsuperscript{1} In addition, in individuals with a Chiari malformation and, particularly, in those with a Chiari Type II malformation, the posterior venous sinuses may be displaced caudally.\textsuperscript{2} In both of these instances, our landmarks would not be useful.

Intraoperatively, the MSC is easily distinguished from the more superficially placed muscleus trapezius and muscleus splenius capitus. The fibers of the MSC are vertically arranged in comparison with the oblique-fiber direction observed in the upper muscleus trapezius and muscleus splenius capitus. The muscle inserts between the superior and inferior nuchal lines, with its uppermost fibers falling short of the SNL.\textsuperscript{9} Our data show that the distance between the SNL and the most cranial fibers of the MSC is fairly consistent, but the relationship between the SNL and the lower edge of the TS is somewhat variable. Using the apex of this muscle, which usually is approximately 2.8 cm from the midline, we have found that the muscle never ascends higher than 5 mm above the level of the corresponding medial TS on either the left or right side. Therefore, in the majority of cases, as long as surgeons stay at least 5 mm below the insertion of the MSC, the TS will be avoided. Also, if surgeons palpate or see the inion, they should be aware that the majority of the torcular herophili will be located superior to this point. Again, the majority of our specimens contained inions that were inferior to the IOP, which approximates the location of the torcular herophili and the very proximal TS.

Conclusions

Although it is not always possible to rely on external landmarks for localizing an intracranial structure, our results have demonstrated that the insertion of the MSC into the occiput provides an excellent landmark for determining the intracranial location of the medial TS in the majority of cases. Other landmarks have also been used, and together with the site of muscle insertion, make it very easy to triangulate onto the medial segment of the TS. We hope that the data collected in this study will prove useful to neurosurgeons as they access the posterior cranial fossa in and around the domain of the medial segment of the TS.

References


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