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New Practical Landmarks to Determine Sigmoid Sinus Free Zones for Suboccipital Approaches: An Anatomical Study

Hasan Caglar Ugur, MD, PhD, Ihsan Dogan, MD,* Gokmen Kahilogullari, MD, PhD,* Eyyub S. M. Al-Beyati, MD,† Mevci Ozdemir, MD,‡ Selim Kayacı, MD,§ and Ayhan Comert, MD||*

Abstract: Literature defines the landmarks to identify the courses and locations of the transverse and sigmoid sinuses on the outer surface of the skull and inner surface of the scalp. These natural landmarks may only be helpful after skin incision and are inadequate to determine the length and size of the skin incision. Still, there is a need to identify palpable landmarks easily to determine the ideal location to open the initial burr hole before an operation. Twenty-eight dried adult human skulls and 2 cadavers were evaluated. The zygomatic root, the inion, and the mastoid process were identified on the external, and the grooves for sigmoid and transverse sinuses, on the internal surfaces. The distances between the 3 landmarks and the midpoints, and the shortest distances of the midpoints to the border of the groove for sigmoid sinus and groove for transverse sinus were measured. Statistically significant differences were evaluated for both sides. Based on the measurements, the defined "artificial landmarks" can be considered safe points that involve no vascular structures and may be used to perform the initial burr hole during posterolateral approaches. Identification of the midpoints and palpation of the defined landmarks easily before the operation render the study feasible and practical unlike with natural landmarks. To avoid venous injury, the midpoints of mastoid-inion line and zygomatic root-inion line can be used safely in skin incision during posterior fossa approaches and craniotomy.

Key Words: Retrosigmoid approach, sigmoid sinus, anatomy, cadaver, skull, landmark, suboccipital supratentorial approach

(*J Craniofac Surg* 2013;24: 00–00)

Planning neurosurgical approaches begins with consideration of the entry point into the cranium with the aid of surface anatomical landmarks. The retrosigmoid craniotomy is the most commonly used neurosurgical approach to access the cerebellopontine angle. Projection of the transverse and sigmoid sinuses and their localizations are very important in planning the incision point to avoid excessive craniotomy defect and sinus injury.[1–3] The presence of complex neurovascular structures and also vital brainstem nuclei and their extension "cranial nerves" in such a narrow space leads neurosurgeons to search for new surgical approaches and corridors.

Previous studies evaluated the relations between some anatomical landmarks and venous sinuses to provide proper surgical orientation and achieve a safe intervention. However, almost all the landmarks that were examined previously to identify location of the transverse and sigmoid sinuses, especially the natural ones (cranial sutures, junction of the cranial sutures, extension of the bony parts of the cranial bones etc) are based on nonpalpable landmarks hidden under the scalp.[4,5]

In this study, novel artificial landmarks were defined through evaluations of the anatomical and geometric relations of the natural landmarks. The study aimed to focus on the surgical area involved and define new landmarks that may assist the surgeon to determine the ideal burr-hole point independent of variable unpalpable landmarks. The study also aimed to determine the reliability and safety of these artificial landmarks, their morphometric measurements, and their exact relation with sigmoid and transverse sinuses for suboccipital approaches in practice.

MATERIALS AND METHODS

Twenty-eight dried adult human skulls and 2 cadavers were evaluated in the Department of Anatomy, Faculty of Medicine, Ankara University (Ankara, Turkey). In each skull, the zygomatic root, the inion, and the mastoid process were identified on the external, and grooves for sigmoid and transverse sinuses, on the internal surfaces. In the cadavers, to achieve easy visualization, the calvarias were removed. The most inferolateral point of the mastoid process, the mastoid point (M), inion (I), and posterior end of zygoma root just superoanterior to the external acustic meatus (Z) were marked on the external surface of each skull (Fig. 1). The distances F1 between the 3 landmarks and the midpoint of mastoid-inion line (MImp) and zygoma-inion line (ZImp) were measured in millimeters with the aid of a ruler or a digital caliper.

Evaluation of the relations of the midpoints with the inner surfaces was assessed using transillumination of the skull with laser (24 skulls). A laser pointer was put in contact with the midpoints externally, and the correspondence of these midpoints on the inner surface was marked with a pencil. In 4 dried skulls and 2 cadavers, transillumination was difficult because of the thickness of the skulls; and thus, a 2-mm drill bit was used so that the midpoints drilled through the bone were perpendicular to the skull surface.

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Fig 1 4/C

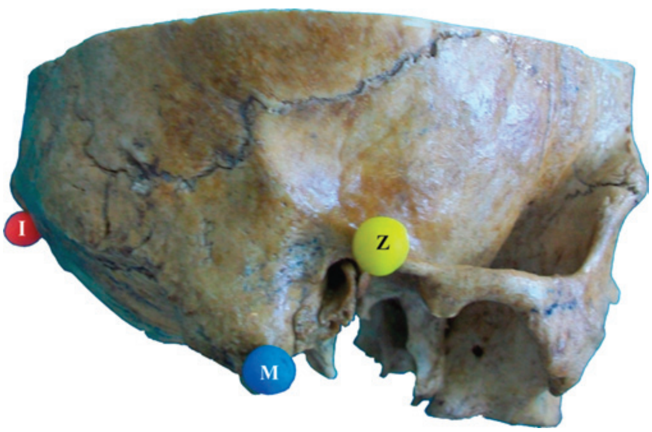

FIGURE 1. Marked landmarks of the external surface of the skull. M indicates mastoid point; I, inion; Z, posterior end of zygoma root just superoanterior to the external acustic meatus.

The shortest distances of the midpoints to the border of the groove for sigmoid sinus and groove for transverse sinus were measured.

Mean and SD were used as descriptive statistics. The paired-samples *t* test was used to evaluate the difference between the mean values of the distances between the right and left sides. SPSS 11.5 (SPSS, Chicago, IL) was used for statistical analysis. A *P* value less than 0.05 was considered statistically significant.

RESULTS

Based on examination of the external and internal surfaces of 28 skulls and 2 cadavers, grooves of the transverse and sigmoid sinuses and related landmarks were identified in all the specimens on both left and right sides. Mean distances of the selected points and their SDs were calculated and represented as the point between the most infeorolateral point of mastoid process (M) and inion (I) as M-I, the most infeorolateral point of mastoid process (M) and posterior end of zygoma root (Z) as M-Z, and posterior end of zygoma
F2 root (Z) and inion (I) as Z-I (Fig. 2). The measurements are presented
T1 in Table 1.

On both left and right sides, all (100%) the transilluminations of laser (or drill holes) of MImp and ZImp were inferior to the groove for transverse sinus and medial to the groove for sigmoid sinus (Figs.
F3 2 and 3). Neither of the 2 artificial landmarks (the MImp and Zimp) was found to be located over the grooves for the venous structures
F4 and over the transverse and sigmoid sinuses in cadavers (Fig. 4).

The minimum to maximum distances of the ZImp to the grooves for transverse (TS) and sigmoid sinuses (SS) were, respectively, 5.00 to 25.00 and 8.00 to 28.00 mm on the right and 5.00 to 21.00 and 7.00 to 27.00 mm on the left side. In addition, the minimum to maximum distances of the MImp to the TS and SS were, respectively, 8.00 to 35.00 and 17.00 to 33.00 mm on the right and 13.00 to 31.00 and 15.00 to 27.00 mm on the left side.

When both sides were compared for the distances, no statistically significant differences were found except the distance between the 2 midpoints and the sigmoid sinus on the right side, which was greater than the distance on left ($P < 0.05$).

DISCUSSION

Suboccipital supratentorial approach, retrosigmoid approach, and midline/posterior suboccipital approach have been commonly applied in posterior fossa surgery. Depending on the size of the lesion in the posterior fossa, the width, location, and borders of the hole to the corridor that will guide the surgeon to the lesion are essentially important.[1–3] Other decisive factors are location, length, and shape of the skin incision that affect the surgical orientation and craniotomy parameters. It was emphasized that the corridors should be made as close to the transverse and sigmoid sinuses as possible to avoid severe complications such as hemorrhage induced by sinus injury.[3,6]

In the literature, landmarks were generally used based on their relations with neural and vascular structures. Sheng et al[7] have claimed that it is not accurate to determine venous sinuses in the posterior fossa merely depending on surface landmarks. Many studies focused on more landmarks with the intention of finding a reliable landmark but with no any satisfactory determination in practice.[4,8–10]

Asterion as a surface landmark may be helpful to identify the transverse-sigmoid sinus junction whose location is indispensable for a successful suboccipital lateral approach. However, a significant rate of variations was found almost in more than 50% of the

Fig 2 4/C

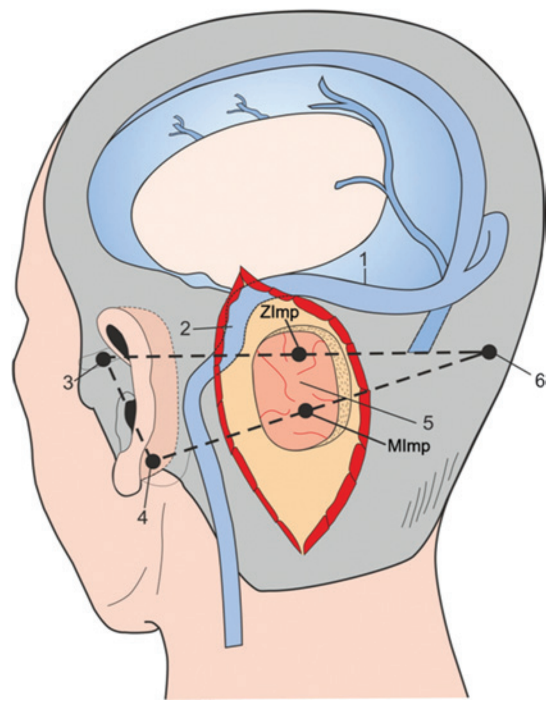

FIGURE 2. Drawing shows the 3 landmarks, the midpoints, and the external view of sigmoid sinus free zone. 1 indicates transverse sinus; 2, sigmoid sinus; 3, zygomatic point; 4, mastoid point; 5, free zone (craniotomy); 6, inion; MImp, midpoint between inion and zygomatic point; ZImp, midpoint between inion and mastoid point

TABLE 1. Mean Values of the Measurements in Millimeter

Parameters	Right side, mm (Mean [SD])	Left side, mm (Mean [SD])	P
M-I	94.10 (6.71)	95.03 (5.97)	>0.05
M-Z	38.46 (3.95)	38.10 (3.80)	>0.05
Z-I	122.66 (6.27)	123.26 (5.68)	>0.05
MImp-TS	23.66 (7.06)	22.10 (5.04)	>0.05
MImp-SS	26.63 (4.18)	23.20 (2.67)	**<0.001**
ZImp-TS	12.63 (5.53)	13.06 (4.78)	>0.05
ZImp-SS	20.36 (5.26)	17.40 (5.21)	**<0.05**

AQ1

M-I indicates the distance between the inferolateral point of mastoid process and inion; M-Z, the distance between the most inferolateral point of mastoid process and posterior end of zygoma root; Z-I, the distance between the distance between posterior end of zygoma root and inion; MImp, midpoint of MI; ZImp: midpoint of ZI; TS, groove for transverse sinus; SS, groove for sigmoid sinus.

Fig 3 4/C

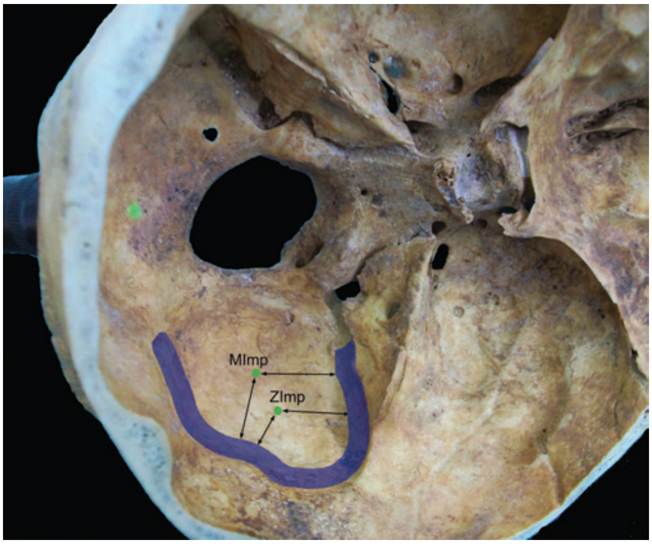

FIGURE 3. Picture demonstrates real transillumination of laser on the inner surface on left side and location of MImp and ZImp with their measured distances to the grooves on right side of the cerebellar fossa. MImp, midpoint between inion and zygomatic point; ZImp, midpoint between inion and mastoid point.

cases.[3,4,11–14] da Silva et al[15] found the asterion to lie directly over the transverse-sigmoid sinus junction in only 23.3% of cases and directly over any point of the inferior margin of the transverse sinus in 63.3% of cases. This creates a potential for sinus laceration during asterion-guided burr-hole placement and mastoid drilling.[5,6,11,13,16]

The superior nuchal line (SNL) was described as a landmark to identify the inferior border projection of the transverse sinus and the posterior edge of the mastoid process that correlates well with the posterior margin of the sigmoid sinus.[1,2] Rhoton[17] preferred to make the initial trephination 2 cm below the asterion, two thirds anteriorly and one third posteriorly to the occipitomastoid suture, whereas Yasargil[18] did not use the asterion as a reference point. Tubbs et al[19] emphasizes the use the landmarks together with the site of muscle insertion. Because of the difficulties in locating the SNL and individual variations, the viewpoint that SNL can be used to estimate the position of transverse sinus lacks accuracy.[16]

Raso and Gusmão[5] defined the “digastric point” and discussed its relation with the sigmoid sinus, to be used as a lateral limit for the suboccipital access. However, depending on whether it is palpable or nonpalpable, a surgeon may not be able to use it until he or she observes it after incision.

Although bony landmarks such as asterion or SNL can be used as a reference point for posterior fossa craniotomies, their location under the scalp and location variations render these bony natural landmarks inefficient in predicting the features of skin incision such as location, length, and shape.[8]

The importance of navigation and three-dimensional imaging reformation techniques during the retrosigmoid approaches was demonstrated. Gharabaghi et al[13] reported a systematic clinical study focusing on image-guided retrosigmoid approaches with computed tomography venography, and Hamasaki et al[16] evaluated 30 cases of image-guided retrosigmoid craniotomy based on computed tomography surgical planning and reported lower incidence of injury. However, it is worth to remember that the literature emphasizes the relative increase of the radiation dose during extra imaging procedures.[7]

In our study, a statistically significant difference was found regarding the sigmoid sinus on the right; however, it is known that the right transverse sinus is usually larger and is situated more inferiorly than the left transverse sinus.[20,21] Shima et al[22] reported 49% of symmetry of the sigmoid sinus. Likewise, Ebraheim et al[23] in their study on 52 dry skulls found that almost half of the projected surface area of the transverse sinuses, especially on the right, was situated inferior to the level of the protuberance. This means that the sigmoid sinus on the right is situated more inferiorly than the left, which explains the difference in our measurements.

In conclusion, when the skin incision is considered the first step in surgery, the artificial landmarks defined in this study may enable the surgeon to locate the venous sinuses as well as help

Fig 4 4/C

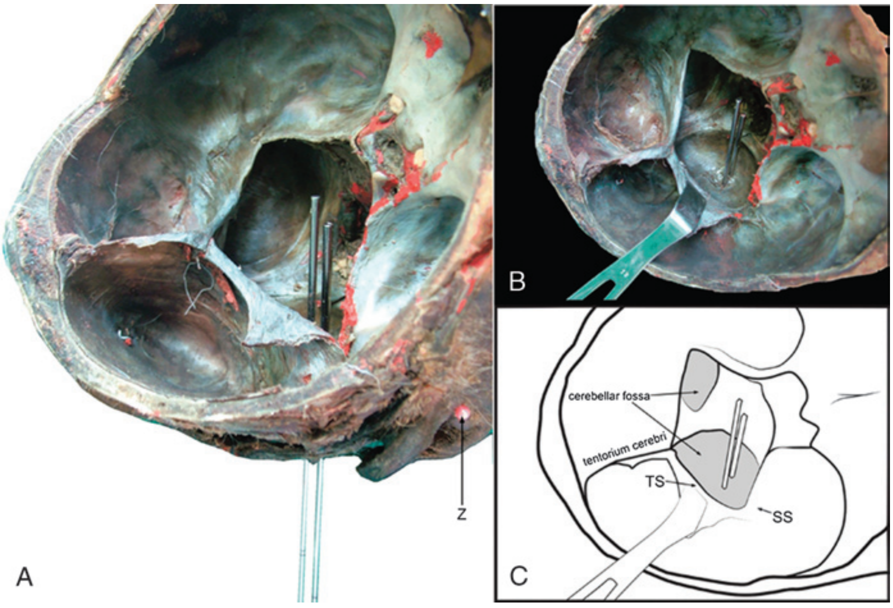

FIGURE 4. Picture demonstrates the relation of the inserted K-wires from drilled holes (MImp and Zimp) with transverse and sigmoid sinuses in cadavers. A, Superolateral view of the posterior cranial fossa. B, Superior view. C, Illustration of superior view of the posterior cranial fossa. TS indicates transverse sinus; SS, sigmoid sinus.

determine the location and length of the incision. Furthermore, these landmarks are reliable for selection of the best patient position to access the suboccipital surface of the skull with corresponding infratentorial fossa.

The artificial landmarks defined here can be considered safe points that involve no vascular structures and may be used to perform the initial burr hole and give clues about the location and length of the skin incision during infratentorial and petrosal approaches. In the light of the neurosurgical principles of "enlarge, come near, and see" philosophy, meticulous and stepwise enlargement of initial burr holes medially and superiorly until venous sinuses are seen will also emphasize the necessity and importance of our artificial landmarks in practice.

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