Temporal Bone Landmarks of the Transverse-sigmoid Sinus Junction: An Anatomical Study in Dried Human Skulls

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ABSTRACT

Objective: To investigate the accuracy in localization of the anterosuperior margin of TSSJ by using the intersection point between the squamosal and parietomastoid sutures (A point) and the intersection of the squamosal suture and supramastoid crest (B point) as bony landmarks.

Materials and Methods: The A and B points were marked on the inner surface of a skull by using the transillumination technique. The anatomical relationship between the projected A point, B point, and groove of TSSJ was investigated in 60 dried Thai human skulls (120 sides).

Results: Of the 120 sides, the projected A points were located exactly on the anterosuperior margin of the TSSJ in 38 (31.7%) instances and adjacent (above and below) the anterosuperior margin in 82 (68.3%) cases. Of the 118 sides with identifiable supramastoid crests, the projected B points were located precisely on the anterosuperior margin of TSSJ in 60 (50.8%) cases and above the anterosuperior margin of the TSSJ in 57 (48.3%) cases. Hence, the projected B point was a more reliable bony landmark for localizing the anterosuperior margin of the TSSJ when compared with the projected A point ($p = 0.003$, OR 2.2, and 95% CI =1.3-3.8).

Conclusion: The B point is a more reliable temporal bone landmark for localization of the TSSJ than the A point. In temporal craniotomy, an initial burr hole at the B point is relatively safe and carries a very low risk of inadvertent venous sinus injury.

Keywords: Relationship; transverse-sigmoid sinus junction; squamosal suture; parietomastoid suture; supramastoid crest; temporal craniotomy; middle cranial fossa (Siriraj Med J 2021; 73: 738-743)

INTRODUCTION

In neurosurgical practice, temporal craniotomy is one of the most common surgical approaches for dealing with lesions that involve the middle cranial fossa. This procedure is also the key component for more aggressive lateral skull base approaches such as the transpetrosal approach. The posterior boundary of this approach is defined by the transverse-sigmoid sinus junction (TSSJ). In order to maximize craniotomy size and to avoid inadvertent venous sinus injury, localization of this major venous sinus is crucial during planning for craniotomy.[1-9] Although the neuronavigation system is extremely useful nowadays, it is not generally available in a resource-limited public hospital or emergency situation.[2] As a result, anatomical landmarks are still important for neurosurgeons, especially when performing initial burr hole placement.[1-9] The temporal bone is known for its complexity with various bony landmarkssuch

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as the squamosal suture, parietomastoid suture, and supramastoid crest. There has been controversy in previous anatomical studies regarding the best bony landmark of TSSJ in which the intersection between the squamosal and parietomastoid sutures and the intersection between the squamosal suture and supramastoid crest have been mentioned.[1,6-9] Both intersections have been commonly used as the bony landmark of TSSJ. Additionally, race-based differences of the skull may also affect the surgical approach and make one bony landmark suitable for one race but unreliable for another.[10-11] The authors of this study used dried human skulls to investigate the relationship between the temporal bone landmarks and TSSJ.

MATERIALS AND METHODS

One hundred twenty temporal bones from 60 dried Thai adult human skulls were evaluated in this study. The squamosal sutures, parietomastoid sutures, and supramastoid crest were identified at the outer surface of the skull. On the inner surface, the grooves of the transverse sinuses and sigmoid sinuses and TSSJ were identified. For practicality issues, if there was variation in sutures such as presence of sutural bone causing multiple sutures, the most conspicuous suture line would be used. After identifying these key structures, a point on the intersection between the squamosal and parietomastoid sutures was labeled as the "Apoint", and the intersection between the squamosal suture and supramastoid crest was determined to be the "Bpoint". Both points were then marked on the outer surface of the skull (Fig1). The A and B points were then projected onto the inner surface of the skull and traced via a transillumination technique using a laser pointer positioned perpendicular to the skull's surface (Fig 2). The projected points A and B were then evaluated according to whether they were situated on TSSJ (Fig 3). If confirmed, it would be further classified as the projected points would be positioned exactly at the anterosuperior margin or other areas of the TSSJ. Also, the relationship between the anterosuperior margin of TSSJ and projected A and B point was described and a distance between these landmarks was measured along the horizontal (X) and vertical (Y) axis.

This study was ethically approved by the Institutional Review Board (IRB) at Siriraj Hospital, Mahidol University (Si 717/2561 (Exempt)).

Statistical analysis

A statistical analysis was performed using PASW version 22.0 (SPSS, Chicago, IL, USA). Descriptive statistics were used to investigate characteristics of the study sample, including median, range, and percentage for numerical data. Accuracy of the projected A point and B point for predicting the location of the TSSJ was analyzed using Pearson's chi-squared test. A p-value of less than 0.05 was considered statistically significant. Odds ratio (OR) and 95% confidence interval (CI) was estimated from Pearson's chi-squared test.

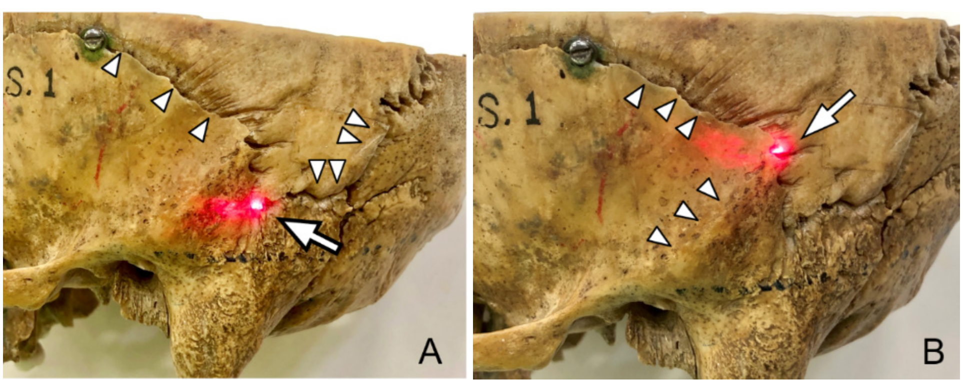

Fig 1. Key points on the outer surface of the skull. (A): "Apoint" (arrow), defined as the point of intersection between the squamosal (arrowhead) and parietomastoid sutures (double arrowheads); (B): "Bpoint" (arrow), defined as the point of intersection between squamosal suture (arrowhead) and supramastoid crest (double arrowheads); MP refers to mastoid process.

Fig 2. Transillumination technique using a laser pointer perpendicular to the outer surface of the skull and marking of the projected point (arrow) on the inner surface of the skull.

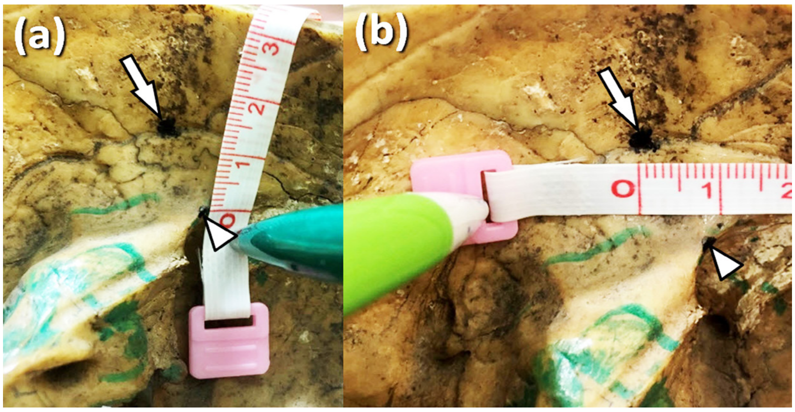

Fig 3. Measurement of distance between the projected A point (arrow) and the anterosuperior margin of TSSJ (arrowhead) in vertical (a) and horizontal (b) directions.

RESULTS

Demographic characteristics

The mean age of the skull specimens was 38 ± 11.1 years (range 18-60 years). Of the sixty skulls, 30 (50%) were male, and 29 (48.3%) were female. The remaining skull (1.7%) belonged to an unknown gender.

The relationship between the projected A point and anterosuperior margin of the TSSJ

The projected A points were located exactly on the anterosuperior margin of the TSSJ in 38 out of 120 cases (31.7%). In 82 out of 120 cases (68.3%), the projected A points were not exactly located on the sinus margin but situated adjacent (either above or below) the anterosuperior margin of the TSSJ (Fig 4A). The distance from the projected A point to the anterosuperior margin of the TSSJ ranged from -16 to 12 mm (median 0 mm) on the X-axis and -14 to 17 mm (median 0 mm) on the Y-axis.

The relationship between the projected B point and anterosuperior margin of the TSSJ

Of the 60 human skulls, one was excluded due to its unidentifiable bilateral supramastoid crest. The projected B points were located exactly on the anterosuperior margin of the TSSJ in 60 of the remaining 118 sides (50.8%). In cases where the projected B points were not exactly located on the sinus margin, almost all of the points were situated above the anterosuperior margin of the TSSJ (57 of 118 sides or 48.3%). The projected B point of the remaining one side was positioned within the TSSJ below the anterosuperior margin (Fig 4B). The distance from the projected B point to the anterosuperior margin of the TSSJ ranged from -14 to 9 mm (median 0 mm) on the X-axis and -4 to 28 mm (median 0 mm) on the Y-axis.

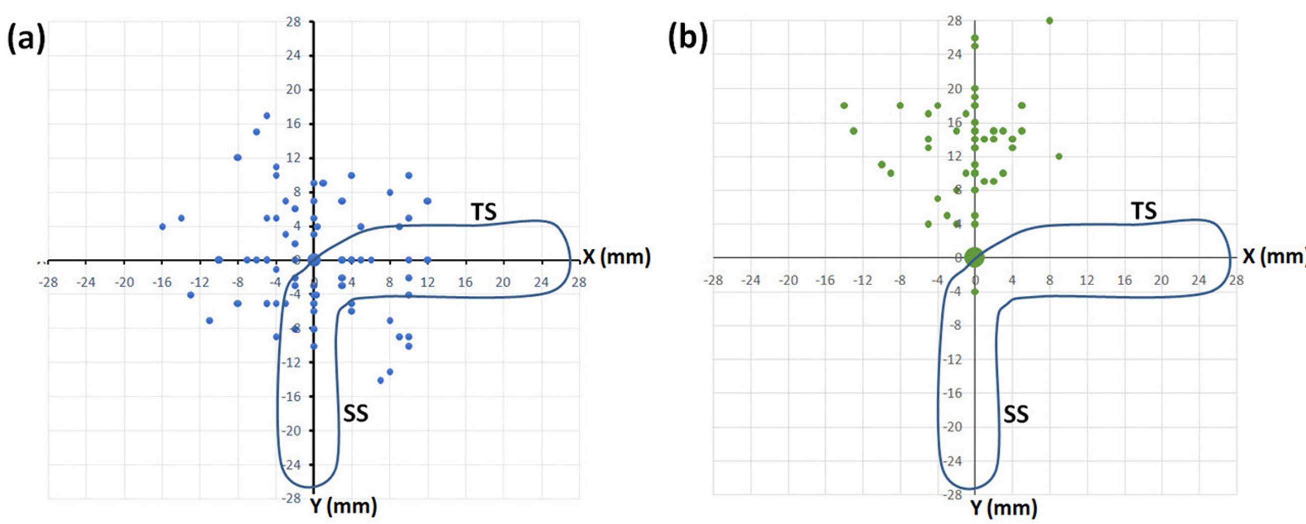

Fig 4. The distribution of the projected A (a) and B points (b) related to the location of the transverse sigmoid sinus junction (TSSJ). In both figures, the intersection between the X- and Y-axis indicate the anterosuperior margin of the TSSJ; SS, sigmoid sinus; TS, transverse sinus.

Comparison between the accuracy of the projected A and B points for predicting the location of the anterosuperior margin of the TSSJ

Sixty out of one-hundred and eighteen sides (50.8%) of the projected B points were located exactly on the anterosuperior margin of the TSSJ whereas the projected A points were located on the anterosuperior margin in 38 of 120 cases (31.7%). This difference in accuracy was statistically significant (p = 0.003, OR 2.2, and 95% CI =1.3-3.8).

Comparison between the accuracy of A and B points for predicting the location of the TSSJ (excluding the anterosuperior margin of the sinus)

The projected A points were located within the TSSJ in 21 of 120 sides (17.5%) while the projected B point was located with the TSSJ in only one out of 118 sides (0.8%). This difference of accuracy was statistically significant (p < 0.001, OR 24.8, 95% CI = 3.3-187.8).

The effect of gender on anatomical relationships

When a subgroup analysis with gender was done, the pattern of relationship between projected A points, B points and the anterosuperior margin of the TSSJ was the same as above in both genders.

Between genders, there was no significant difference in relationship between the projected A point, B point and the anterosuperior margin of the TSSJ (p=0.291 for A point, p=0.475 for B point)

In both genders, the projected B point was significantly more accurate in predicting the location of the TSSJ (excluding the anterosuperior margin of the sinus) than the A point (p < 0.001). When predicting the location of the anterosuperior margin of the TSSJ, the projected B point was significantly more accurate than the A point in females (p=0.004, OR 2.8) but not significant in males (p=0.267, OR 1.5).

DISCUSSION

In dealing with surgical lesions in the middle cranial fossa, temporal craniotomy is the key procedure. However, it is also used as the major component of more aggressive skull base approaches such as the transpetrosal approach. In order to perform an effective craniotomy, neurosurgeons should create an appropriately-sized cranial opening while avoiding injury of the adjacent major venous sinuses.[1-10] Since the posterior boundary of temporal craniotomy is determined using the position of TSSJ, precise identification of this major venous structure, especially the anterosuperior margin of the venous junction, is crucial. Moreover, despite technological advancements in the neuronavigation system, which helps facilitate safer and faster surgery[2], it is not usually available in a resource-limited public hospital or emergency situation. Therefore, anatomical bony landmarks are still essential for neurosurgeons in the initial burr hole process before beginning temporal craniotomy.

The temporal bone is one of the most complex in the human body as it is full of various anatomical landmarks, such as squamosal suture, parietomastoid suture, supramastoid crest, etc. The point of intersection between the squamosal and parietomastoid sutures (A point) and the point of intersection between the squamosal suture and supramastoid crest (B point) are commonly used as the surface landmark to help locate TSSJ.[1,6-10] However, previous anatomical and clinical studies reported heterogeneous results and no direct comparison between both the bony landmarks was studied.

Ucerler and Gosva noted that the asterion was a reliable bony landmark for TSSJ, however, when it was not exactly superficial, it was mostly inferior to TSSJ.[5] This meant that the asterion was a suitable bony landmark for posterior cranial fossa approachesbut not for temporal craniotomy, in which the location of the craniotomy is superior to TSSJ. Raza and Quinones-Hinojosa proposed a surgical technique for the extended retrosigmoid approach that includes an initial burr hole that encompasses TSSJ, however, it was slightly supratentorial.[2] Despite this, they did not mention the exact landmark of the burr hole. Ribas et al. also studied dried human skulls and found that the meeting point between the parietomastoid and squamous sutures could be easily identified and were related to the superior margin of the transverse sinus or floor of the middle cranial fossa.[1] However, this study did not mention TSSJ directly. Studies by Bozbuga et al and Day et al used an imaginary line connecting the squamosal-parietomastoid suture junction and mastoid tip to the identify sigmoid sinus trajectory but they did not directly study the relationship between this line and the TSSJ.[6-7]

Goto and his coworkers also described their technique for the safe exposure of the sigmoid sinus in presigmoid approaches. They used the intersection between the supramastoid crest and squamosal suture as a landmark for the anterior margin of TSSJ in this large case series.[9] Li et al. studied anatomical landmarks of the anterosuperior point of the TSSJ using dried human skulls. They compared the location of the squamosal-parietomastoid suture junction with their coordinate system and concluded it was more accurate in localization of the venous sinus junction.[8]

Additionally, a radiological study of cranial surface landmarks and the venous sinus was conducted by Sheng and colleagues. They used computerized tomography angiography and found that 89% of the squamosal-parietomastoid suture junctions were located superior and anterior to TSSJ.[10] In our opinion, the use of a 3-dimensional anatomical study is more accurate than a 2-dimensional radiological study.

There are also studies showing that how the size, shape, and structure of the cranium could be different across ethnic groups.[11] These differences can be large enough to affect surgical approaches. Low et al. found that Europeans had a greater petrous angle than Chinese people and therefore they recommended a larger craniotomy size in Europeans.[12] For this reason, our study was specific to the Thai population. Duangthongpon et al. studied supramastoid crest as a surgical landmark for temporal craniotomy and found that the supramastoid crest is easy to identify and safe from injury. However, they did not compare it with other available landmarks.[13]

In our study, three major anatomical landmarks, including the squamosal and parietomastoid sutures, and supramastoid crest, were consistently identifiable in almost all specimens. It was only in one specimen (0.8%) that the supramastoid crest could not be identified bilaterally. Comparing the accuracy of the projected A and B points in predicting the location of the anterosuperior margin of the TSSJ, B point was relatively more accurate when it came to bony landmarks (p = 0.003, OR 2.2, 95% CI 1.3-3.8).

Following the exclusion of the anterosuperior margin of TSSJ, a significantly greater proportion of the projected A point was located within the TSSJ when compared with the projected B point (p < 0.001, OR 24.8, 95% CI 3.3-187.8). This result implied that using the B point as a bony landmark for the initial burr hole in temporal craniotomy carries less risk of major venous sinus injury.

Moreover, when the projected A and B point were not located at the anterosuperior margin or within the TSSJ, the projected B point had a greater accuracy in localization of initial burr hole and was also able to avoid inadvertent venous sinus injury. Almost all of the remaining projected B points were positioned above the anterosuperior margin of the TSSJ (48.3%) compared with the remaining projected A points which were mostly positioned around (above or below) the anterosuperior margin of the TSSJ (68.3%).

Our results suggest that when performing temporal craniotomy in Thais, the B point or the intersection between the squamosal suture and supramastoid crest, is a more reliable temporal bone landmark for localizing the anterosuperior margin of the TSSJ than the A point, which is the intersection between the squamosal and parietomastoid sutures. This is due to the B point consistent higher accuracy in correct identification, better predictable relationship, and lower risk of venous sinus injury.

In order to explain our results, we have to understand the controversy whether sutural landmarks such as the asterion are reliable or not.[14-16] In general, sutural landmarks can be used to "estimate" the location of major venous sinuses but with caution of individual variations.

One factor that makes sutural landmarks less accurate is the presence of additional, irregular sutural (Wormian) bones which make sutures more varied.[17] This presence of sutural bone is used to classify the asterion into type I (with sutural bone) and II.[18-19] However, the prevalence of type I asterion was round 10-20% and generally not mentioned in anatomical studies for surgical purposes.[1-7,9-10,15-16] Since the aim of our study was practical usage, we used only conspicuous suture lines. The prevalence of this bone is highest in the lambdoid suture followed by posteriorly located sutures such as parieto-mastoid suture.[20] This might explain our result that show how using 2 sutures is less reliable compared to the landmark which uses only 1 suture.

There are three factors that are known to affect skull size and shape and they may have impacted our results. The first factor is race, however, comparing races was not our goal. As our study population included only Thais, our results are very race-specific and might not be suitable for other ethnic groups.

The second factor is gender. However, Johnson et al. showed that the difference between races is larger than the difference between gender within the same race. Moreover, gender differences are also unique in each race.[21] We used equal proportions of both genders in our study to prevent selection bias. Our results showed that there were no statistically significant difference between gender regarding relationship between both skull landmarks and the anterosuperior margin of TSSJ.

Last but not least, the third factor is age. In early life, the human skull size and shape can change rapidly but there is minimal growth after 15 years.[22] In adults, bone resorption from increasing age can change cranial morphology.[23] However, this change might not be clinically significant. A study of cranial morphometry by Nikita showed that unlike gender, changes in cranial shape due to increasing age is not statistically significant and therefore it was justifiable to pool different age groups in a bioarcheological analyses.[24] Gapert and colleagues also studied the age effect on sexual dimorphism of adult foramen magnum. They found no significant age effect, suggesting that a separation by age is not necessary.[25] From all this evidence, it is reasonable to generalize our results for Thai adults without age stratification.

CONCLUSION

The intersection between the squamosal suture and supramastoid crest serves as a more reliable temporal bone landmark for localizing the anterosuperior margin of TSSJ than the intersection between the squamosal and parietomastoid sutures. Most points with greater reliability were located at/or superior to the anterosuperior margin of the TSSJ.

We have no conflict of interest to disclose.

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