

ORIGINAL ARTICLE

Morphometric Evaluation and Clinical Significance of Prominent Superficial Landmarks of the Cranium

Kraniumun Belirgin Yüzeyel Landmarklarının Morfometrik Değerlendirilmesi ve Klinik Önemi

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ABSTRACT

Aim: This study aims to evaluate the localization and morphometry of important points such as the nasion, lambda, superciliary arch, lambdoid suture, and occipitomastoid suture using bregma as the reference point among the prominent superficial landmarks of the neurocranium. We believe that distinguishing these external points in radiological imaging and guiding surgical interventions will be beneficial.**Methods:** This study was conducted on dry skulls in the student laboratory of the Department of Anatomy, Selçuk University Faculty of Medicine. A total of 52 skulls of unknown age, gender, and population were examined. However, 21 damaged skulls were excluded due to lack of integrity, and a total of 31 skulls were evaluated. On these materials, anatomical landmarks such as the bregma, pterion, asterion, nasion, lambda, superciliary arch, lambdoid suture, and occipitomastoid suture were identified, measurements were made, and the presence of wormian bones was recorded.**Results:** Among the 31 dry skulls examined, the bregma-nasion distance ranged from 92 to 120 mm (108.3±7.3 mm), and the bregma-lambda distance ranged from 92 to 127 mm (107±7 mm). The bregma-pterion distance was 82 to 110 mm on the right side (91±6 mm) and 81 to 105 mm on the left side (91±5 mm). The bregma-superciliary arch distance ranged from 82 to 110 mm on the right (98±7 mm) and 84 to 109 mm on the left (98±7 mm). The nasion-lambda distance ranged from 184 to 245 mm (215.4±12.3 mm). Wormian bones were observed in all skulls analyzed. Among the regions examined, the lambdoid suture was the most common site for wormian bones, whereas the bregma region showed the lowest occurrence.**Conclusions:** The measurements obtained from this study provide current data on the region's anatomy and may guide the planning of surgical interventions.**Keywords:** Bregma, Cranial sutures, Wormian bone

Öz

Amaç: Bu çalışmanın amacı, neurocraniumdaki belirgin yüzeyel landmarklardan bregma referans noktası alınarak, nasion, lambda, arcus superciliaris ile sutura lambdoidea ve sutura oksipitomastoidea gibi önemli noktaların lokalizasyonunun ve morfometrisinin değerlendirilmesidir. Kafatasındaki bu dış noktaların radyolojik görüntülemelerde kinklardan ayırtedilebilmesi ve cerrahi girişimlerinde rehberlik edeceğini düşünmekteyiz.**Gereç ve Yöntemler:** Bu çalışma Selçuk Üniversitesi Tıp Fakültesi Anatomi Anabilim Dalı öğrenci laboratuvarındaki kuru kemikler üzerinde gerçekleştirildi. Toplamda yaş, cinsiyet ve popülasyonu belli olmayan 52 adet kafatası incelendi. İnceleme sırasında zarar görmüş olan 21 kafatası bütünlüğü bozulmuş olduğu için çalışma dışı bırakıldı ve toplamda 31 adet kafatası değerlendirildi. Bu materyaller üzerinde bregma, pterion, asterion, nasion, lambda, arcus superciliaris, sutura lambdoidea ve sutura oksipitomastoidea noktaları belirlendi, ölçümler yapıldı ve wormian kemik varlığı incelenerek kayıt edildi.**Bulgular:** Değerlendirilen 31 kuru kafatasında bregma-nasion mesafesi 92-120 mm (108.3±7.3 mm), bregma-lambda mesafesi 92-127 mm (107±7 mm), bregma-pterion sağ mesafesi 82-110 mm (91±6 mm), bregma-pterion sol mesafesi 81-105 mm (91±5 mm), bregma-arcus superciliaris sağ mesafesi 82-110 mm (98±7 mm) bregma-arcus superciliaris sol mesafesi 84-109 mm (98±7 mm), Nasion-lambda mesafesi 184-245 mm (215.4±12.3 mm) olarak bulunmuştur. Değerlendirmeye alınan tüm kuru kafataslarında wormian kemiğe rastlanmıştır. İncelenen bölgeler arasında en sık rastlanan bölge sutura lambdoidea olup en az görülen bölge ise bregma olmuştur.**Sonuçlar:** Çalışmadan elde edilen ölçümlerin, bölgenin anatomisine ilişkin güncel veriler sağlayacağı ve cerrahi müdahalelerin planlanmasında yol gösterici olabileceği kanaatindeyiz.**Anahtar Kelimeler:** Bregma, Kranium suturları, Wormian kemik

Introduction

The skull, when viewed from above, consists of the frontal, parietal, and occipital bones forming the calvaria. The coronal suture connects the frontal and parietal bones, the sagittal suture connects the two parietal bones and the lambdoid suture connects the parietal and occipital bones. The parietal foramen, located near the posterior edge of the parietal bone, can be observed from above (1,2). The point where the sagittal suture meets the coronal suture is called bregma. Bregma marks the location of the anterior

fontanelle during fetal life, closing approximately at the eighteenth month after birth (3,4).

Wormian bones are accessory bones not normally found in the cranial region. They often appear at the ossification centers (sutures) of the skull (4). Cranial sutures may close early or late due to epigenetic and hypostatic differences. Wormian bones formed in these sutures are frequently observed in the pterion and lambda regions but are rare in the bregma (5).

Bregma is one of the reference points used in surgical interventions (6).

Inion, pterion, asterion, and lambda are anatomical landmarks that can be used for surgical planning, as they are accessible and static (7). Recognizing external anatomical landmarks of the skull is crucial for various neurosurgical procedures. Defining the anatomical features of internal cranial landmarks is crucial for reducing surgical complications and morbidity rates (7-10). Moreover, knowing the variations and morphology of sutures is important to prevent confusion with fractures or other structures in radiological images (11). To obtain practical insights applicable to neurosurgical procedures, this region was examined in detail. Our study aimed to evaluate the relationship and distances of landmarks around the bregma reference point and to assess the presence of wormian bones.

Materials and Methods

This study was conducted on dry human skulls in the student laboratory of the Department of Anatomy, Faculty of Medicine, Selçuk University. The study received ethical approval from the Local Ethics Committee of Selçuk University (Decision No: 2024/614). A total of 52 skulls of unknown age, gender, and population were examined. Due to damage, 21 skulls with compromised integrity were excluded from the study, leaving a total of 31 skulls for evaluation. Anatomical reference points including the bregma, pterion, lambda, superciliary arch, lambdoid suture, and occipitomastoid suture were identified and measured. The presence of wormian bones was also recorded. All measurements were performed using a digital caliper with a precision of 0.01 mm and were independently repeated three times by two researchers. The average values were calculated and recorded in millimeters.

Morphometric Measurements:

- Br - Na: Distance between Bregma and Nasion
- Br - Acc R: Distance between Bregma and Right superciliary arch
- Br - Acc L: Distance between Bregma and Left superciliary arch
- Br - Pt R: Distance between Bregma and Right pterion
- Br - Pt L: Distance between Bregma and Left pterion
- Br - Lm: Distance between Bregma and Lambda

- Lm - Na: Distance between Lambda and Nasion (Figure 1)

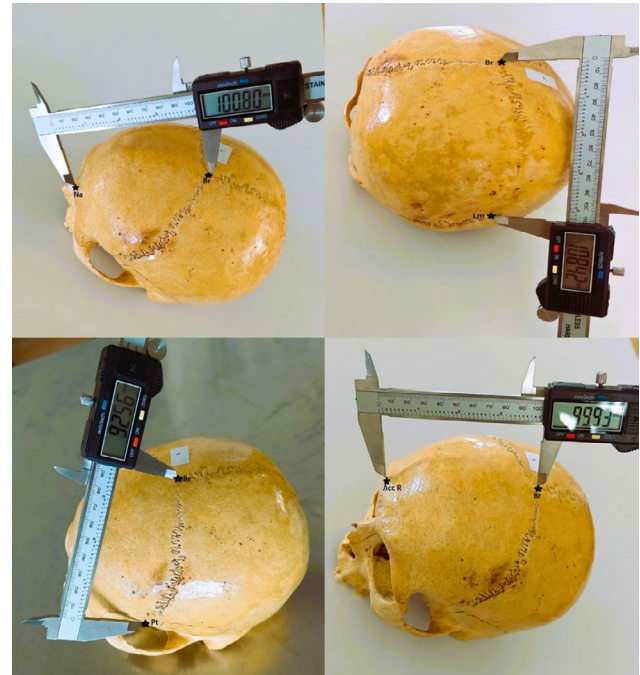


Figure 1. Measurement of distances between prominent cranial landmarks around the bregma

BR: Bregma, **NA:** Nasion, **ACC:** Superciliary arch, **PT:** Pterion, **LM:** Lambda

- W: Presence of Wormian bone (Figure 2)



Figure 2. Wormian bones observed at cranial surface landmarks. **A:** Wormian bone at lambda **B:** Wormian bone at the right lambdoid suture **C:** Wormian bone at the left lambdoid suture **D:** Wormian bone at the right pterion **E:** Wormian bone at the right asterion **F:** Wormian bone at the left pterion **G:** Wormian bone at the left asterion **H:** Wormian bone at bregma **O:** Wormian bone at the occipitomastoid suture

1.Statistical Analysis

The statistical analysis of the obtained data was performed using the “Statistical Package for Social Sciences for Windows 22.0 (SPSS 22.0, IBM Corp., Armonk, NY, USA)” program. Descriptive statistical methods (mean, standard deviation, minimum, and maximum) were used to evaluate data showing a normal distribution. Dry skulls were evaluated after approval was obtained Ethics Committee (Decision No: 03.12.2024, 2024/614). The study was conducted under the principles of the Declaration of Helsinki.

Results

In the 31 dry skulls we examined, the bregma–nasion distance ranged from 92 to 127 mm (108.3±7.3 mm), the bregma–lambda distance ranged from 92 to 127 mm (107±7 mm), the bregma–right pterion distance ranged from 82 to 110 mm (91±6 mm), the bregma–left pterion distance ranged from 81 to 105 mm (91±5 mm), the bregma–right superciliary arch distance ranged from 82 to 110 mm (98±7 mm), the bregma–left superciliary arch distance ranged from 84 to 109 mm (98±7 mm), and the nasion–lambda distance ranged from 184 to 245 mm (215.4±12.3 mm) (Table 1).

Table 1. Minimum, maximum, mean, and standard deviation values of the distances between landmarks on the external cranium

Parameter(mm)	Min.	Max.	Meant±SDstd
Br- – Na	91.7	126.5	108.2±7.3
Br- –Acc R	82.3	109.5	98.1±7.1
Br- –Acc L	83.9	109.1	98.2±7.2
Br- –Pt R	81.8	109.5	91.1±5.8
Br- –Pt L	81.2	105.1	91.2±5.6
Br- -Lm	91.7	126.5	107.2±7.2
Lm- – Na	184.1	244.7	215.4±12.3

Br - Na: Distance between Bregma and Nasion, **Br- –Acc R:** Distance between Bregma and right superciliary arch, **Br- –Acc L:** Distance between Bregma and left superciliary arch, **Br- –Pt R:** Distance between Bregma and right pterion, **Br- –Pt L:** Distance between Bregma and left pterion, **Br- - Lm:** Distance between Bregma and Lambda, **Lm- – Na:** Distance between Lambda and Nasion, Max.: Maximum, Min.: Minimum, SD: Standard deviation

In our study, wormian bones were observed in all 31 dry skulls evaluated. Among the regions examined, the most common occurrence of wormian bones was found in the lambdoid suture, with 10 on the right side and 9 on the left side. In the asterion region, 8 wormian bones were identified on the right side and 7 on the left side, indicating a high prevalence in this area as well. In the pterion region, the occurrence of wormian bones was less frequent, with 5 on the right side and 3 on the left side. In the lambda region, 3 wormian bones

were observed, while in the occipitomastoid suture region, 2 wormian bones were found on the right side. At the bregma, only 1 wormian bone was detected. These findings reveal that wormian bones are most commonly seen in the lambdoid suture and asterion regions, while they are less frequently observed in other regions (Table 2). The data we obtained regarding the areas and frequencies of wormian bone occurrence are presented in Table 2.

Table 2. Areas and frequencies of wormian bone occurrence

W	Midline	Right	Left	Total (n=:31)
Bregma	1			1 (%3.1%)
Lambda	3			3 (% 9.6%)
Pterion		5	3	8 (%25.8%)
Asterion		8	7	15 (%4.3%)
Sutura Lm		10	9	19 (%61.2%)
Sutura Om		2	0	2 (%2.4%)

W: Wormian bone **Lm:** Lambdoidea, **Om:** Occipitomastoidea, **W:** Wormian bone

Discussion

Cranial surface landmarks are critically important in neurosurgical approaches and planning due to their proximity to key cortical structures. Accurate identification of these landmarks contributes to reducing surgical mortality and morbidity while ensuring the preservation of brain tissue (12). Structures such as bregma, nasion, pterion, lambda, superciliary arch, and the lambdoid suture, which can be easily palpated beneath the skin, are clinically significant points of the skull, as they are easily recognizable radiologically. While there are studies in the literature examining the relationship between the coronal suture and the central sulcus, morphometric studies focusing on bregma and other surface landmarks are limited (13). In the dry skulls we examined, the bregma–nasion distance ranged from 92 mm to 127 mm, with an average of 108.3±7.3 mm. These findings are largely consistent with previous studies in the literature. For example, Ribas et al. (14) in their study on 16 cadaveric skulls, reported the bregma–nasion distance as 120–140 mm. Similarly, Solmaz (15) in a study on 72 dry skulls, reported this distance as 124.3±6.9 mm. In another study using computerized tomography (CT) imaging on 100 individuals, he found the range to be 107–139 mm, with an average of 126.6±7.3 mm. These findings are largely in agreement with those of our study, providing an opportunity for comparison with various imaging modalities. In another similar study, Oberman et al. (16) conducted research on CT images of 71 individuals (38 female, 33 male) and reported the

bregma–nasion distance as 137.4 ± 7.8 mm. Although these findings differ from those of our study, they offer an opportunity for comparison with different imaging methods. Techataweewan et al. (17), examined 65 cadaveric skulls (32 female, 33 male) and 729 dry skulls (349 male, 380 female), reporting that the bregma–nasion distance averaged 127.9 mm in males and 124.0 mm in females. Measurements from dry skulls were approximately 8 mm shorter than those from cadaveric skulls. These data are consistent with our findings and facilitate comparisons regarding gender differences and variations between cadaveric and dry skulls.

The point of intersection between the sagittal and lambdoid sutures, known as the lambda, corresponds to the fetal posterior fontanelle, closing within the first 2–3 months after birth (1,4). The frontal bone forms a joint with the nasal bone, creating a depression at the nasal root known as the frontonasal suture. The intersection of the frontonasal suture with the internasalis suture is considered an anthropometric landmark known as the nation (1,4,5). In our study, the bregma–lambda distance ranged between 92 mm and 127 mm, with an average of 107 ± 7 mm, while the nasion–lambda distance ranged between 184 mm and 245 mm, with an average of 215.4 ± 12.3 mm. Ribas et al. (14) reported the bregma–lambda distance as 120–130 mm and the nasion–lambda distance as 240–250 mm in their study on 16 cadaveric skulls. These findings are largely consistent with ours.

The pterion is the H-shaped sutural junction formed by the parietal, sphenoidal, frontal, and temporal bones. It is a region of particular surgical importance due to its proximity to the anterior branch of the middle meningeal artery and the lateral cerebral fissure (18). In our study, the bregma–pterion distance ranged between 82 mm and 110 mm on the right side and between 81 mm and 105 mm on the left side, with an average of 91 ± 6 mm on both sides. The bregma–superciliary arch distance ranged between 82 mm and 110 mm on the right side and between 84 mm and 109 mm on the left side, with an average of 98 ± 7 mm on both sides. A review of the literature revealed no prior studies specifically evaluating the bregma–pterion and bregma–superciliary arch distances, highlighting the novel contributions of our study.

Wormian bones, commonly found in the skull, are believed to form due to insufficient closure of sutures influenced by epigenetic factors (5). The presence of wormian bones should be carefully considered as

they may pose potential anatomical and surgical complications. In our study, wormian bones were observed in all examined dry skulls. The lambdoid suture was the most common site, while the bregma was the least common. Bergman (19) reported that wormian bones are most frequently found in the lambdoid suture, followed by the pterion. Our findings align with these observations, although the second most common site in our study was the asterion. Similar to our findings, Kumar et al. (4) investigated wormian bones in 50 skulls and reported their presence in 22 skulls at the lambdoid suture (15 on the left, 7 on the right). They also observed wormian bones in 3 skulls at the asterion (1 on the right, 2 on the left), 1 at the pterion (on the right), 3 at the lambda, and 3 at the occipitomastoid suture (2 on the right, 1 on the left). No wormian bones were observed at the bregma. In contrast, our study identified one wormian bone at the bregma in one of the 31 dry skulls examined. Bilgin (20), in a study on 185 patients using CT imaging, also reported the asterion (left side) as the most common site for wormian bones. Additionally, he identified a wormian bone at the left pterion in one female patient and at the bregma in another. Although we were unable to perform a gender comparison in our study, the bregma was confirmed as the least common site for wormian bones, while the lambdoid suture was the most frequent. O'Loughlin (21), in a study on 127 deformed and unshaped skulls, reported no wormian bones at the bregma, noting its rarity. The single instance of a wormian bone at the bregma in our study supports this observation.

Conclusion

This study provides an important resource for the accurate and reliable measurement of landmarks such as the bregma, nasion, pterion, and lambdoid suture. The presence of wormian bones should be considered in anatomical and surgical evaluations, as they can impact the structural integrity of the skull. By presenting morphometric data on prominent anatomical landmarks, our study enhances the reliability of reference points for clinical applications.

Conflict of interest

The authors declare no conflict of interest.

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