Skull thickness changes in skeletal deep bite: Implications for orthodontic treatment planning- A comparative cohort observational study.

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Abstract

Background: Craniofacial skeletal structure plays an important role in orthodontic diagnosis and treatment planning. Changes in skull thickness are associated with skeletal malocclusions, such as deep bite, which affect the vertical jaw relationship and facial esthetics. Despite considerable evidence on craniofacial growth dynamics, research on skull thickness changes in skeletal deep bite cases remains limited.

Objective: The aim of this study was to evaluate the frontal, parietal, and occipital skull thickness in skeletal deep bite cases compared with controls, focusing on gender differences and their impact on orthodontic treatment planning.

Methods: A retrospective observational cohort study was conducted in 68 subjects (34 males, 34 females) with skeletal deep bite and 34 control subjects with normal occlusion. Skull thickness was measured from pretreatment lateral cephalometric radiographs using a standardized imaging protocol. Statistical analysis included unpaired t-tests and descriptive statistics, with significance set at $p < 0.05$.

Results: Subjects with skeletal deep bite had significantly thicker skulls compared to control subjects, especially in the parietal region. Gender differences were observed, with female skulls being thicker in the parietal region than males. Both groups were thinnest in the forehead region. These results highlight the structural adaptations associated with skeletal deep bite.

Conclusion: This study showed a strong correlation between skull thickness and skeletal deep bite, with significant regional and gender differences. These results provide important insights into orthodontic treatment planning, especially when surgical intervention or bone screw insertion is required. Further studies on long-term changes and different populations are needed to confirm these findings.

Keywords: skull thickness, skeletal deep bite, neutral occlusion, frontal bone, occipital bone

Running title: Comparison of skull thickness and skeletal deep bite

Introduction

The vertical relationship of facial features in face type, especially in long and short faces, is important for orthodontic treatment planning and prognosis[1]. Various skeletal units of the craniofacial complex are involved in this. Inappropriate development of skeletal units can lead to open bite or deep bite, increasing or decreasing the distance between the maxilla and mandible, affecting the vertical growth and aesthetics of the face[2].

Skeletal deep bite is caused by: In forward growth, mandibular rotation reduces the interbasal angle between the bases of the maxilla and mandible, allowing the soft tissue structures to adapt to the bone and increasing the thickness of the skull1-2. Genetic, environmental and behavioural factors contribute to a deep bite, and studies have identified mutations in genes such as IRF6 and BMP4, and in bone growth and development genes such as RUNX2 and COL1A1[3].

Deep bite is a skeletal malocclusion that results in clinical growth of the anterior teeth and is caused by a reduced angle between the maxillary and mandibular bases[4]. It is also influenced by various factors such as mandibular rotation, reduced angle, genetic, environmental and behavioral[5]. Mutations in genes such as IRF6 and BMP4, as well as genes that support bone growth and development such as RUNX2 and COL1A1, have been studied[3,6].

In the literature, most studies on skull thickening have shown that abnormal chewing forces are transmitted, resulting in increased skull thickness in specific regions of the skull[7]. Israel H et al. In 1970, it was reported that physiological growth of the skull is due to the forces exerted by the growing head lobes[13]. However, Arntsen et al. and Jacobsen PE et al. in 2008 reported that dentoskeletal malocclusion also plays an important role in the increase in skull thickness and in the growth of certain areas of the skull[15].

Jacobsen PE et al. also found an association between a deep occlusion on the skeleton and an increase in overall skull thickness, revealing that female subjects had thinner skulls in the occipital and frontal regions compared to male subjects[15]. To support the above studies, Sonnesen L[16] and Mashita M[24] also reported changes in skull thickness during growth, deep occlusion, and skeletal malpositioning, as reported by Alcofied EA[37].

Björk's historical evidence suggests that well-built children respond better to orthodontic treatment because of their increased growth activity[30]. Skull thickness appears to be important for orthodontic treatment planning, as it may be an indicator of bone thickness, which may affect treatment time[8,9,10,11,12]. Therefore, skull thickness is very important for orthodontic treatment planning.

Previous studies on skull thickness have shown that skull thickness is more prevalent in socioeconomically weaker areas and is characterized by a thicker buccal cortex and lower mandibular angle in women (Tsunori et al.)29. These typical features may help clinicians treat maxillary hypoplasia with additional bone during jaw deformity surgery and improve facial esthetics (Ribeiro et al.)[20].

Various techniques have been used to measure human skull thickness. Anthropological specimens and cadaveric biopsy samples have been measured using calipers[14,17,18,21,22,24]. Cephalometric analysis X-rays have been used in anthropology and clinical research. Cephalometric assessment of skull thickness has limitations and inaccuracies that can be overcome using modern software and computer technology.

The main focus of this study was to compare patients with skeletal deep bite with controls and to determine the differences in skull thickness in the frontal, parietal and occipital bones and to determine the role that these differences play in orthodontic treatment planning and prognosis. Research question: How do skull thicknesses in individuals with skeletal deep bite

and controls differ with respect to the frontal, parietal and occipital bones and how does this affect orthodontic treatment planning? Study objective: To evaluate and compare skull thicknesses in the frontal, parietal and occipital bone regions in patients with skeletal deep bite and controls and to investigate the clinical relevance of these differences in orthodontic treatment planning and prognosis.

Material and methods

Material

This study is a retrospective observational cohort study of subjects diagnosed with skeletal deep bite and treated orthodontally. The dataset consisted of 68 profile radiographs purposefully selected from 783 patients registered with the Department of Orthodontics, Mansarovar Dental College, Bhopal, Madhya Pradesh. The study included 34 girls aged 19-28 years (mean age 24.25 years) and 34 men aged 19-31 years (mean age 25.90 years). The ethical committee of Mansarovar Dental College gave approval after the submission of the study. (EC/13-11-2023/MDC/BLP-174).

All selected cephalograms were pre-treatment records and subjects had not undergone any orthodontic treatment during childhood. Recode selected subjects with at least 24 permanent teeth without a history of craniofacial deformities or systemic muscle or joint problems. Thirty four undergraduate dental students aged 18 to 24 years were included as a control group. These students were diagnosed with skeletal overbite on lateral radiographs and their treatment plan included treatment as orthodontic surgery. These students also met the inclusion criteria as they had no history of orthodontic treatment or craniofacial abnormalities, at least 24 permanent teeth, neutral occlusion, and normal vertical jaw relationship. Both groups had a vertical overbite of more than 5 mm and a vertical jaw relationship of more than 2 standard deviations.

Methods

The previously stored cephalograms and the lateral cephalograms of the control group were recorded with the same equipment using all standard criteria, such as a cephalostat with a film-to-focus distance of 180 cm and a film-to-median plane distance of 10 cm. No correction was made for the constant linear magnification of 5.6%.

Cephalometric analysis. The obtained lateral cephalometric radiographs were manually traced, reference points were defined according to Bjork[30] to detect skeletal deep bite, and skull thickness was defined as described by Axelsson et al.[12].

Method error

To minimize errors and to evaluate the reliability of the variables representing the thickness of the frontal, parietal and occipital bones, 34 randomly selected lateral radiographs from the previously recorded radiographs and 12 from the control group were remeasured. After 15 days, the radiographs were evaluated again and the differences between the two sets of recordings were calculated. No significant differences were found between the two sets of recordings. The method error was 0.30–0.41 mm, and the reliability coefficient was 0.79–0.86. This range was within the method error reported in previous studies.

Statistical analysis

The obtained data were statistically analyzed for normal distribution by applying the Shapiro-Wilks W test with skewness and kurtosis parameters. The results of the Shapiro-Wilks W test showed that the data distribution was not normal, with skewness and kurtosis values significantly deviating from zero. Skull thickness (parietal, occipital, and frontal) showed moderate deviations from normal distribution.

Descriptive statistics were performed to determine the frequency of sample distribution and the mean and standard deviation of skull thickness. The determined characteristics of skull thickness were presented along with bite depth and gender of individual skeletons. The results showed that there were statistically significant differences in the thickness of parietal, occipital and frontal bones between the two groups. Furthermore, gender differences were found to be significant in the thickness of parietal and occipital bones as well as frontal bone. The differences in the mean thickness of parietal, occipital and frontal bones between the two

groups and between sexes were then determined using unpaired t-tests. The results of the test were considered significant when the p-value was less than 0.05. The analysis revealed that there was a statistically significant difference in bone thickness between the two groups and gender.

Results

In this study, gender differences were observed in skull thickness, with the skeletal deep bite group having thicker skulls than the normal bite group. Regardless of the group, the thickest skull was observed in the parietal region and the thinnest in the frontal region. The results are shown in the table and in Figures 1 and 2.

Discussion

The main objective of this retrospective cohort study was to evaluate the correlation of skull thickness (frontal, parietal, and occipital) with skeletal deep bite and control subjects (neutral bite). The results of this study showed that subjects with deep bite had significantly greater skull thickness than subjects with neutral bite, especially in the posterior region (Table and Figure 1). The difference in skull thickness was most pronounced in the frontal and occipital bones compared to the parietal bone, suggesting possible structural adaptations related to the occlusal relationship.

Consistent with the results of this study, previous studies have also found that skull thickness correlates with the occlusal relationship (Lynnerup et al. 2001; Moreira-Gonzalez et al. 2008). (2006) which suggests a strong relationship between skull thickness and occlusion status in various studies. The present study reported a significant difference in skull thickness between men and women, statistically significant in both the skeletal deep bite group and the neutral bite control group, with women having thicker parietal skulls than men (Table and Graph 2). Similar results have been reported by Israel H. et al[13]. (1973), Arntsen T. et al. (2008), Jacobsen et al. (2008) and Axelsson S. et al. (2015)[12].Furthermore, Sonnesen et al.[16] (2008) reported significant differences in craniofacial morphology between the two groups.

Significant differences were observed in the dimensions of the dental arch. In contrast, Smith P. et al.[25] reported. (1985), Ishida H et al1[7] (1990), and Ross AH et al[23] (1998) reported no significant differences between the sexes. Furthermore, Alkofide EA et al[35] (1994), Dostalova et al[38] (2003), and Hofmeyr LM et al[32] (2004) reported a strong positive correlation between the sexes of patients with maxillary hypoplasia and retrognathic mandible.

This study found that subjects with skeletal deep bite (scissor bite, unilateral or bilateral Brodie bite syndrome) had thicker skulls at the occipital region, especially at the parietal region,

thinner at the occipital region, and thinnest at the frontal region (Table and Graph 1). In support of this study, Bjork[30] reported in 1954 that men with robust bones tend to have a scissor bite and larger dental arches, suggesting a link between bone thickness and the development of malocclusion. Children with a robust physique respond better to orthodontic treatment because they are more active in growth.

These studies (Ingerslev CH[36] 1975, Brown T[37] 1979, Dostalova [38]2003) suggest that there is a relationship between malocclusion, orthodontic treatment, and bone thickness. Skull thickness is very important for orthodontic treatment planning, as it indicates bone thickness and estimates treatment time. Therefore, skull thickness is crucial to understanding the relationship between malocclusion, orthodontic treatment, and bone thickness.

The study found an association between skull thickness and skeletal deep bite, highlighting the need for future research on skull thickness in other malocclusions. Previous studies have shown that buccal cortical bone thickness is associated with mandibular angle and ramus width in patients with mandibular retrognathism and mandibular prognathism. CT scans support this hypothesis.

Adeloye[19] (1975), Hershkovitz I[21] (1999), and Bukhary MT[11] (2005) point out that orthodontists and oral surgeons often use profile radiographs for skeletal analysis, so linear measurements of the skull are useful for treatment planning. Skull thickness is an indicator of bone thickness, and standard cephalometric data are essential for the assessment of skull thickness.

A longitudinal study by Axelsson et al.[12] showed the development of the braincase in Norwegian males and females aged 6 to 21 years. However, the data are not relevant for patients over 21 years of age, as the increase in skull thickness in adults is unknown. Craniometry can also be useful in orthodontic practice.

Strengths of the study

The study was based on a large dataset obtained from accurate lateral cephalometric radiographs, which increases reliability. Data were collected from pretreatment records of subjects who underwent surgical orthodontics, providing precise measurements of skull thickness compared with subjects with normal occlusion, with results highly relevant for clinical orthodontic practice. Focusing on skull thickness in cases of skeletal deep bite has a direct impact on orthodontic treatment planning and contributes to the understanding of craniofacial growth variability and treatment outcome. Standardized imaging techniques were used in the study, reducing measurement variability and increasing the validity of the results.

Limitations of the study

This is a retrospective observational cohort study, therefore it is based on previously collected data, which limits the control of variables and may lead to selection bias. The study did not consider changes in skull thickness over time, which may provide further insight into growth patterns and treatment outcomes. The study population was not representative of all ethnicities and age groups, which may limit the generalizability of the results. Focusing only on subjects treated with surgical orthodontics may not reflect differences between non-surgical cases and cases treated with other modalities.

Conclusion

This study was conducted with the research question: "How does the skull thickness of the frontal, parietal, and occipital bones differ between people with a skeletal deep bite and a control group, and how does this affect orthodontic treatment planning?"

We found that people with a skeletal deep bite tend to have a thicker skull thickness compared to people with a neutral bite.

The variation in skull thickness was clear, with the skull being thickest at the parietal region, the skull being thinnest at the forehead region, and the skulls of women being thicker than those of men.

People who underwent surgical correction and bone screw treatment have healthy, thick bones to undergo corrective surgery and bone screw insertion.

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Legendary of images

Table 1: The mean average of skull thickness between Controls vs. Deep Bite Group

Bone	Group	n	Mean (mm)	SD	Range (mm)	Significance
Frontal Bone	Controls	18	6.33	0.97	[4.39, 8.27]	*
	Deep Bite	18	7.61	1.80	[3.81, 11.41]	
Parietal Bone	Controls	18	8.78	2.37	[4.04, 13.52]	***
	Deep Bite	18	11.22	1.60	[8.02, 14.42]	
Occipital Bone	Controls	18	7.58	1.24	[5.10, 10.06]	***
	Deep Bite	18	9.31	1.62	[6.07, 12.55]	

Significance levels: * = p < 0.05; ** = p < 0.01; *** = p < 0.001.

Graph 1: The mean average of skull thickness between Controls vs. Deep Bite Group

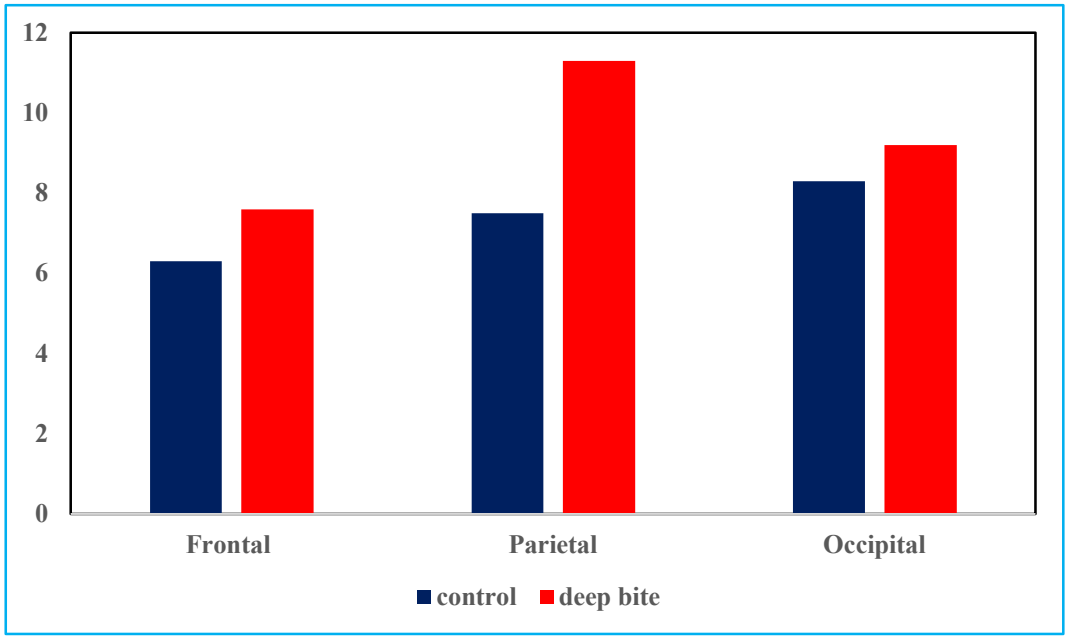
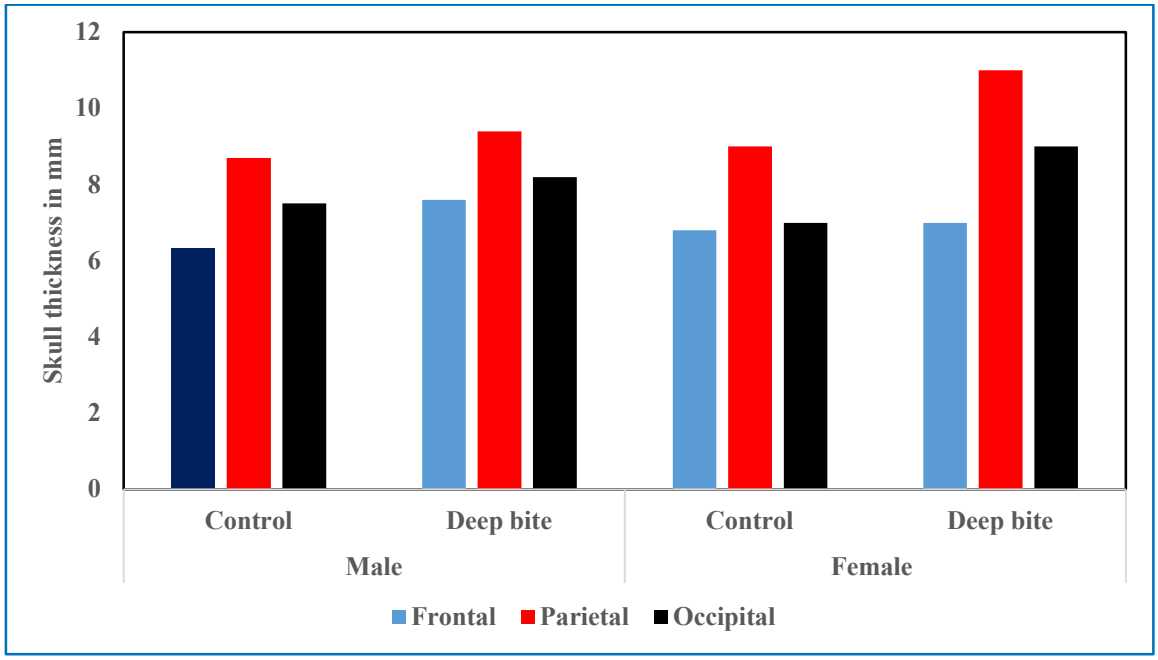


Table 2: mean skull thickness between Gender (Controls vs. Deep Bite Group)

Bone	Male (Mean ± SD) (n=36)		Female (Mean ± SD) (n=36)		Average		Significance
	Control	Deep bite	Control	Deep bite	Control	Deep bite	
Frontal Bone	6.33 ± 0.9	7.61 ± 1.8	6.46 ± 0.9	7.76 ± 1.8	6.40	7.69	*
Parietal Bone	8.78 ± 2.3	11.22 ± 1.6	8.96 ± 2.7	11.45 ± 1.6	8.87	11.34	***
Occipital Bone	7.58 ± 1.2	9.31 ± 1.2	7.73 ± 1.4	9.50 ± 1.2	7.66	9.41	***

Significance levels: * = p < 0.05; ** = p < 0.01; *** = p < 0.001.

Graph 2: mean skull thickness between Gender (Controls vs. Deep Bite Group)



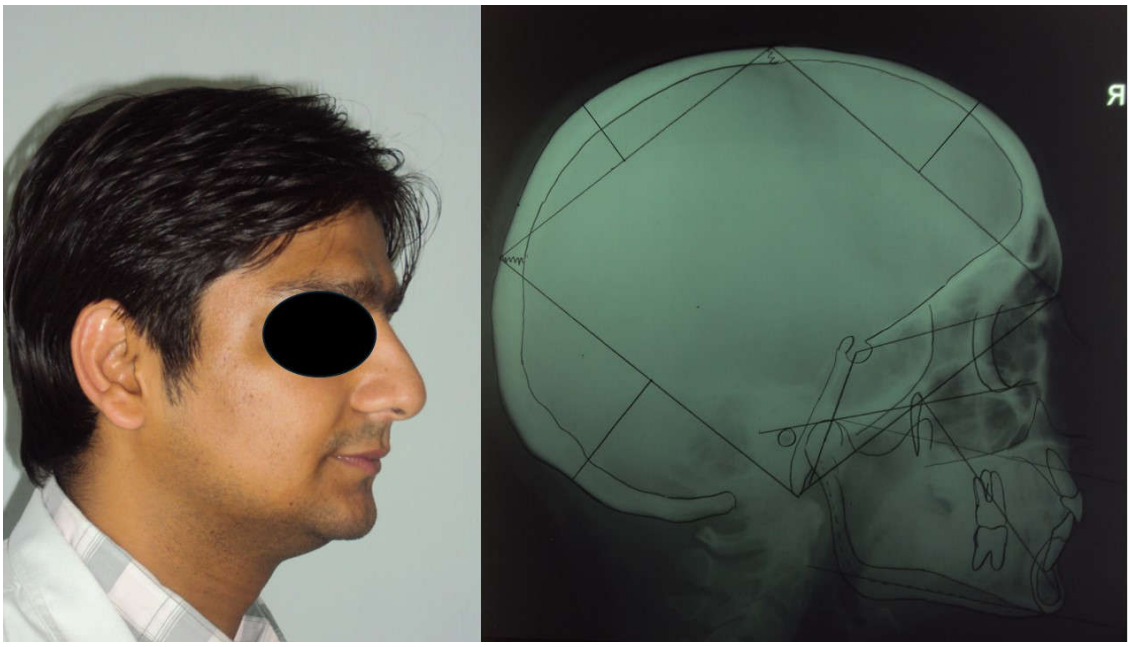


Figure 1. Lateral Profile photograph of neutral occlusion and lateral cephalogram.

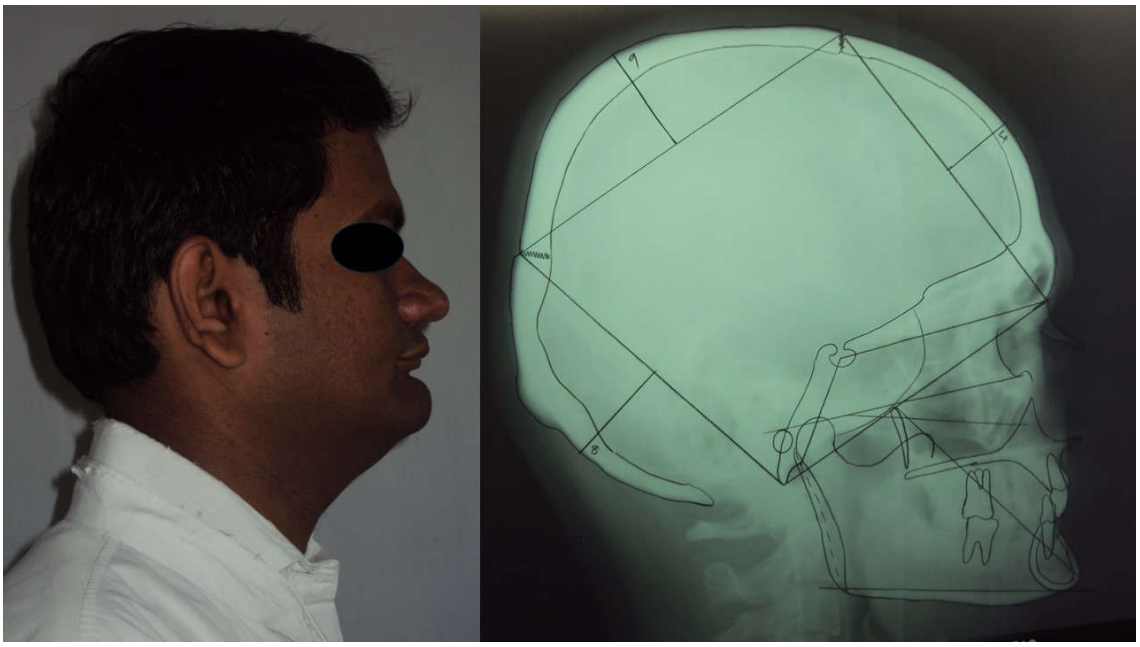


Figure 2. Lateral Profile photograph of Skeletal Deep bite and lateral cephalogram.

Measurements of cephalometric Points and lines according to Bjork and Axelsson:

Basion (ba): the most postero-inferior point on the clivus.

B**regma (br):** the intersection between the sagittal and coronal sutures on the surface of the cranial vault.

Frontale (f): the point on the surface of the frontal bone determined by a perpendicular to the line joining the nasion and bregma and passing through its midpoint.

Lambda (l): the intersection between the lambdoid and sagittal sutures on the surface of the cranial vault.

Nasion (n): the most anterior point on the fronto-nasal suture. Skull thickness according to Axelsson et al. the thickness of the frontal, parietal and occipital bones was defined as the distance.

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