ORIGINAL ARTICLE

PE Jacobsen
I Kjær
L Sonnesen

Skull thickness in patients with skeletal deep bite

Authors' affiliations:
Pernille Endrup Jacobsen, Community Dental Service, Herlev, Denmark
Inger Kjær, Liselotte Sonnesen, Department of Orthodontics, School of Dentistry, University of Copenhagen, Denmark

Correspondence to:
Liselotte Sonnesen
Department of Orthodontics
School of Dentistry
Faculty of Health Sciences
University of Copenhagen
20 Nørre Alle
DK-2200 Copenhagen N
Denmark
E-mail: lls@odont.ku.dk

Structured Abstract
Authors – Jacobsen PE, Kjær I, Sonnesen L
Objectives – Skull thickness in relation to patients with skeletal deep bite has not been reported previously. The present study examines the skull thickness in patients with skeletal deep bite and compares it with the skull thickness in subjects with neutral occlusion and normal craniofacial morphology.
Design – A retrospective case–control study.
Setting and Sample Population – The material comprised 36 patients divided into two groups, a group of 18 patients with skeletal deep bite (eight females, 10 males) and a control group of 18 subjects (eight females, 10 males) with neutral occlusion and normal craniofacial morphology.
Outcome – Skull thickness measurements.
Results – No significant gender differences were found regarding skull thickness. The skull was thicker in the deep bite group compared with the group with neutral occlusion and normal craniofacial morphology ($p < 0.05$).
Conclusion – The present study demonstrates that patients with skeletal deep bite have a significantly thicker skull than subjects with neutral occlusion and normal vertical craniofacial morphology. This is considered important for the treatment planning for orthodontic and orthognathic patients.

Key words: bone; human; malocclusion; radiography; skull

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Introduction

The thickness of the human skull has been the focus of great interest for more than a century, and several studies have been carried out reporting different results on the relationship between cranial thickness, gender and age (1–4). In two recent studies (5, 6), no association between age and cranial thickness was found, but with regard to gender, the Moreira-Gonzalez study (6) showed that female skulls on average were significantly thicker than male skulls. Lynnerup (5), on the other hand, reported no significant difference between genders.

Many studies have described an association between normative cephalometric values and ethnic groups (2, 7, 8), whereas studies on the skull thickness are limited. It has been found though that African-Americans and Australian Aborigines had a significantly thicker skull than Caucasians (6, 9).

Several pathological conditions influence the skull thickness. In acromegaly (10), the thickness of the skull increases during the course of the illness if the disease is not treated endocrinologically. In William's syndrome (11), the thickness of the skull increases more during development than under normal conditions. The same abnormal theca development is described in a number of blood disorders (12).

In order to evaluate the skull thickness, normative cephalometric data are necessary for comparison. Axelsson et al. (13) reported such normal data for the skull thickness in a longitudinal study, describing the development of the neurocranium in Norwegian males and females aged 6–21 years. These data provide a method of expressing abnormal conditions in skull thickness.

In severe malocclusion traits, abnormal bone thickness has been observed in different areas of the cranium. Tsunori et al. (14) found a strong association between the buccal cortical bone and various craniofacial morphologies. They demonstrated that the thicker the bone the smaller the gonial angle and vertical jaw relation. Ribeiro et al. (15) found that the width of the ramus mandibulae varies in patients with prognathia and retrognathia and concluded that the retrognathic patients had a significantly thicker ramus than the prognathic patients.

The aim of the present study was therefore to compare the skull thickness in patients with skeletal deep bite with the skull thickness in subjects with neutral occlusion and normal craniofacial morphology.

Material and methods

Material

The material comprised profile radiographs from 18 patients, systematically selected among 378 patients registered in the orthodontic surgical archive since 1975 at the Department of Orthodontics, Copenhagen School of Dentistry, Denmark. The study included eight females aged 19–34 years (mean 24.25) and 10 males aged 19–35 years (mean 25.90). All participants were Danish Caucasians with no prior history of orthodontic treatment during childhood. They had no craniofacial anomalies, systemic muscle or joint disorders, and they had at least 24 permanent teeth present. All patients had developed a skeletal deep bite diagnosed on lateral radiographs of each individual and were all treated as orthodontic surgical cases. The skeletal deep bite was defined as a vertical overbite >5 mm and a vertical jaw relationship of more than two standard deviations according to Björk (16).

The control group comprised 18 subjects, 10 males and eight females, all dental students aged 20–30 years, selected from material registered by Solow (17) and Ingerslev (18). The control group subjects were Danish Caucasians with no prior history of orthodontic treatment or craniofacial anomalies. They had at least 24 permanent teeth present, neutral occlusion and normal vertical jaw relationship diagnosed according to Björk (16).

Methods

The profile radiographs were taken in 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 enlargement of 5.6% (19).

Cephalometric analyses

The reference points were defined according to Björk (20), and the measurements of the skull thickness were defined according to Axelsson et al. (13) (Fig. 1).

Method error

The reliability of the variables describing the thickness of the frontal, parietal and occipital bones was assessed by re-measurement of 12 lateral radiographs selected at random from the previously recorded radiographs. The radiographs were measured again after 2 weeks, and the difference between the two sets of recordings were calculated. No significant difference was found between the two sets of recordings. The method errors (21) ranged from 0.10 to 0.51 mm and the reliability coefficient (22) from 0.80 to 0.96. The range was within the range of method errors reported in a previous study (23).

Statistical analyses

The normality of the distribution was assessed by parameters of skewness and kurtosis and by the Shapiro–Wilks *W*-test. The thickness of the parietal and occipital bones was normally distributed, whereas the

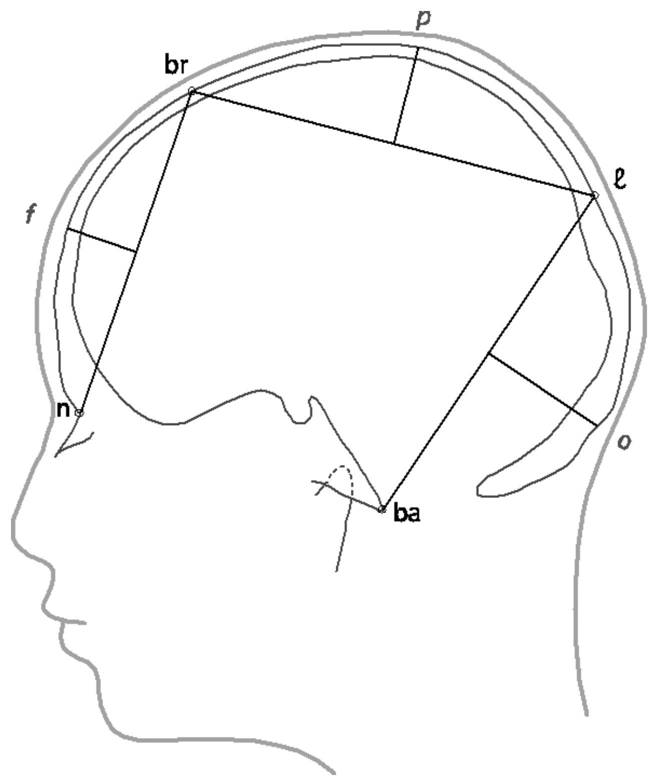

Fig. 1. Points and lines according to Björk (20): basion (*ba*): the most postero-inferior point on the clivus; *bregma* (*br*): the intersection between the sagittal and coronal sutures on the surface of the cranial vault; *frontale* (*f*): the point on the surface of the frontal bone determined by 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. (13): the thickness of the frontal, parietal and occipital bones was defined as the distance from the point where the perpendicular from the midpoint of the cords nasion–bregma, bregma–lambda and lambda–basion intersect the inner and outer contours of the respective bones.

frontal bone differed moderately from normal distribution. Differences in the means of thickness of the parietal, occipital and frontal bones between the two groups and between genders were assessed by unpaired *t*-tests. The results of the test were considered to be significant at *p*-values below 0.05. The statistical analyses were performed using SPSS 13.00 (SPSS Inc., Chicago, IL, USA).

Results

No significant gender differences were found regarding skull thickness, and the sample was gender pooled. The unpaired *t*-test showed a significantly thicker skull in the group with skeletal deep bite than in the group with normal occlusion ($p < 0.05$). The thickest skull was found in the occipital area, and the thinnest skull was located in the frontal region, independent of the group. The results are shown in Table 1 and an example of a deep bite patient with thick skull is shown in Fig. 2.

Table 1. **Thickness of the frontal, parietal and occipital bone in the controls and in the skeletal deep bite group**

	Controls			Deep bite			
	n	Mean	SD	n	Mean	SD	Significance
Thickness of the frontal bone	18	6.33	0.97	18	7.61	1.80	*
Thickness of the parietal bone	18	7.58	1.24	18	9.31	1.62	***
Thickness of the occipital bone	18	8.78	2.37	18	11.22	1.60	***

The thickness of the skull appears in millimeters.
*Significant at $p < 0.05$; *** significant at $p < 0.001$. Pooled across gender.

Fig. 2. Profile radiograph of a deep bite patient with thick skull.

Discussion

The aim of this study was to evaluate the skull thickness in patients with skeletal deep bite and to compare it with the skull thickness in subjects with neutral occlusion and normal vertical relation. The sample consisted of 18 skeletal deep bite patients and 18 gender-matched controls. The sample is sufficient to perform an unpaired *t*-test as the variables are normally distributed.

The results showed no difference in the skull thickness between the genders. This is in agreement with previous studies (5, 6), although some studies have concluded differently (2, 3). To our knowledge, no study similar to the present one has been published in which the skull thickness in patients with a skeletal malocclusion is compared with normal conditions.

In 1954, Björk (24) found that men with skeletal sturdiness had a tendency to scissors bite and larger dental arches compared with the slender build male patients. These results suggest a connection between the thickness of the bone in general and the development of malocclusions. In the same article, Björk (24) also found that 'sturdily build children respond better to orthodontic treatment, explained by a greater growth activity'. These studies indicate that there may be an association between malocclusion, orthodontic treatment and thickness of the bone in general. If this is the case, the skull thickness is considered to be important for the orthodontic treatment planning, as the skull thickness could be an indicator for the thickness of the bone in general. This information could also contribute to estimate the treatment time.

The present study revealed an association between the skull thickness and skeletal deep bite. This finding signifies the importance of future studies of the skull thickness in other malocclusions. Previous studies have shown a connection between the thickness of the buccal cortical bone and the gonial angle (14) and have determined that the width of the ramus mandibulae varies in retrognathic and prognathic patients (15). These findings, based on CT scans, support the hypothesis that there is a connection between malocclusions and bone thickness in the craniofacial area.

As orthodontists and oral surgeons often have profile radiographs at their disposal for skeletal analysis, a linear measurement of the skull can be a simple and informative procedure useful for treatment planning as the skull thickness is considered an indicator for the bone thickness in general. In order to evaluate the skull thickness, it is important to have normative cephalometric data. Axelsson et al. (13) reported such data in a longitudinal study, describing the development of the neurocranium in Norwegian males and females aged 6–21 years. Accordingly, these data cannot be used with patients older than 21 years as a further increase in thickness of the skull in adulthood is uncertain. As most patients undergo orthodontic treatment before or at the end of the growth period, the skull measuring method will be valid for orthodontic practice.

In conclusion, the present study demonstrates that patients with skeletal deep bite have a significantly thicker skull than subjects with neutral occlusion and normal vertical craniofacial morphology. This is considered important for the treatment planning for orthodontic and orthognathic patients.

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