Acta Odontologica Scandinavica, 2009; 67: 265–270

informa healthcare

ORIGINAL ARTICLE

Lengths of the maxillary central incisor, the nasal bone, and the anterior cranial base in different skeletal malocclusions

TORILL ARNTSEN, INGER KJÆR & LISELOTTE SONNESEN

Department of Orthodontics, School of Dentistry, Faculty of Health Sciences, University of Copenhagen, Copenhagen, Denmark

Abstract

Objective. Based on the results of previous studies of osseous structures within the frontonasal field in patients with a known malformation in the frontonasal field, the aim of the present study was to clarify whether the same structures were malformed in patients with severe skeletal malocclusions. ***Material and methods.*** Incisor, nasal, and cranial base lengths were measured on lateral radiographs of adult patients with skeletal malocclusions, including open bite ($n = 35$), mandibular overjet ($n = 56$), maxillary overjet ($n = 31$), deep bite ($n = 19$), and compared with those of a control group with neutral occlusion and normal craniofacial morphology ($n = 39$). Two-way ANOVA tests were used to evaluate differences in lengths between groups and gender. ***Results.*** Statistically shorter maxillary central incisor length was found in the open bite group ($p < 0.05$), the mandibular overjet group ($p < 0.001$), and in the deep bite group ($p < 0.001$) compared to the controls. Nasal bone length was shorter in the maxillary overjet group compared to controls ($p < 0.05$). ***Conclusions.*** The lengths of the maxillary central incisor and nasal bone, both parameters located in the frontonasal field, are affected in different skeletal malocclusions. The present findings, especially the deviation of the upper incisor length in different skeletal malocclusions, are considered relevant for orthodontic diagnostics and treatment.

Key Words: *Cephalometry, human, incisors, malocclusion, nasal bone*

Introduction

Associations have been described between dental anomalies and malocclusions. Thongudomporn & Freer [1] reported that 74.8% of 111 pretreatment orthodontic patients showed at least one dental anomaly, e.g. invagination, dental agenesis, taurodontism, ectopic eruption, etc. Willems et al. [2] studied the prevalence of dentofacial characteristics in malocclusion groups. Furthermore, several studies have focused on the differences in tooth-size associated with malocclusions, primarily on the mesiodistal dimension [3–7].

In craniofacial malformations seen in cleft lip and palate patients, abnormalities in tooth number, size, timing of formation, shape, and eruption are more frequent than in the general population [8]. Root development of the permanent cleft-side lateral incisor is often delayed compared to the non-cleft side in these patients [8–11]. Furthermore, this patient group has a higher prevalence of hypodontia compared to healthy subjects, both within and outside the cleft area [11,12]. Nielsen et al. [13] have shown that in patients with cleft lip the nasal bone is significantly shorter than in subjects with a cleft in the palate. It has been suggested that the cleft in cleft lip subjects could be associated with deviations in the development of the frontonasal field, which originates from the frontonasal neural crest cells.

The frontonasal field is a fan-shaped, axially orientated, field anterior of the cranial base (Figure 1). Involved in its formation are neural crest cells from the junction between the neural plate and the surface ectoderm. These cells form the external and internal nose and the anterior part of the maxilla after migration from the neural crest to the area between the eyes and to the premaxillary area where they interact with the local ectoderm. They also form the dentine and pulp tissue in the incisor region. Roughly, the frontonasal field forms the lower part of the frontal bone, the external and internal nose, the four maxillary incisors with surrounding alveolar

Correspondence: Liselotte Sonnesen, Department of Orthodontics, School of Dentistry, Faculty of Health Sciences, University of Copenhagen, 20 Nørre Alle, DK-2200 Copenhagen N, Denmark. Tel: +45 35 32 66 70. Fax: +45 35 32 66 86. E-mail: LLS@odont.ku.dk

(Received 14 August 2008; accepted 22 October 2008)

ISSN 0001-6357 print/ISSN 1502-3850 online
DOI: 10.1080/00016350802572314

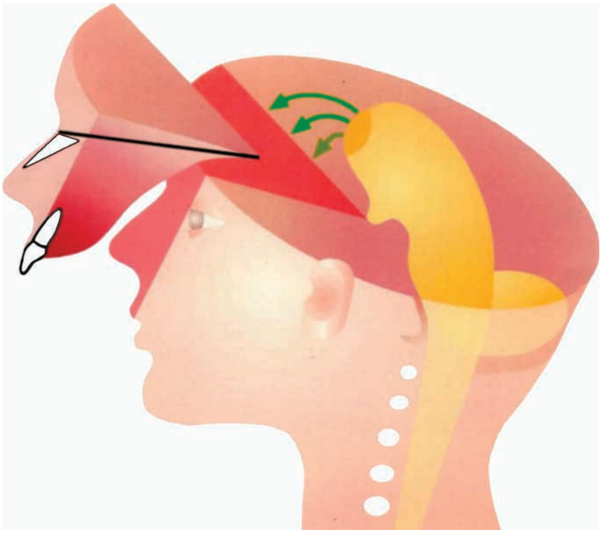

Figure 1. Schematic drawing demonstrating the frontonasal developmental field, including the three measured variables: the nasal bone, the nasion-sella distance (the anterior cranial base), and the maxillary central incisor.

bone and soft tissue. The field is limited posterior by the sella turcica.

The reason for measuring the length of the anterior fossa crania, the nasal bone, and the incisors, all structures belonging to the frontonasal field [14], is that these structures deviate from normal structures in patients with malformations of the frontonasal field. Examples of such malformations are SMMCI (single median maxillary central incisor) [15–17] and cleft lip [18,19]. Studies of these malformations have documented that the nasal bone and the fossa crania anterior are short in SMMCI and in cleft lip. In both conditions, malformations occur in the upper incisor region.

Based on such analyses of osseous structures within a malformed field, the present study focuses on the same structures in patients with severe skeletal malocclusions. The aim of this study was to clarify whether structures within the frontonasal field were malformed in patients with severe skeletal malocclusions. This has not been described before.

Material and methods

The present study consisted of profile radiographs from four groups of adult patients with severe skeletal malocclusions ($n = 141$) and from an adult control group ($n = 39$).

The four malocclusion groups

The malocclusion groups comprised a skeletal deep bite group ($n = 19$; 9 F, 10 M), a skeletal open bite group ($n = 35$; 28 F, 7 M), a skeletal maxillary overjet and Cl II group ($n = 31$; 26 F, 5 M), and a skeletal mandibular overjet and Cl III group ($n = 56$; 32 F, 24 M). All profile radiographs from the four malocclusion groups were systematically selected according to the inclusion criteria (mentioned below) from patients registered since 1975 in the orthodontic surgical patient archive (378 records) of the Department of Orthodontics, University of Copenhagen, Denmark.

The inclusion criteria for the four groups of patients with severe skeletal malocclusions were: 1) adult patients aged between 17 and 42 years; 2) no history of orthodontic treatment during childhood; 3) skeletal deep bite, skeletal open bite, skeletal maxillary overjet and Cl II, or skeletal mandibular overjet and Cl III (the vertical jaw relationship smaller or larger than 1 SD and the vertical overbite > 5 mm or < 0 mm, respectively, according to the standard material described by Björk [20] assessed by profile radiographs of each individual). The sagittal jaw relationship larger or smaller than 1 SD and the horizontal overjet > 6 mm and < 0 mm, respectively, according to the standard material described by Björk [20] assessed by profile radiographs of each individual; 4) at least 24 permanent teeth present; 5) no syndrome anomalies or systemic muscle or joint disorders, and 6) accessibility of a profile radiograph before presurgical orthodontic treatment.

The cephalometric mean values for the sagittal (ss-n-pg) and vertical (NL/ML) jaw relationships and the horizontal overjet and vertical overbite were calculated for the malocclusion groups and are listed in Table I.

Control group

The control group comprised 39 subjects (19 F and 20 M), all dental students aged between 22 and 30 years selected from material registered by Solow [21]

Table I. Mean values for the sagittal and vertical jaw relationship, and the horizontal overjet and vertical overbite in the skeletal malocclusion groups and in the control group.

Group	N	Sagittal jaw relation	SD	Vertical jaw relation	SD	Horizontal overjet	SD	Vertical overbite	SD
Open bite	35	1.8°	4.1	36.8°	4.3	6.4 mm	4.8	−4.2 mm	3.5
Mandibular overjet	56	−7.7°	3.2	25.5°	6.3	−4.4 mm	2.3	0.6 mm	2.9
Maxillary overjet	31	7.6°	2.5	31.3°	8.0	10.8 mm	3.7	1.3 mm	5.7
Deep bite	19	1.1°	2.7	14.5°	3.5	6.8 mm	4.7	9.2 mm	2.3
Control group	39	1.8°	1.7	24.2°	2.9	3.4 mm	0.9	3.0 mm	1.2

and Ingerslev [22] at the Department of Orthodontics of the University of Copenhagen, Denmark. The control group included healthy 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 and sagittal jaw relationship diagnosed according to Björk [23]. The cephalometric mean values for the sagittal and vertical jaw relationship and the horizontal overjet and vertical overbite in the control group are given in Table I.

Cephalometric analyses

The cephalometric tracing and measurements on conventional profile radiographs were done by T.A. and checked by L.S. using the cephalometric digitizing program Tiops2005 (Total Interactive Orthodontics Planning System, Tiops 2005, v. 2.12.4). 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% [23].

Three variables measured to describe the frontonasal area (Figures 1 and 2) were expressed as the distance in millimeters. The length of the maxillary central incisor was measured as the distance from the tooth's incisal edge (is) to the tip of its apex (as). The length of the nasal bone was measured as the distance from the most anterior point on the nasal bone (na) to the nasion (n). The length of the anterior cranial base was measured using the nasion (n) and sella (s) reference points (Figure 2). The reference points n, s and were defined according to Björk [24].

Method error

The reliability of the variables describing the three frontonasal variables was assessed by re-measurement of 20 lateral radiographs selected at random from the previously recorded radiographs. The radiographs were measured again after 2 weeks, and the differences between the two sets of recordings were calculated. No significant differences between the two sets of recordings were found by paired *t*-test. The method errors calculated by Dahlberg's formula ranged from 0.20 to 0.50 mm [25] and the Houston reliability coefficients ranged from 0.96 to 1.00 [26].

Statistical methods

Normality of the distribution was assessed by parameters of skewness and kurtosis and by using the Shapiro-Wilks W-test. The lengths of the central upper incisor, the nasal bone, and the anterior cranial base were normally distributed in all groups,

Figure 2. Profile radiograph of an adult female with skeletal maxillary overjet. The location of the cephalometric reference points for measuring the length of the central maxillary incisor, the nasal bone, and the anterior cranial fossa are marked on the radiograph. Nasion (n): the most anterior point on the frontonasal suture. Sella (s): the center of sella turcica. Incision superius (is): the midpoint of the incisal edge of the most prominent maxillary central incisor. Nasale (na): the tip of the nasal bone. Apex superius (as): the apical point of the maxillary central incisor. Reference points according to Björk [24]. The lines indicate the distances measured.

except for the nasal bone in the skeletal open bite group, where the distribution differed moderately from normal distribution. Differences in the means of the length of the central upper incisor, the nasal bone, and the anterior cranial base between groups and between genders were assessed by two-way analysis of variance (ANOVA), where length of the central upper incisor, the nasal bone, or the anterior cranial base was a dependent variable and groups and gender were independent variables. With only two independent variables in the analyses, a sample size of 20 subjects in each group was sufficient. The results of the test were considered to be significant at p-values <0.05. The statistical analyses were done using SPSS statistical software v. 3.00 (Statistical Package for Social Science, SPSS Inc., Chicago, Ill., USA).

Results

Statistically shorter maxillary central incisor length was found in the skeletal open bite group ($p<0.05$), the skeletal mandibular overjet group ($p<0.001$), and in the skeletal deep bite group ($p<0.001$) compared with the control group (Table II). A

Table II. Significant differences in mean length of the upper central incisor, the nasal bone and the anterior cranial base between the skeletal malocclusion groups and the control group.

		Malocclusion		Control		
Variable	Malocclusion group	Mean	SD	Mean	SD	P-value
Incisor	Open bite	23.07	2.36	24.46	1.60	P <0.05[1]
	Mandibular overjet	22.21	1.93	24.46	1.60	P <0.001
	Maxillary overjet	22.99	2.67	24.46	1.60	NS
	Deep bite	20.86	1.71	24.46	1.60	P <0.001[1]
	Open bite	22.41	3.45	22.74	2.60	NS
Nasal bone	Mandibular overjet	22.79	3.40	22.74	2.60	NS
	Maxillary overjet	21.19	2.51	22.74	2.60	P <0.05
	Deep bite	22.31	2.21	22.74	2.60	NS
	Open bite	67.58	4.34	68.53	3.39	NS
Anterior cranial base	Mandibular overjet	67.75	4.01	68.53	3.39	NS
	Maxillary overjet	67.72	3.33	68.53	3.39	NS
	Deep bite	69.07	4.03	68.53	3.39	NS

[1]: Significant gender effect: Maxillary incisor length shorter in females
NS: Not significant
SD:Standard deviation

significant gender effect was found in the skeletal open bite and deep bite groups (Table II), and in these two groups the maxillary incisor length was shorter in females.

Furthermore, the nasal bone length was significantly shorter in the maxillary overjet group compared to the control group ($p < 0.05$) (Table II). No significant differences in the anterior cranial base length were found between the skeletal malocclusion groups and the control group (Table II).

Discussion

The most important finding in this study was an earlier unknown difference in maxillary central incisor length when subjects with a skeletal malocclusion prior to orthodontic treatment are compared with controls with a normal jaw relationship and a neutral occlusion. Statistically shorter maxillary central incisor length was found in the skeletal open bite group, the skeletal mandibular overjet and CL III group, and in the skeletal deep bite group. A significant gender effect was found in the skeletal open bite and deep bite groups, and in these groups the maxillary incisor length was shorter in females. Furthermore, the nasal bone length was shorter in the maxillary overjet group compared to that in controls.

The methods used in this study were connected with some uncertainties. Marking of the tip of the nasal bone was sometimes difficult, especially in cases with slender bone contours. The apex of the central maxillary incisor was also sometimes difficult to measure. Therefore a method error of the three variables describing the frontonasal field in the present study was performed. No systematic error of the method was found and the method error and the reliability of the method were very precise. The etiology of the skeletal malocclusions was not analyzed, and the subjects in each group were therefore not subdivided. Still, the sample was considered sufficient to clarify whether structures within the frontonasal field were malformed in patients with severe skeletal malocclusions, which has not been described before.

Jakobsson & Lind [27] published a study on root lengths of permanent maxillary central incisors in a normal Swedish population of 1038 children. They used a definition of short root as defined by Lind [28]. Accordingly, a root length/crown height ratio ≤ 1.1 ($R/C \leq 1.1$) is defined as a short root. Two-point-four percent had short roots, and this anomaly affects girls more so than boys (ratio about 2.7:1). In the present study, a significant gender effect was found, where the maxillary incisor length was shorter in females in the skeletal open bite and deep bite groups. No other associations can be drawn from these two studies, as Jakobsson & Lind did not exclusively examine subjects with malocclusion.

Thongudomporn & Freer [1] found that short or blunt roots were seen in 23.4% of orthodontic patients and significantly more prevalent in females (14.1%) than in males (6.3%). Their method of measuring was similar to the method described by Lind [28]. The most affected teeth were the maxillary lateral and central incisors. This, and the gender differences, correlates well with the findings in our study. Thongudomporn & Freer [1] did not differentiate between skeletal and dental malocclusion. The present study only included skeletal malocclusions.

The present study showed that the lengths of the maxillary central incisor and the nasal bone, both parameters located in the frontonasal field, are affected differently in different skeletal malocclusions. A question that remains unanswered is why the parameters measured in this study are different in different malocclusions.

One explanation for a shorter maxillary incisor could be clenching, which could be the case in the skeletal deep bite group. A recent study has shown that nocturnal and diurnal clenching occurred significantly more often in adult patients with skeletal deep bite compared to age and gender matched controls [29]. Other factors could be dental trauma, because patients with severe maxillary overjet and insufficient lip closure are more often affected by dental trauma [30]. Still, in the present study no significant differences regarding incisor length were found in the skeletal maxillary overjet and CL II group. Furthermore, several studies have reported an altered crown-root angle in different groups of malocclusions [31–33]. This could perhaps influence the length measurements in the present study when the incisor length is measured from the incisal edge to the apex. Still, in the present study we found that structures within the frontonasal field were different in patients with severe skeletal malocclusions.

Recently, studies have been published on associations between skeletal malocclusions and different bony structures seen on profile radiographs. Sonnesen & Kjær [34–37] found associations between deviations in the cervical vertebrae and skeletal malocclusions. They localized fusions between the vertebrae more often and in different locations in patients with different skeletal malocclusions. Alkofide [38] studied and compared the sella turcica morphology in Class I, II, and III malocclusions. They found a significant difference between Class II and III, the former having a smaller diameter. Polat & Kaya [39], in comparing cranial base morphology in subjects with Class I, II, and III malocclusion, found no difference between these three groups in the length of the anterior cranial base. The present study adds deviations in the nasal bone to this list of skeletal deviations associated with different skeletal malocclusions.

In conclusion, the lengths of the maxillary central incisor and nasal bone, both parameters located in the frontonasal field, are affected in different skeletal malocclusions.

The present findings, especially the deviation of the upper incisor length in different skeletal malocclusions, are considered relevant for orthodontic diagnostics and treatment.

Acknowledgments

The Danish Medical Research Council and the IMK Foundation are acknowledged for funding. Maria Kvetny is acknowledged for manuscript preparation and linguistic support.

Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

References

[1] Thongudomporn U, Freer TJ. Prevalence of dental anomalies in orthodontic patients. Aust Dent J 1998;43:395–8.
[2] Willems G, De Bruyne I, Verdonck A, Carels C. Prevalence of dentofacial characteristics in a Belgian orthodontic population. Clin Oral Investig 2001;5:220–6.
[3] Ballard ML. Asymmetry in tooth size: a factor in the etiology, diagnosis and treatment of malocclusion. Angle Orthod 1944;14:67–71.
[4] Bolton WA. Disharmony in tooth size and its relation to the analysis and treatment of malocclusion. Angle Orthod 1958; 28:113–30.
[5] Lavelle CLB. Maxillary and mandibular tooth size in different racial groups and in different occlusal categories. Am J Orthod 1972;61:29–37.
[6] Nie Q, Lin J. Comparison of intermaxillary tooth size discrepancies among different malocclusion groups. Am J Orthod Dentofacial Orthop 1999;116:539–44.
[7] Al-Khateeb SN, Alhaija ESJA. Tooth size discrepancies and arch parameters among different malocclusions in a Jordanian sample. Angle Orthod 2006;76:459–65.
[8] Ranta R. A review of tooth formation in children with cleft lip/palate. Am J Orthod Dentofacial Orthop 1986;90:11–8.
[9] Solis A, Figueroa AA, Cohen M, Polley JW, Evans CA. Maxillary dental development in complete unilateral alveolar clefts. Cleft Palate Craniofac J 1998;35:320–8.
[10] Ribeiro LL, das Neves LT, Costa B, Gomide MR. Dental development of permanent lateral incisor in complete unilateral cleft lip and palate. Cleft Palate Craniofac J 2002;39: 193–6.
[11] Deepti A, Muthu MS, Siva Kumar N. Root development of permanent lateral incisor in cleft lip and palate children: a radiographic study. Indian J Dent Res 2007;18:82–6.
[12] Ribeiro LL, das Neves LT, Costa B, Gomide MR. Dental anomalies of the permanent lateral incisors and prevalence of hypodontia outside the cleft area in complete unilateral cleft lip and palate. Cleft Palate Craniofac J 2003;40:172–5.
[13] Nielsen BW, Mølsted K, Kjær I. Cross-sectional study of the length of the nasal bone in cleft lip and palate subjects. Cleft Palate Craniofac J 2005;42:417–22.
[14] Kjær I. Neuro-osteology. Crit Rev Oral Biol Med 1998;9: 224–44.
[15] Kjær I, Becktor KB, Lisson J, Gormsen C, Russell BG. Face, palate and craniofacial morphology in patients with a solitary median maxillary central incisor. Eur J Orthod 2001;23: 63–73.
[16] Becktor KB, Sverrild L, Pallisgaard C, Burhøj J, Kjær I. Eruption of the central incisor, the intermaxillary suture and maxillary growth in patients with a single median maxillary central incisor, SMMCI. Acta Odontol Scand 2001;59: 361–6.

[17] Tabatabaie F, Sonnesen L, Kjær I. The neurocranial and craniofacial morphology in children with solitary median maxillary central incisor (SMMCI). Orthod Craniofacial Res 2008;11:96–104.
[18] Dahl E. Craniofacial morphology in congenital clefts of the lip and palate. Acta Odontol Scand 1970;28: suppl 57.
[19] Nielsen BW, Mølsted K, Skovgaard LT, Kjær I. Cross-sectional study of the length of the nasal bone in cleft lip and palate. Cleft Palate-Craniofacial J 2005;42:417–22.
[20] Björk A. The face in pro?le. Svensk Tandläkare Tidskr 1947;40: Suppl 5B.
[21] Solow B. The pattern of craniofacial associations. Acta Odontol Scand 1966;24:21–41.
[22] Ingerslev CH, Solow B. Sex differences in the craniofacial morphology. Acta Odontol Scand 1975;33:85–94.
[23] Björk A. Kæbernes relation til det øvrige kranium. In: Ahlgren J, editor. Nordisk Lärobok i Ortodonti. Stockholm: Sveriges Tandläkarförbunds Förlagsförening; 1975.
[24] Björk A. Cranial base development. Am J Orthod 1955;41: 198–225.
[25] Dahlberg G. Statistical methods for medical and biological students. New York: Interscience Publications; 1940.
[26] Houston WJB. The analysis of errors in orthodontic measurements. Am J Orthod 1983;83:382–90.
[27] Jakobsson R, Lind V. Variation in root length of the permanent maxillary central incisor. Scand J Dent Res 1973;81:335–8.
[28] Lind V. Short root anomaly. Scand J Dent Res 1972;80:85–93.
[29] Sonnesen L, Svensson P. Temporomandibular disorders and psychological status in adult patients with a deep bite. Eur J Orthod 2008 Aug 5 [Epub ahead of print].
[30] Shulman JD, Peterson J. The association between incisor trauma and occlusal characteristics in individuals 8–50 years of age. Dent Traumatol 2004;20:67–74.
[31] Delivanis HP, Kuftinec MM. Variation in morphology of the maxillary central incisors found in class II, division 2 malocclusions. Am J Orthod 1980;78:438–43.
[32] Harris EF, Hassankiadeh S, Harris JT. Maxillary incisor crown-root relationships in different angle malocclusions. Am J Orthod Dentofacial Orthop 1993;103:48–53.
[33] McIntyre GT, Millett DT. Crown-root shape of the permanent maxillary central incisor. Angle Orthod 2003;73:710–5.
[34] Sonnesen L, Kjær I. Cervical vertebral body fusions in patients with skeletal deep bite. Eur J Orthod 2007;29:464–70.
[35] Sonnesen L ,Kjær I. Cervical column morphology in patients with skeletal Class III malocclusion and mandibular overjet. Am J Orthod Dentofacial Orthop 2007;132:427.e7–12.
[36] Sonnesen L, Kjær I. Cervical column morphology in patients with skeletal open bite. Orthod Craniofac Res 2008;11:17–23.
[37] Sonnesen L ,Kjær I. Anomalies of the cervical vertebrae in patients with skeletal Class II malocclusion and horizontal maxillary overjet. Am J Orthod Dentofacial Orthop 2008;133:188.e15–20.
[38] Alkofide EA. The shape and size of the sella turcica in skeletal Class I, Class II, and Class III Saudi subjects. Eur J Orthod 2007;29:457–63.
[39] Polat OO, Kaya B. Changes in cranial base morphology in different malocclusions. Orthod Craniofac Res 2007;10: 216–21.