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Craniofacial morphology in 6-year-old Icelandic children

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SUMMARY The purpose of the study was to describe the craniofacial characteristics of 6-year-old Icelandic children, make a normative standard for children with an Angle Class I molar relationship, and compare them to those with an Angle Class II molar relationship. The material consisted of the radiographs of 363 children, 184 (50.7 per cent) boys and 179 (49.3 per cent) girls with a mean age of 6 years 7 months (range: 5 years 7 months–7 years 8 months). Twenty-two reference points were digitized and processed by standard methods with the Dentofacial Planner® computer software program. The 33 variables calculated included both angular and linear. Two sample *t*-tests were used to study the differences between different groups. Only minimal differences could be noted between sexes in sagittal and vertical angular measurements. Linear measurements, on the other hand, were usually larger for the boys. When compared with Norwegian material of the same age group, similar trends were observed between sexes in both studies, but the Icelandic children showed slightly more mandibular prognathism and a lower mandibular plane angle. When compared with children with an Angle Class I molar relationship, children with an Angle Class II molar relationship did not have a different maxillary prognathism nor a different mandibular length. Cranial base dimensions were all significantly greater and the cranial base flexure was also significantly more obtuse in the distal group.

Introduction

Numerous studies have shown that various linear and angular cephalometric measurements differ between males and females and change with age (Björk, 1947; Riolo *et al*., 1974; Ødegaard, 1970; Bishara, 1981; Berg, 1983; El-Batouti *et al*., 1994). Furthermore, differences have been demonstrated among races (Cotton *et al.,* 1951; Altemus, 1960; Miyajima *et al.*, 1996), among Caucasians (Canut *et al*., 1987; Argyropoulos and Sassouni, 1989; El-Batouti *et al.,* 1995), and even among Scandinavians (Solow and Sarnäs, 1982). Therefore, cephalometric standards should be available for different populations, sex, and age groups to be used for orthodontic and other diagnosis, and treatment planning.

Orthodontic treatment in the early mixed and even in the late deciduous dentition has been indicated for several reasons (McNamara and Brudon, 1993; Tindlund, 1994) and is a common treatment modality. Hence, relative cephalometric normative standards for young individuals are essential in the diagnosis of and treatment planning for these age groups.

The purpose of the study was to describe the craniofacial characteristics of 6-year-old Icelandic children, make a normative standard for children with an Angle Class I molar relationship and compare them to those with an Angle Class II molar relationship.

Material and methods

Subjects

The material used in this investigation was collected at the Faculty of Odontology, University of Iceland, in 1987 and 1988 by two of the authors (AT and TEM) and has been described elsewhere (Johannsdottir *et al*., 1997). From the original sample of 396 children lateral cephalographs of 371 subjects were available. Films of

poor quality and those where the posterior teeth were not occluded were rejected, six altogether. One subject with cleft lip and palate and one of foreign origin were also excluded from the study. Thus, cephalographs from 363 children, 184 boys and 179 girls, were analysed. The mean age of the sample was 6 years and 7 months (range: 5 years 7 months–7 years 8 months). Most of the children were in dental stage DS1 (permanent incisors erupting), 67.9 and 84.9 per cent of the boys and girls, respectively.

Cephalometric analysis

The cephalographs were taken with a Lumex cephalostat (Tagarno). The focus-median plane distance was 180 cm and the focus-film distance 190 cm, producing a 5.6 per cent enlargement of midline structures. The cephalographs were taken with the subjects in an upright position with their teeth occluded. The films were then traced on acetate paper by one of the authors (BJ) in a negatoscope in a half-dark room. Reference points were identified and later digitized on a digitizing table (Numonics®, Vertigraph Inc., Dallas, Texas, USA) and processed using the Dentofacial Planner® (Dentofacial Software Inc., Toronto, Ontario, Canada) software. The magnification of the radiographs was corrected by the computer software program.

The following cephalometric landmarks were identified on each radiograph (Figure 1):

ai	apex inferius	The most apically positioned point on the root of the most labially positioned mandibular incisor, lying in the axis of the root canal
ans	anterior nasal spine	The apex of the anterior nasal spine
ar	articulare	The point of intersection of the dorsal contour of the condylar head and the contour of the external cranial base
as	apex superius	The most apically positioned point on the root of the most labially positioned maxillary incisor, lying in the axis of the root canal

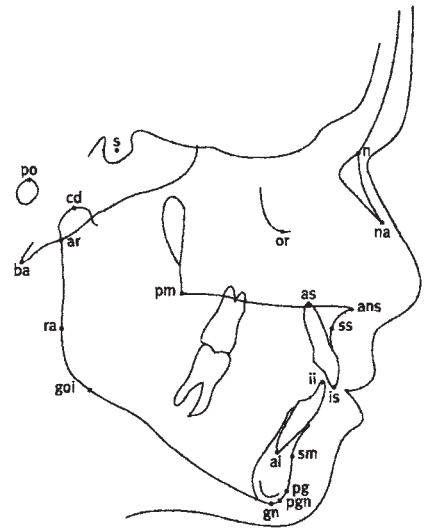

Figure 1 Cephalometric landmarks. Apex inferius (ai); anterior nasal spine (ans); articulare (ar); apex superius (as); basion (ba); condylion (cd); gnathion (American menton) (gn); gonion inferius (goi); incision inferius (ii); incision superius (is); nasion (n); nasal apex (na); orbitale (or); pogonion (pg); prognathion (American gnathion) (pgn); pterygomaxillare (pm); porion (po); ramus point (ra); sella (s); supramentale (Downs point B) (sm); subspinale (Downs point A) (ss).

ba	basion	The lowest, most posterior point on the anterior margin of the foramen magnum at the base of the clivus
cd	condylion	Point on the contour of the condyle obtained by bisecting the angle formed by tangents to the upper and posterior borders of the condyle, the tangents being parallel to the ML and perpendicular to the ML, respectively
gn	gnathion	The most inferior point of the mandibular symphysis (American menton)
goi	gonion inferius	The tangent point of the inferior border of the mandible near gonion
ii	incision inferius	The midpoint on the incisor edge of the most labially positioned mandibular central

is	incision superius	The midpoint on the incisor edge of the most labially positioned maxillary central
n	nasion	Anterior limit of the naso-frontal suture
na	nasal apex	The most inferior and anterior point of the nasal bone
or	orbitale	The deepest point on the infra-orbital margin
pg	pogonion	The most prominent point of the mandibular symphysis
pgn	prognathion	The point on the mandibular symphysis farthest from the condylion (American gnathion)
pm	pterygo-maxillare	Point of intersection of hard palate, soft palate and pterygopalatal fissure
po	porion	The mid-point on the upper contour of the external auditory canal
ra	ramus point	The lower tangent point of the posterior border of the ramus
s	sella	Centre of sella turcica
sm	supramentale	The deepest point on the contour of the mandibular alveolar process, in relation to the NL (Downs B-point)
ss	subspinale	The deepest point on the contour of the maxillary alveolar process, in relation to the NL (Downs A-point)

Reference lines are shown in Figure 2. From the cephalometric landmarks and reference lines the following linear and angular measurements were carried out.

Basal sagittal measurements:
Angular: s–n–ss (SNA), s–n–sm (SNB), s–n–pg, ss–n–sm (ANB), n–ss–pg;
Linear: ss ⊥ n–pg;

Basal vertical measurements:
Angular: s–n/po–or (NSL/FH), s–n/pm–sp (NSL/NL), pm–sp/goi–gn (NL/ML), s–n/goi–gn (NSL/ML), ra–ar/goi–gn (RL/ML);

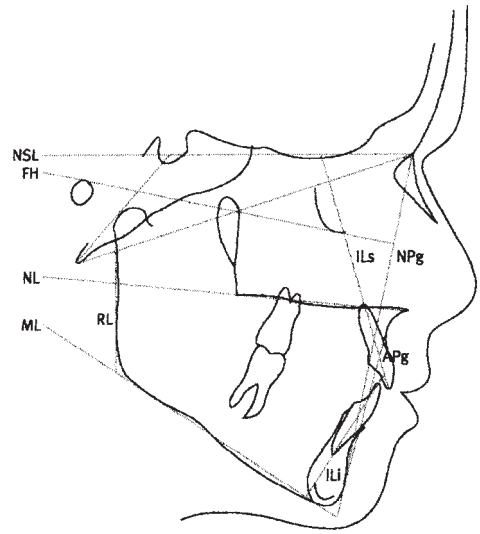

Figure 2 Reference lines. NSL: nasion–sella line (n–s); FH: Frankfort horizontal (po–or); NL: nasal line (pm–ans); ML: mandibular line (goi–gn); RL: ramus line (ra–ar); NPg: nasion–pogonion line (n–pg); APg: supbspinale–pogonion line (ss–pg); ILs: long axis of the upper incisors (as–is); ILi: long axis of the lower incisors (ii–ai).

Linear: n–gn (anterior face height), s–goi (posterior face height);
Ratio: n–ans/ans–gn (anterior face ratio);

Mandibular length:
Linear: cd–tgo, cd–pgn, ar–pgn;

Dental measurements (dental variables were evaluated only in subjects where permanent incisors had erupted):
Angular: as–is/sn, as–is/pm–sp, ii–ai/goi–gn, as–is/ii–ai;
Linear: is ⊥ ss–pg, is ⊥ n–ss, ii ⊥ ss–pg, ii ⊥ n–sm;

Cranial base:
Angular: n–s–ba, n–s–ar;
Linear: s–n, s–ba, s–ar, n–ba;

Nasal bone:
Angular: s–n–na;
Linear: n–na.

Comparison of craniofacial morphology according to molar relationship

Based on an earlier investigation (Johannsdottir *et al.*, 1997) on plaster models, the children were divided into two groups, a normal occlusion group and a distal occlusion group. Those children that had an Angle Class I molar relationship on both sides belonged to the normal occlusion group. The criterion for the distal occlusion group was a distal relationship on the molars, one cusp distal or more, on one or both sides. According to this categorization the normal group consisted of 200 individuals, 100 boys and 100 girls, and the distal group included 16 boys and 16 girls.

Statistical method

Descriptive statistics including mean, standard deviation, and maximum and minimum values were computed for each variable. Two-sample *t*-tests were used to compare the means of different groups and 95 per cent confidence intervals (CI) were calculated.

Reliability

Thirty-two randomly selected cephalographs were traced and digitized after an interval of at least 1 month. In order to estimate the measurement error,

Dahlberg's formula $Se = \sqrt{\Sigma d^2/2n}$

was used, where d is the difference between repeated measurements and n is the number of paired measurements. Systematic error was estimated by a one-sample *t*-test, as suggested by Houston (1983).

Results

In general, the error of the measurements was small; variables involving teeth such as as–is/sn, as–is/pm–sp, ii–ai/goi–gn and as–is/ii–ai showed the largest variance. One variable, sn/po–or, reached the 5 per cent level of significance in the paired *t*-test. This could be associated to the known difficulty of localizing both the point porion and orbitale in the Frankfort horizontal plane.

The whole sample

The results of skeletal variables are presented in Table 1. Average values of both maxillary and mandibular prognathism were slightly higher in the girls than in the boys, but the differences were small and did not reach the 5 per cent level of significance except for the variable s–n–pg ($P \leq 0.05$). The basal sagittal jaw relationship (ANB angle) did not show a significant difference between the sexes. There was no difference between the boys and the girls in the inclination of the upper and the lower jaw, and the same was true for the gonial angle. The total face heights, posterior and anterior, were significantly larger in the boys ($P \leq 0.001$), but the anterior face ratio was not different. Mandibular base length was significantly larger in the boys ($P \leq 0.001$). Dental variables did not show a statistical difference between sexes. Anterior, posterior, and total cranial base dimensions were significantly larger in the boys ($P \leq 0.001$). The length of the nasal bone was not different, but there was slightly more prominence of the nasal bone in the girls ($P \leq 0.05$).

Comparison of the normal and the distal group

The craniofacial morphology of children with normal and those with Class II occlusion are presented in Table 2. There was no difference between the two groups in maxillary prognathism. The distal group appeared to have increased mandibular retrognathy, judging from the sagittal position of both point B ($P \leq 0.001$) and point pogonion ($P \leq 0.01$). The sagittal jaw discrepancy expressed by the ANB angle was 2 degrees greater in the distal group ($P \leq 0.001$). The convexity of the face (n–ss–pg) was greater in the distal group ($P \leq 0.001$). Total anterior and posterior facial heights did not appear different. There was no difference in the mandibular length. In the normal group the upper incisors were more protruded in relation to the n–ss line ($P \leq 0.05$), whereas the lower incisors were more protruded in relation to the ss–pg line ($P \leq 0.05$). In the distal group the cranial base flexure was more obtuse ($P \leq 0.001$) and the length of the anterior cranial base was greater ($P \leq 0.05$), as

Table 1 Craniofacial morphology of 6-year-old Icelandic children.

Measurement		Boys					Girls					Mean difference	95% CI
		n	Mean	SD	Min	Max	*n*	Mean	SD	Min	Max		
Basal sagittal													
s–n–ss (SNA)	degree	184	81.5	3.3	73.1	91.3	179	82.1	3.2	75.2	90.4	–0.59	(–1.25/0.07)
s–n–sm (SNB)	degree	184	77.4	3.0	68.4	88.6	179	78.0	3.2	70.2	89.8	–0.63	(–1.27/0.02)
s–n–pg	degree	184	77.5	3.0	68.6	89.2	179	78.2	3.2	70.1	89.9	–0.73	(–1.38/–0.09)*
ss–n–sm (ANB)	degree	184	4.1	2.1	–2.5	10.4	179	4.0	2.0	–1.2	9.3	0.03	(–0.40/0.45)
ss ⊥ n–pg	mm	184	3.2	1.9	–2.8	9.5	179	3.0	1.7	–1.9	7.1	0.22	(–0.16/0.60)
n–ss–pg	degree	184	8.3	4.9	–7.8	22.1	179	7.9	4.6	–5.3	18.4	0.33	(–0.65/1.31)
Basal vertical													
s–n/po–or (NSL/FH)	degree	184	8.6	2.4	–0.4	15.8	179	8.6	2.7	1.8	16.6	–0.01	(–0.54/0.51)
s–n/pm–sp (NSL/NL)	degree	184	5.7	2.9	–3.2	12.4	179	5.5	2.7	–1.9	13.3	0.17	(–0.40/0.75)
pm–sp/goi–gn (NL/ML)	degree	184	27.6	4.2	17.8	43.3	179	27.5	3.9	17.1	41.0	0.12	(–0.72/0.96)
s–n/goi–gn (NSL/ML)	degree	184	33.3	4.2	23.8	49.5	179	33.0	4.2	18.3	46.1	0.29	(–0.58/1.15)
n–ans/ans–gn	per cent	184	76.5	6.6	61.1	100.2	179	75.7	6.0	61.6	93.2	0.84	(–0.47/2.15)
n–gn (ant. face height)	mm	184	95.9	4.4	85.5	109.3	179	93.3	3.8	82.9	104.7	2.57	(1.72/3.42)***
s–goi (post. face height)	mm	184	61.2	3.4	52.1	69.7	179	59.6	3.0	51.5	68.5	1.59	(0.93/2.25)***
ra–ar/goi–gn (RL/ML)	degree	184	128.3	5.2	113.6	146.5	179	127.6	5.3	109.3	144.9	0.72	(–0.36/1.80)
Mandibular length													
cd–tgo	mm	184	44.3	2.7	36.1	51.4	179	43.8	2.7	36.5	52.5	0.53	(–0.02/1.08)
cd–pgn	mm	184	92.5	3.8	84.1	102.4	179	91.2	3.7	78.0	100.3	1.37	(0.59/2.15)***
ar–pgn	mm	184	87.7	3.6	80.4	97.9	179	86.1	3.4	72.6	94.3	1.62	(0.90/2.35)***
Dental													
as–is/sn (ILs/NSL)	degree	38	101.2	6.6	91.0	118.2	64	99.7	6.8	85.10	115.8	1.54	(–1.18/4.26)
as–is/pm–sp (ILs/NL)	degree	38	106.5	6.7	93.8	126.2	64	105.2	7.0	91.0	119.8	1.39	(–1.41/4.19)
is ⊥ ss–pg	mm	38	3.8	1.8	–0.1	8.2	64	3.7	2.0	–1.9	8.2	0.06	(–0.72/0.83)
is ⊥ n–ss	mm	38	1.4	1.8	–1.6	5.7	64	1.6	1.9	–2.3	6.0	–0.16	(–0.91/0.58)
ii–ai/goi–gn (Ili/ML)	degree	125	88.7	6.6	72.4	110.9	152	89.3	7.0	70.1	105.4	–0.60	(–2.22/1.03)
ii ⊥ ss–pg	mm	125	0.1	1.9	–4.2	6.4	152	0.4	1.7	–3.9	5.6	–0.27	(–0.69/0.15)
ii ⊥ n–sm	mm	125	2.1	1.8	–2.5	8.8	152	2.3	1.6	–2.3	6.5	–0.17	(–0.57/0.23)
as–is/ii–ai (ILs/ILi)	degree	24	134.8	8.4	118.1	147.2	36	139.2	9.0	122.4	156.1	–4.36	(–9.00/0.28)
Cranial base													
n–s–ba	degree	184	130.3	4.6	117.0	141.3	179	130.0	4.7	118.2	142.7	0.24	(–0.72/1.20)
n–s–ar	degree	184	121.8	4.4	106.7	131.2	179	121.6	4.9	104.4	132.3	0.22	(–0.74/1.18)
s–n	mm	184	63.0	2.6	56.3	70.6	179	61.2	2.3	55.8	68.9	1.86	(1.35/2.36)***
s–ba	mm	184	37.4	2.3	32.0	42.5	179	36.6	2.3	29.5	41.7	0.78	(0.31/1.25)***
s–ar	mm	184	28.2	2.3	22.7	34.8	179	27.2	2.1	21.7	34.0	0.95	(0.50/1.40)***
n–ba	mm	184	91.7	3.5	83.4	103.5	179	89.2	3.3	80.1	97.7	2.47	(1.76/3.17)***
Nasal bone													
n–na	mm	184	18.1	2.6	10.2	24.1	179	17.8	2.2	11.1	24.3	0.26	(–0.24/0.76)
s–n–na	degree	184	104.1	5.5	90.5	120.3	179	105.3	5.3	92.3	121.2	–1.16	(–2.27/–0.05)*

*$P \leq 0.05$; ***$P \leq 0.001$.

Table 2 Craniofacial morphology of 6-year-old Icelandic children with Angle Class I normal occlusion and Angle Class II (1/1 cusp distal) occlusion.

Measurement		Class I					Class II					Mean difference	95% CI
		n	Mean	SD	Min	Max	*n*	Mean	SD	Min	Max		
Basal sagittal													
s–n–ss (SNA)	degree	200	81.8	3.2	73.1	90.4	32	81.6	2.8	76.9	89.5	–0.25	(0.94/–1.44)
s–n–sm (SNB)	degree	200	78.2	3.0	70.2	86.0	32	75.9	3.9	69.7	89.8	–2.29	(–1.12/–3.46)***
s–n–pg	degree	200	78.2	3.1	70.1	86.4	32	76.4	3.7	71.0	89.9	–1.81	(–0.63/–2.99)**
ss–n–sm (ANB)	degree	200	3.7	1.9	–1.2	8.2	32	5.7	2.1	–0.3	10.4	2.05	(2.77/1.33)***
ss ⊥ n–pg	mm	200	2.8	1.7	–1.9	7.1	32	4.2	1.9	–1.0	9.5	1.38	(2.03/0.72)***
n–ss–pg	degree	200	7.4	4.5	–5.3	18.4	32	10.8	4.8	–2.6	22.1	3.46	(5.15/1.76)***
Basal vertical													
s–n/po–or (NSL/FH)	degree	200	8.6	2.4	1.2	14.5	32	9.4	2.4	2.8	15.2	0.83	(1.73/–0.08)
s–n/pm–sp (NSL/NL)	degree	200	5.5	2.8	–1.9	13.3	32	6.0	2.8	1.3	12.0	0.51	(1.55/–0.53)
pm–sp/goi–gn (NL/ML)	degree	200	27.8	4.1	17.2	43.3	32	26.7	4.6	18.8	41.0	–1.10	(0.46/–2.67)
s–n/goi–gn (NSL/ML)	degree	200	33.3	4.2	20.8	49.5	32	32.7	4.5	24.6	46.1	–0.58	(1.01/–2.17)
n–ans/ans–gn	per cent	200	75.6	6.3	61.1	100.2	32	78.2	6.7	63.3	89.5	2.58	(4.97/0.19)*
n–gn (ant. face height)	mm	200	94.5	4.4	82.9	109.3	32	95.3	4.4	86.6	108.3	0.84	(2.47/–0.80)
s–goi (post. face height)	mm	200	60.1	3.3	51.5	66.7	32	60.9	2.9	54.5	66.4	0.77	(1.98/–0.44)
ra–ar/goi–gn (RL/ML)	degree	200	128.1	5.1	113.2	146.5	32	127.1	5.5	115.1	144.9	–0.99	(0.95/–2.93)
Mandibular length													
cd–tgo	mm	200	44.0	2.7	36.1	52.5	32	44.1	2.6	36.5	49.3	0.13	(1.16/–0.89)
cd–pgn	mm	200	92.0	3.8	78.0	102.1	32	92.2	4.3	80.2	100.9	0.24	(1.69/–1.21)
ar–pgn	mm	200	87.0	3.7	72.6	96.8	32	87.2	4.1	78.6	97.2	0.21	(1.61/–1.19)
Dental													
as–is/sn (ILs/NSL)	degree	49	100.8	7.0	88.6	115.8	16	97.2	5.7	88.9	107.8	–3.61	(0.26/–7.48)
as–is/pm–sp (ILs/NL)	degree	49	106.0	7.3	93.8	119.8	16	103.1	6.0	94.1	112.1	–2.88	(1.15/–6.91)
is ⊥ ss–pg	mm	49	3.7	1.7	–0.1	7.0	16	3.5	2.3	–1.9	7.1	–0.26	(0.80/–1.33)
is ⊥ n–ss	mm	49	1.7	1.7	–1.4	6.0	16	0.4	1.9	–2.3	3.3	–1.30	(–0.28/–2.32)*
ii–ai/goi–gn (Ili/ML)	degree	147	88.7	7.1	70.1	110.9	25	91.2	7.7	74.3	104.4	2.42	(5.48/–0.64)
ii ⊥ ss–pg	mm	147	0.6	1.8	–3.6	6.4	25	–0.8	1.5	–4.2	3.0	–1.40	(–0.66/–2.13)***
ii ⊥ n–sm	mm	147	2.3	1.8	–2.3	8.8	25	2.2	1.7	–0.8	6.1	–0.11	(0.64/–0.85)
as–is/ii–ai (ILs/ILi)	degree	26	137.6	8.4	123.2	156.1	9	139.6	9.2	124.8	155.6	2.06	(8.84/–4.72)
Cranial base													
n–s–ba	degree	200	129.5	4.5	117.0	140.7	32	132.9	4.2	125.7	142.7	3.39	(5.06/1.72)***
n–s–ar	degree	200	121.0	4.6	104.4	131.2	32	124.3	4.2	115.7	131.7	3.34	(5.05/1.62)***
s–n	mm	200	62.1	2.6	55.8	70.6	32	63.1	3.1	58.0	69.1	1.01	(2.01/0.02)*
s–ba	mm	200	36.7	2.2	29.5	42.5	32	38.0	2.5	30.6	41.9	1.33	(2.17/0.49)**
s–ar	mm	200	27.4	2.1	21.7	33.7	32	28.6	2.2	23.4	34.0	1.28	(2.09/0.47)**
n–ba	mm	200	89.9	3.5	80.1	103.5	32	93.1	4.2	84.4	99.9	3.27	(4.62/1.92)***
Nasal bone													
n–na	mm	200	17.9	2.4	11.5	24.3	32	18.4	2.5	11.1	23.2	0.47	(1.38/–0.44)
s–n–na	degree	200	104.6	5.2	90.5	116.9	32	104.1	4.9	95.7	117.4	–0.52	(1.40/–2.45)

*$P \leq 0.05$; **$P \leq 0.01$; ***$P \leq 0.001$.

were the posterior cranial base ($P \leq 0.01$) and the total cranial base ($P \leq 0.001$).

Discussion

The whole sample

Boys consistently showed larger values for most of the linear variables, but the angular variables were usually not found to be different between the sexes. This finding is in agreement with other studies dealing with children of the same age (Ødegaard, 1970; Berg, 1983). The Icelandic group demonstrated slightly more mandibular prognathism than the 6-year-old Norwegian children (Berg, 1983). The mean value for the variable s–n–sm for the Norwegian children was 76.4 degrees (SD: 3.3) and 76.5 degrees (SD: 3.3), for the variable s–n–pg. Respective figures for the Icelandic children were 77.4 degrees (SD: 3.0) and 78.0 degrees (SD: 3.2), for boys and girls respectively. The mean values for the variable s–n–pg in the Icelandic sample were 77.5 degrees (SD: 3.0) for the boys and 78.2 degrees (SD: 3.2) for the girls. The mandibular plane angle (NSL/ML) was slightly smaller in the Icelandic sample as compared with Berg's (1983) study. The mean value for both sexes in the Norwegian sample was 34.1 degrees (SD: 4.4) compared with 33.3 degrees (SD: 4.2) and 33.0 degrees (SD: 4.2) for the Icelandic boys and girls, respectively. The results of the present study are in agreement with those of Berg (1983), who showed that boys had larger vertical face dimensions.

The clear sex difference in the size of the cranial base observed at 6 years of age in our sample and the absence of clear sex dimorphism in cranial base flexion is consistent with observations in other studies (Ødegaard, 1970; Berg, 1983). The cranial base angles n–s–ba and n–s–ar were slightly smaller in our material in comparison with Berg (1983).

Comparison of the normal and the distal group

Increased mandibular retrognathism associated with post-normal occlusion as observed in this study has been noticed earlier (Björk, 1947; Solow, 1966; Ingervall and Lennartsson, 1972; McNamara, 1981; Berg, 1983; Karlsen, 1994).

Increased maxillary retrognathism in association with mandibular retrognathism reported in some investigations (Ingervall and Lennartsson, 1972; Berg, 1983) could not be confirmed in this study. On the other hand, Björk (1947), Solow (1966), Kerr and Adams (1988), and Karlsen (1994) found, in agreement with this study, no difference in maxillary prognathism associated with post-normal occlusion. McNamara (1981) found that in Class II cases the maxilla was, on average, in a neutral position, and in those cases where the maxilla was not in a neutral position it was more often in a retruded than in a protruded position.

A shorter mandible has been described as one of the characteristics of post-normal occlusion (Ingervall and Lennartsson, 1972; Berg, 1983; Karlsen, 1994), but the results of this study did not confirm this observation. On the other hand, and in agreement with our study, Dibbets (1996) did not find a different mandibular base length in association with the three different Angle classes.

The anterior cranial base and the middle cranial fossa have been reported as longer in individuals with Class II malocclusion (Enlow and Hans, 1996). Our results are in agreement with this opinion. A clear difference of the cranial base size and shape, especially the posterior cranial base, between the normal and post-normal groups was found and has also been reported by others (Ingervall and Lennartsson, 1972; Kerr and Hirst, 1987; Kerr and Adams, 1988; Bacon *et al.*, 1992; Dibbets 1996). On the other hand, Berg (1983) did not find any differences between the normal and the distal occlusion groups regarding the size and dimensions of the cranial base.

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