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Sagittal occlusal relationships and asymmetry in prematurely born children

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SUMMARY The aim of this investigation was to examine the effect of pre-term birth on sagittal occlusal relationships. The subjects were 328 prematurely born white and black children and 1804 control children who participated in the cross-sectional study of the Collaborative Perinatal Project (USA) in the early 1960s and 1970s. Dental examinations, including dental casts and photographs, were performed at the age of 6–12 years. The sagittal occlusion of the permanent molars and the canine relationship was recorded by examining and measuring the hard stone casts. The pre-term and comparison groups were divided by sex and race.

A significantly greater prevalence of pre-normal canine relationships was found in the pre-term group than in the controls ($P < 0.001$). The incidence of a bilateral symmetrical canine relationship was 60.3 per cent in both the pre-term and control groups, but in the pre-term group the girls had better symmetry than the boys. Asymmetry occurred significantly more often on the left side ($P < 0.001$), especially in the control boys, but this was not so clear in the pre-term group. The prevalence of mesial molar occlusion was greater in the pre-term group.

These results suggest that premature birth and the consequent exceptional adaptation from intra- to extra-uterine nutrition may influence dental occlusal development. This emphasizes the importance of early functional activity and differences in masticatory muscle activity and the largely unknown phenomenon of early catch-up growth. Individual differences in neonatal factors, in the need for intubation and other medical care are also of importance. Pre-term birth may also interfere with the development of symmetry and lateralization.

Introduction

Both genetics and environment may influence the development of the occlusion, but relatively little is known about the effects of peri-natal factors such as masticatory muscle activity, oral habits, the state of health of the mother and child, or nutrition on the growth of the jaws. Individual occlusal relationships have been reported to indicate a dominance of environmental over genetic factors, while some combinations of occlusal traits show a noticeable genetic influence (Harris and Smith, 1982). Infants born pre-term, i.e. prior to 37 gestational weeks, are predisposed to various peri-natal and neonatal complications and developmental problems, which can affect their development and growth in infancy and childhood and also interfere with the developing dentition. Prematurely born children have been reported to have a period of catch-up growth, an accelerated growth period, when the velocity of growth is above normal for their age (Prader *et al.*, 1963). Although the mechanism of catch-up growth has not been ascertained, the factors influencing general growth and development also seem to apply to this period (Hack *et al.*, 1984).

A number of systemic derangements are associated with enamel hypoplasia and hypo-mineralization of primary and permanent teeth in prematurely born children, including hypocalcaemia (Seow *et al.*, 1984), respiratory distress syndrome (Johnsen *et al.*, 1984), neonatal infections (Funakoshi *et al.*, 1981), nutritional disorders, and hypophosphataemic rickets (Seow *et al.*, 1984). Premature infants often have to undergo neonatal laryngoscopy and endotracheal intubation for resuscitation to relieve respiratory distress, and these are reported to be related to local dental defects (Moylan *et al.*, 1980; Noren *et al.*, 1993; Seow, 1997), palatal groove formation (Saunders *et al.*, 1976; Erenberg and Nowak, 1984; Molteni and Bumstead, 1986), a high-arched palate (Fadavi *et al.*, 1992; Procter *et al.*, 1998), palatal asymmetry (Kopra and Davis, 1991; Macey-Dare *et al.*, 1999), and posterior crossbite (Fadavi *et al.*, 1992).

The growth and development of the dentition continues from about the age of 5 weeks *in utero* until approximately 20 years post-natally. At the time of full-term birth (40 gestational weeks) mineralization of the crowns of the primary incisors is almost complete and that of the other primary crowns has already started. Initiation of all the anterior permanent teeth begins *in utero*, but their completion in terms of size extends over a wide range and is highly variable. Calcification of the first permanent molar crown begins at the 28th to the 30th gestational week, the intercuspal distances are complete 6 months after birth, and all dimensions by the age of 3–4 years post-natally. Completion of the rest of the permanent tooth crowns, excluding the third molars, has been shown to occur up to 7 or 8 years of age (Kraus and Jordan, 1965). In pre-term children primary and permanent tooth crown size variability has been observed (Seow and Wan, 2000; Harila-Kaera *et al.*, 2001).

Variation between individuals exists in the onset and direction of changes and in the total increments in arch length, breadth, and circumference (Moorrees, 1959). The changes in maxillary and mandibular arch length are not continuous during the development of the dentition but occur in the form of growth periods, mainly from 4 to 6 and 10 to 14 years of age. The patterns of mean changes in maxillary and mandibular arch length and breadth are associated in a general way with the emergence of the permanent incisors, canines, and premolars, when the changes are greatest (Moorrees, 1959). The mandible is composed of different functional and morphogenetic units, among which the condyle is considered to be a growth zone that is affected by functional alterations (Kiliaridis, 1995). Less attention has been paid to the role of the mandibular symphysis. Throughout foetal life the mandible is a paired bone and at the end of the first year small, irregular bones fuse with the mandibular body, and the two halves of the mandible unite by ossification of the symphyseal fibrocartilage (Bhaskar, 1980); a remodelling process then takes place during post-natal bone growth to maintain a form appropriate to their biomechanical function.

Imbalance in the mechanical forces acting on malleable tissues may result in deformations, and gravitational and positioning forces may lead to deformations and deviation of the cranial and facial bones in immature, prematurely born infants. The bones of the skull are thin and soft, and post-natal moulding of the head shape, i.e. side-to-side flattening of the head, is commonly seen in pre-term infants, especially during the first few months (Baum and Searls, 1971; Marsden, 1980; Elliman *et al.*, 1986). In the early stages of the development of the oral cavity, the soft bones of the palate are malleable and pressure from any object can easily mould the shape of the palate (Palmer, 1998). The aim of this work was to examine the influence of pre-term birth on the occlusal sagittal relationships.

Subjects and methods

The subjects consisted of 328 pre-term and 1804 control children, giving a total of 2132. There were 60 white children (40 boys and 20 girls) and 268 black children (140 boys and 128 girls) in the pre-term group, and 803 white children (408 boys and 395 girls) and 1001 black children (477 boys and 524 girls) in the control group. The limit for prematurity was placed at 36 gestational weeks for whites and 35 gestational weeks for blacks, in order to maintain practical proportions between the pre-term and control children in the statistical comparisons. The mean gestational age was 33.7 weeks in the pre-term white boys and

40.3 weeks in their controls, with corresponding figures of 34.6 weeks and 40.6 weeks for the white girls, 31.7 weeks and 39.8 weeks for the black boys, and 32.2 weeks and 39.9 weeks for the black girls. The average period of gestation was approximately 9 days shorter for blacks than for whites (Hardy *et al*., 1979).

All children were among the 60 000 participants in the Collaborative Perinatal Study of the National Institute of Neurological Disorders and Stroke (NINDS) in the 1960s. The dental examinations were performed in six collaborating medical centres (Buffalo, NY; Richmond, VA; Portland, OR; Philadelphia, PA; Providence, RI; and Johns Hopkins, MD) in the 1970s. Medical background data were obtained from the first registration of the pregnancy up to the seventh year of age, including anamnestic information on the mother's health and background (Hardy *et al*., 1979). The duration of gestation was taken to be the time elapsing between the first day of the last menstrual period (LMP) reported by the woman and delivery, computed in days and then transposed to weeks and rounded to the nearest week. The date of the LMP was ascertained by a special interviewer, and the duration of gestation was also based on the history and physical findings and an estimate by the obstetrician, which was confirmed at each pre-natal visit. Data concerning the type of delivery, including birth weight, birth length, head circumference, etc. were obtained within 1 hour of delivery by an observer using calibrated scales (Hardy *et al*., 1979). The measurements were repeated at 4, 8, and 12 months and at the ages of 3, 4, and 7 years.

The dental examinations were carried out cross-sectionally, with dental casts made and photographs taken in a standardized fashion at the age of 6–12 years in 95 per cent of the subjects. Alginate impressions were taken at each co-operating centre and plaster casts were made (Hunter and Priest, 1960). All the casts were checked and trimmed at the University of Wisconsin, and the arch dimensions and occlusal variables, including the molar and canine sagittal relationships (n = 189 variables), were recorded by examining and measuring the hard stone casts by a modified version of the methods used by Björk *et al.* (1964) and Laine and Alvesalo (1986). The mean chronological age at which the dental casts were taken was 8.8 years in the pre-term group and 8.5 years in the controls, and the conceptional ages of the groups were also quite similar. The occlusal variables were compared between the pre-term and control groups, each divided by sex and race, the canine relationship being recorded in the sagittal plane with the hard stone casts in centric occlusion looking along the tangent to the upper incisors on both sides of the face. The points at which the measurements were taken in the primary, mixed, and permanent dentitions were the mesial prominences of the canines, the approximal points of the lower canine, and the lower second incisor in the mandible (Grön and Alvesalo, 1997). The canine relationship was classified as pre-normal, normal, cusp/cusp, or post-normal (Figure 1). In the pre-normal relationship the lower canine was situated more mesially than

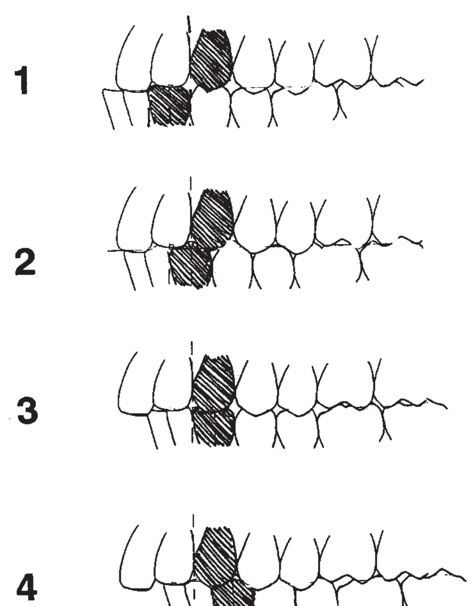

Figure 1 The canine relationship in the sagittal plane. (1) Pre-normal canine relationship: if the lower canine is situated more mesially than is considered normal (>2.0 mm). (2) Normal canine relationship: the lower canine is situated (>0.0–2.0 mm) mesially with respect to the upper canine. (3) Cusp/cusp canine relationship: if the mesial prominences of the canine are equally situated in the sagittal plane (0.0 mm). (4) Post-normal canine relationship: if the lower canine is situated more distally than is considered normal (<0.0 mm).

could be considered normal (less than 2 mm), in the normal relationship the lower canine was located more than 0.0–2.0 mm mesially with respect to the upper canine, in the cusp-to-cusp relationship the mesial prominences of the canine were situated equally in the sagittal plane (0.0 mm), and in the post-normal relationship the lower canine was more distal than could be considered normal (less than 0.0 mm). The sagittal asymmetry of the bilateral canine relationships was classified as either symmetrical (left and right side gradings equal) or asymmetrical: either left side ahead (the canine relationship on the left side more mesial than on the right side), or right side ahead (the reverse). The statistical method used was chi-squared analysis, and directional asymmetry was explored using the binomic test for asymmetrical cases.

The sagittal occlusion of the permanent molars was determined in a corresponding manner, using Angle's classification and the method of Björk *et al.* (1964) as guides in recording the results. A classification of the occlusion on both sides of the dental arch to an accuracy of half a cusp was thus obtained. The occlusion of the molars was classified as either neutral, mesial, or distal. A neutral molar relationship was either definite (the mesiobuccal cusp of the permanent upper first molar occluded into the buccal fossa of the lower first molar), or less than half cusp mesial or distal (the mesiobuccal cusp of the upper first molar occluded less than half a cusp mesially or distally relative to the buccal fossa of the lower first molar), whereas a distal or mesial molar relationship was either from half to full cusp mesial/distal, or more than full cusp mesial/distal.

The level of intra-examiner error in the analysis of molar and canine occlusions was estimated as the percentage reproducibility of the same occlusal status in double determinations. Double determinations were performed on 70 dental casts and the reproducibility in the analysis of molar occlusions was 95 per cent, and that of canine occlusions 83 per cent. In subjects without eruption of the permanent first molars, the molar sagittal relationship was recorded from the primary second molars. The statistical method used was the chi-squared analysis.

Results

The results suggest a significantly greater prevalence of a mesial sagittal occlusion in the prematurely born children. A pre-normal canine relationship was found on the right side in 42.9 per cent in the pre-term group and in 33.0 per cent of the controls [95% confidence interval (CI) 3.86, 16.0] (Table 1), and on the left side in 48.6 per cent of subjects in the pre-term group and 34.8 per cent in the controls (95% CI 7.55, 20.0) when all the pre-term infants were compared with all the controls. The prevalence of a normal canine relationship was reduced by 5.3 per cent on the right side and 7.9 per cent on the left side in the pre-term group compared with the controls, and there were less cusp/cusp and post-normal canine relationships.

The same trend still existed when the groups were divided by sex and race (Table 2), the prevalence of a pre-normal canine relationship on the left side being 14.6 per cent greater in the pre-term black girls than in their controls, which was statistically significant (95% CI 4.17, 25.0) (Table 3). The incidence of a normal canine relationship was reduced by 11.8 per cent, and that of a cusp/cusp relationship by 6.1 per cent, relative to the controls. A greater proportion of pre-normal canine relationships was also found in the pre-term white boys and white girls, being 13.3 per cent greater in boys and 1.3 per cent greater in girls on the left side (Table 3). The results on the right side showed an 8.5 per cent greater prevalence in the pre-term white boys, 5.8 per cent in the pre-term black girls, 0.2 per cent in pre-term white girls, and 0.4 per cent in the pre-term black boys. These results were not statistically significant (Table 2).

The results concerning the molar relationships suggest a greater prevalence of Class AI (Proffit, 1986) molar occlusions in the pre-term group than in the controls. There was a significantly greater prevalence of bilateral Class AI molar relationships, 78.9 per cent of cases in the pre-term group, and 69.4 per cent in the controls (95% CI 4.48, 14.5) (Table 4), whereas the proportion of bilateral Class AII molar relationships was reduced by 3.4 per cent in the pre-term group relative to the controls (6.0 and

Table 1 Comparison of the canine relationship in the pre-term and control groups.

Canine relationship	Right		Left	
	Premature	Control	Premature	Control
Pre-normal (%)	42.9	33.0	48.6	34.8
n	127	521	139	553
% difference	+9.9		+13.8	
95% CI	3.86, 16.0		7.55, 20.0	
Normal (%)	36.2	41.4	35.0	42.9
n	107	655	100	681
% difference	–5.2		–7.9	
95% CI	–11.3, 0.71		–13.9, –1.85	
Cusp/cusp (%)	10.1	10.6	5.9	9.7
n	30	167	17	154
% difference	–0.5		–3.8	
95% CI	–4.18, 3.33		–6.85, –0.64	
Post-normal (%)	10.8	15.1	10.5	12.7
n	32	238	30	201
% difference	–4.3		–2.2	
95% CI	–8.20, –0.29		–6.07, 1.75	
Chi-squared value	12.0		20.8	
P	0.007**		0.001**	

Table 2 Comparison of the canine relationship on the right side between the premature and control groups by sex and race.

Right canine	White boys		White girls		Black boys		Black girls	
	Premature	Control	Premature	Control	Premature	Control	Premature	Control
Pre-normal (%)	27.0	18.6	21.1	20.8	44.5	44.1	50.0	44.2
n	10	70	4	72	57	183	56	196
% difference	+8.4		+0.3		+0.4		+5.8	
Normal (%)	48.7	44.6	26.3	48.0	35.2	37.1	34.8	37.7
n	18	168	5	166	45	154	39	167
% difference	+4.1		–21.7		–1.9		–2.9	
Cusp/cusp (%)	10.8	14.6	21.1	13.0	9.4	8.0	8.9	7.7
n	4	55	4	45	12	33	10	34
% difference	–3.8		+8.1		+1.4		+1.2	
Post-normal (%)	13.5	22.3	31.6	18.2	10.9	10.8	6.3	10.4
n	5	84	6	63	14	45	7	46
% difference	–8.8		13.4		+0.1		–4.1	
Chi-squared value	2.9		4.4		0.3		2.6	
P	0.4		0.2		0.9		0.5	

9.4 per cent, respectively) (95% CI –6.35, –0.44). The prevalence of bilateral Class III occlusions was similar in both groups, being 1.6 per cent in the pre-term children and 1.1 per cent in the controls. The differences in Class AII and III prevalences were not significant.

When the right/left-side symmetry of the canine relationship was assessed, the incidence of a symmetrical relationship was 60.3 per cent for both the pre-term and control children (Table 5). When the groups were divided by sex, a symmetrical canine relationship was found in 55.7 per cent of the pre-term boys and 60.5 per cent of the controls, and in 66.4 per cent of the pre-term girls and 60.1 per cent of the controls (Table 6), differences that were not statistically

Table 3 Comparison of the canine relationship on the left side between the premature and control groups by sex and race.

Left canine	White boys		White girls		Black boys		Black girls	
	Premature	Control	Premature	Control	Premature	Control	Premature	Control
Pre-normal (%)	33.3	20.1	23.5	22.2	50.0	51.8	56.0	41.1
n	12	75	4	79	62	216	61	183
% difference	+13.2		+1.3		–1.8		+14.6	
95% CI							4.17, 25.0	
Normal (%)	33.3	46.5	47.1	49.2	37.1	34.1	31.2	43.0
n	12	174	8	175	46	142	34	190
% difference	–13.2		–2.1		+3.0		–11.8	
95% CI							–21.6, –1.95	
Cusp/cusp (%)	13.9	13.4	5.9	12.1	6.5	5.3	2.8	8.8
n	5	50	1	43	8	22	3	39
% difference	+0.5		–6.2		+1.2		–6.0	
95% CI							–2.82, 9.43	
Post-normal (%)	19.4	20.1	23.5	16.6	6.5	8.9	10.1	6.8
n	7	75	4	59	8	37	11	30
% difference	–0.7		+6.9		–2.4		+3.3	
95% CI							–2.82, 9.43	
Chi-squared value	4.0		1.0		1.2		12.7	
P	0.3		0.8		0.7		0.005**	

Table 4 Comparison of the molar relationship between the premature and control groups.

Molar relationship	Premature	Control	Total
AI/AI (%)	78.9	69.4	
n	250	1197	1447
% difference	+9.5		
95% CI	4.48, 14.5		
AII/AII (%)	6.0	9.4	
n	19	162	181
% difference	–3.4		
95% CI	–6.35, –0.44		
AIII/AIII (%)	1.6	1.1	
n	5	19	24
% difference	+0.5		
95% CI	–0.98, 1.93		
Asymmetrical occlusion (%)	13.6	20.1	
n	43	347	390
% difference	–6.5		
95% CI	–10.8, –2.33		
n total	317	1725	2042
Chi-squared value	13.4		
P	0.004**		

significant. In the pre-term group, girls appeared to achieve more symmetrical results than boys (66.4 and 55.7 per cent, respectively), but the small number of pre-term girls involved must also be taken into consideration (Table 6).

For the asymmetrical subjects, a left-side involvement was found significantly more often in the total series ($P < 0.001$) (Table 7) and in the controls ($P = 0.001$), whereas the value for the pre-term group was $P < 0.05$. When the groups were divided by sex, the same trend existed in all groups, but only the result for the control boys reached statistical significance ($P < 0.001$) (Table 7).

The prevalence of an asymmetrical molar relationship was 6.6 per cent lower in the pre-term children, 13.6 per cent versus 20.1 per cent in the controls, a difference that was statistically significant (95% CI –10.8, –2.33) (Table 4).

Discussion

The 10–14 per cent increase in the prevalence of a pre-normal canine relationship and mesial molar occlusion in the prematurely born children focuses attention on the importance of peri-natal factors in the development of the dentition. Although both genetic and environmentalfactors affect craniofacial morphology, it has been suggested that occlusal similarities in families may be more related to common environmental

Table 5 Comparison of the canine relationship symmetry between the pre-term and control children.

Canine relationship	Pre-term	Controls	Total
Symmetrical *n* (%)	158 (60.3%)	9.23 (60.3%)	1081 (60.3%)
Left side ahead *n* (%) (more mesial)	62 (23.7%)	344 (22.5%)	406 (22.7%)
Right side ahead *n* (%) (more mesial)	42 (16.0%)	263 (17.2%)	305 (17.0%)
Total *n*	262	1530	1792
Chi-squared value	0.3		
P	0.9		

Table 6 Comparison of the canine relationship symmetry between the pre-term and control boys and the pre-term and control girls.

Canine relationship	Pre-term boys	Control boys	Pre-term girls	Control girls	Total
Symmetrical *n* (%)	83 (55.7%)	466 (60.5%)	75 (66.4%)	457 (60.1%)	1081 (60.3%)
Left side ahead *n* (%)	39 (26.2%)	184 (23.9%)	23 (20.4%)	160 (21.1%)	406 (22.7%)
Right side ahead *n* (%)	27 (18.1%)	120 (15.6%)	15 (13.3%)	143 (18.8%)	305 (17.0%)
Total *n*	149	770	113	760	1792
Chi-squared value	1.3		2.3		
P	0.5		0.3		

Table 7 Asymmetry of the canine relationship (left/right side ahead) in the pre-term and control children.

	Left side ahead (*n*)	Right side ahead (*n*)	Total (*n*)	*P* (binomic)
Pre-term children	62 (59.6%)	42 (40.4%)	104	0.05
Control children	344 (56.7%)	263 (43.3%)	607	0.001
Total	406 (57.1%)	305 (42.9%)	711	<0.001
Pre-term boys	39 (59.1%)	27 (40.9%)	66	0.14
Pre-term girls	23 (60.5%)	15 (39.5%)	38	0.20
Control boys	184 (60.5%)	120 (39.5%)	304	<0.001
Control girls	160 (52.8%)	143 (47.2%)	303	0.33

effects than to genetic factors, and that the genetic contribution to occlusal variation is quite low, at least for the molar relationship (Harris and Smith, 1980). Townsend *et al.* (1988) similarly arrived at generally low heritability estimates for overbite, overjet, and sagittal molar relationship (30 per cent), emphasizing the importance of environmental influences on occlusal variation. Various environmental factors influence the dentition during the period of occlusal development, including general health and growth disturbances in childhood, masticatory muscle activity, mouth breathing, oral habits, and even socio-economic status. It has also been suggested that hereditary factors determine the development of the jaws and occlusion, and that environmental factors only have a modifying effect (Myllärniemi, 1972).

The influence of masticatory muscle function on craniofacial growth has been demonstrated in animal studies, which have shown that increased masticatory function may lead to increased sutural growth and bone apposition, and reduced muscle function to a decrease in bone mineral mass (Kiliaridis, 1995). Prematurely born infants have to adapt to extra-uterine conditions exceptionally early, and oral function (extra-uterine nutrition, sucking) begins approximately 1–1.5 months earlier than in full-term children. Nyqvist *et al.* (1999) found that nutritive sucking occurs from 31 weeks post-menstrual age (PMA) onwards, and full breast-feeding at a mean PMA of 36 weeks. Prematurely born infants are often underweight and immature, and may have retarded growth, but they have been reported to have a period of catch-up growth of greater velocity than is normal for their age, which continues until the standard growth curve has been achieved (Prader *et al.*, 1963; Hack *et al.*, 1984). In a study of mandibular growth in rats after short-term dietary protein restriction (Alippi *et al.*, 1999), the posterior part of the mandible showed an ability to achieve complete catch-up in approximately 30 days during nutritional rehabilitation. Although there are differences between species, the investigation of Alippi *et al.* (1999) may provide some information on the possible effect of catch-up growth and increased functional activity on mandibular growth in prematurely born children.

Oral habits such as thumb sucking, mouth breathing, and tongue thrusting, and also oromuscular forces affecting the developing dentition in formative periods, are important as aetiological factors for malocclusions (Nanda *et al.*, 1972; Larsson, 1994). Prematurely born children have a higher incidence of infections, respiratory problems, and systemic diseases in infancy and early childhood, while allergies, adenoids, and respiratory infections are the most frequent causes of mouth breathing and it has been assumed that the latter, involving a low tongue position, has an adverse influence on the development of the occlusion (Nanda *et al.*, 1972). Large tonsils can reduce the space in the mouth and cause the tongue to be low and pushed forward, pressing against the teeth of the lower jaw (Ricketts, 1968; Myllärniemi, 1972). Children with a mouth breathing habit have been shown to have a greater prevalence of a Class III canine and molar relationship and greater overjet than others, while tongue thrust is an infantile habit that is apt to lead to an increased prevalence of a Class III canine and molar relationship and open bite with little or no overjet (Nanda *et al.*, 1972). An association has also been reported between postural disorders, head posture, and dental occlusion (Huggare, 1998; Solow and Sonnesen, 1998). Impaired nose breathing triggers an increase in craniocervical angulation (Solow and Sierbæk-Nielsen, 1984), and sagittal dentofacial development has been found to be restrained by an increased craniocervical angle, and released by a reduction in this angle (Solow and Sonnesen, 1998).

Pre-term and low-birthweight infants often have an unusually long, narrow head (dolicocephaly) compared with full-term babies (Baum and Searls, 1971; Marsden, 1980; Elliman *et al.*, 1986; Rutter *et al.*, 1993). This post-natal moulding of head shape results from the quite long immobile neonatal period, when pre-term babies lie with their heads turned to one side and prolonged pressure is applied to a small area of the skull. The head position is due to a relatively large head mass and poor neck muscle tone, and the skull bones are thin and soft (Baum and Searls, 1971; Rutter *et al.*, 1993). This altered head shape does not appear to be related to developmental delay, nor to abnormal cranial ultrasound results (Elliman *et al.*, 1986). Head flattening in pre-term infants may resolve with time (Rutter *et al.*, 1993), but adults who were born prematurely have been found to show a persistence of the skull deformation acquired neonatally and to have significantly elongated and narrower skulls than is normal for young adults (Baum and Searls, 1971; Elliman *et al.*, 1986). It has been suggested that the way the infant is nursed, e.g. the use of water pillows, may reduce skull deformation in pre-term infants (Marsden, 1980; Schwirian *et al.*, 1986). A significant increase in growth of the craniofacial and palatal width and palatal area has been observed in very low birthweight infants wearing specially designed, foam pressure-dispersing pads during hospitalization compared with those not wearing them (Morris and Burns, 1994). Premature infants often require neonatal oral intubation for resuscitation, when the orotracheal tube may press the alveolar ridge and midline of the palate disturbing palatal growth. Prolonged intubation has been associated with narrowing and deepening of the palate and palatal asymmetry (Ash and Moss, 1987; Macey-Dare *et al*., 1999). The narrow high-vaulted palate may also be an oral manifestation of the narrow, elongated head of the prematurely born infant (Ash and Moss, 1987). Procedures during delivery and post-natally causing moulding of head shape may also influence the development of the jaws and the occlusion (Pirttiniemi *et al*., 1994), in that prematurely born children with a long, narrow head may also have a tendency for a longer, narrower mandible, and one area for future research will be to examine dental arch dimensions in prematurely born infants.

According to some studies, pre-term delivery and adverse peri-natal factors may interrupt the normal development of brain asymmetry and lead to an atypical direction of lateralization (Powls *et al*., 1996). An increased prevalence of non-right-handedness has been found among very low and extremely low birthweight children (Ross *et al*., 1987; Marlow *et al*., 1989; Powls *et al*., 1996), and also among mentally handicapped individuals (Batheja and McManus, 1985). Peri-natal stress during development has been reported to increase the magnitude of fluctuating asymmetry in calcium-dependent systems, i.e. the dentition, long bones, and membranous bones (Siegel and Mooney, 1987). In the present study the prevalence of asymmetry in the occlusion did not differ between pre-term and control children, but a sex difference was found to exist, in that the pre-term boys appeared to have greater asymmetry than the pre-term girls. On the other hand, the pre-term girls formed the smallest group (20 subjects) and this small sample size must be taken into consideration when evaluating the results. This finding supports earlier reports concerning the sex difference in symmetry, girls generally having greater symmetry than boys, e.g. in permanent tooth eruption (Heikkinen *et al*., 1999). General directional asymmetry and left-side dominance in the mandible has been reported by Huggare and Houghton (1995). When the asymmetrical cases of bilateral canine relationships were explored, the prevalence of left-side involvement was greater than the right side in the total population and in the controls, especially the control boys. However, the prevalence of this directional asymmetry in the occlusion was not so clear in the pre-term group.

Conclusions

Analysis of sagittal occlusal variables indicated a significantly greater prevalence of pre-normal canine and mesial molar relationships in the pre-term group than in the controls, and this persisted even when the groups were divided by sex and race. These results suggest that premature birth and the consequent exceptional adaptation from intra- to extra-uterine life may influence dental occlusal development. This emphasizes the importance of early functional activity and post-natal moulding of head shape, and the largely unknown phenomenon of early catch-up growth. Individual differences in neonatal factors, in the need for intubation, and other medical care are also of importance. Pre-term birth may also interfere with the development of symmetry and lateralization.

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