Primary Dentition Unilateral Crossbite in Relation to Functional Lateralities

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ABSTRACT

Purpose: The aim of this study was to explore primary dentition unilateral crossbite malocclusion prevalences in functionally true right-sided and nonright-sided children, with the latter having 1 or more left-sided or indeterminate functions (eye, hand, foot).
Methods: The transversal relationship of the primary teeth was determined from dental casts of 1,835 young African American (60%) and Caucasian (40%) children in a cross-sectional sample at a mean age of 8.5 years. Hand, foot, and eye preferences (right, left, or indeterminate) were recorded at the age of 4 years during the same collaborative perinatal study. The prevalences of left and right crossbites were compared between true right-sided and mixed or completely nonright-sided children using chi-square analysis.
Results: Unilateral crossbite occurred in 140 cases with a complete set of laterality tests: 65 were right-sided and 75 left-sided. True right-sided children had more bilaterally symmetric occlusions and less crossbite on the right side than those having nonright-sidedness in their functions, with the differences being statistically significant ($P<.01$).
Conclusions: These results point to anatomical relationships between the structures supporting the occlusion, the asymmetric neurocranium, and the cranial base. This suggests variable unilateral compensatory growth after unbalanced fetal asymmetry, modified by sidedness and the growth-stimulating effects of early lateralized functions and oral habits. (J Dent Child 2005;72:81-87)

KEYWORDS: MALOCCLUSION, LATERALITY, LEFT-SIDEDNESS, RIGHT-SIDEDNESS

Many etiological factors exist behind unfavorable occlusal states, and the role of some functional factors, such as thumb-sucking and mouth-breathing in transversal malocclusions, has been brought up in the course of the written history of orthodontics.[1] Asymmetric growth in the mandibulofacial region occurs frequently. Yet, little research has been conducted on the basic mechanisms of the developmental processes leading to the final occlusion. It is commonly assumed for many paired structures that the genetic information is identical for both sides, and the interpretation of small differences in an individual depends on whether or not the environmental conditions are the same on each side.[2]

Relatively little attention has been paid in the orthodontic literature to the natural midline asymmetry of the human cranium and to the balance between a normal symmetric ideal occlusion and asymmetries elsewhere in the skull. The normal asymmetry of the skull is directional and is manifested in larger occipital, malar, and sphenoid bones on the left side than on the right side. Meanwhile, the frontal, temporal, and parietal bones show the opposite difference, and the internal length of the skull is greater on the right side than on the left.[3,4] In the brain case, the left planum temporale is larger than the right prenatally, and a long frontal lobe is more common on the right. Some of these asymmetries are significant in right-handed individuals, but less marked in functionally nonright-sided individuals.[5]

The placement of the temporomandibular joint is of crucial importance for the developing occlusion, and agreement exists concerning the remodelling capacity of the glenoid fossa and condyle. Many factors implicated in this adaptation, however, have not been investigated. During the eighth to ninth gestational week, the temporomandibular joint develops from 2 blastemas (condylar and temporal), which are independent of mechanical stimulation in the early phases of development.

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Figure 1. Unilateral crossbite.

Asymmetry of the glenoidal fossa position relative to the skull base structures has been reported in human adult skulls, with the right-side structures being more laterally and distally positioned than the left-side ones,[6,7] while a larger size of the left mandible has been reported.[8]

There is considerable evidence that some of the anatomical differences between the left and right sides result from unbalanced fetal midline growth, so that the asymmetry in the human skull originates from the prenatal period.[9] Some upper facial malformations are more common on the left side, such as cleft lip. Likewise, some lower facial malformations are more common on the right side, such as hemifacial microsomy.[10] Both types of malformations have early embryonal backgrounds. Right-left balances in a developmental sense vary in terms of their location and timing during gestational development, and the discovery of the first asymmetrically expressed genes in the vertebrate (chick) embryo in 1995 has subsequently led to the proposal of models of left-right determination involving complex cascades of genetic interactions.[11,12]

Although it is difficult to postulate direct associations between early embryonal development in other species and the human occlusion—which is a complicated system of morphologically variable teeth, functional matrices, postnatal growth, etc—the same mechanisms lie behind the basic asymmetries (of the heart, intestine, and brain) in different species.[13] Asymmetric teeth and jaws are normal in some fish and whales, for example, and the beak may be asymmetric in birds. A new machine vision-based technique has shown directional asymmetry differences in the morphology of the human first permanent molars between right- and left-handed individuals, suggesting that human teeth do not lie beyond the process of lateralization during development.[14] Data from various vertebrates have recently been used to suggest a model for genetic interactions explaining how asymmetric patterns of gene expression and "nodal flow" movement of ciliae and early embryo growth factors are translated into spatial patterns of variable asymmetric organ development.[12]

The aim of this study was to explore the frequencies of primary dentition unilateral crossbite in relation to functional lateralities by functionally comparing true right-sided individuals with nonright-sided ones and to investigate the etiologies behind early unilateral malocclusions.

METHODS

The subjects were 1,835 children from approximately 60,000 pregnancies comprising the collaborative perinatal study carried out by the National Institute of Neurological Disorders and Stroke in the United States in the 1960s. In the early 1970s, the dental examinations (including casts and photographs) were performed at 6 of the collaborating medical centers (Buffalo, NY, Richmond, Va, Portland, Ore, Philadelphia, Pa, Providence, RI, and Johns Hopkins, Md) in a cross-sectional manner at ages varying from 6.9 to 12.7 years in 95% of cases. Mean ages in years at the time of the dental examination were: (1) 7.9 for Caucasian boys and 7.8 for girls; and (2) 8.9 for African American boys and 9.3 for girls. Forty percent of the children were Caucasian and 60% were African American. This facilitates comparison between the occurrences of the types of occlusion in the primary and both early and late mixed dentition phases.

Alginate impressions were taken at each cooperating institution, and normal dental plaster casts were then made as soon as was practicable. These casts were checked and compared with oral photographs taken of all the children in the study. Teeth with heavy attrition, decay, restorations, in the process of exfoliation, or orthodontic appliances, etc. on the surfaces were not studied. Crossbite determinations (yes/no) were made by one observer on trimmed casts with a wax bite in the intercuspal position. The classification procedure was repeated in 70 cases to determine the intraexaminer methodological error, which was approximately 3%.[15-17] In statistical testing, a case was regarded as a crossbite regardless of the number of teeth in crossbite (Figure 1).

Neurological and other medical background data were obtained from the record reaching from the moment of the first registration of the pregnancy[18] (ie, during the first or second trimesters) and continuing up to the child's seventh year of age. Eye, hand, and foot laterality examinations were recorded at each center, according to the uniform manual instructions followed in the collaborative perinatal study.

Hand preference was evaluated by placing 3 colored pencils directly in front of the child, who was asked to draw an "x" on a piece of paper with each pencil. If the same hand was not used with each of the 3 pencils, the test was repeated twice. Any preference less than 4 out of 5 was coded as indeterminate. Eye preference was detected by asking the child to look through a kaleidoscope, with the investigator noting which eye was used. Foot preference was determined by placing a ball in front of the child and asking him/her to kick it 3 times, each time from a stable initial standing position. The investigator noted whether there was any consistent preference in the 3 trials. If mixed responses (2 right and 1 left, or vice versa) were obtained, 2 more trials were made and any preference fewer than 4 out of 5 was coded as indeterminate. The patterns of lateral preferences, interrelationships, sex, and race differences in functional lateralities determined in the collaborative perinatal study children have been presented and discussed elsewhere.[19-21]

Functional true right-sidedness was compared with nonright-sidedness using combinations constructed from all 3 functional categories (ie, the children with a complete set of right-handedness, right-footedness, and right-eyedness (RRR) were compared to those with variable amounts of mixed or complete nonright-sidedness (NRS), including indeterminate cases. Statistical testing was performed by comparing the occlusal symmetry/asymmetry proportions (2×3 tables, 2×2 tables, and chi-square tests). This was also done separately for each laterality. $P<.05$ were taken as significant.

Table 1. Proportions of Functional Laterality Combinations in Children With Primary Dentition Unilateral Crossbite Giving a Complete Set of Tests*

Eye/hand dominance	Leg dominance			
	Right	Left	Indeterminate	Total
Right/right	52	3	2	57
Right/left	3	1	0	4
Right/indeterminate	10	4	2	16
Left/right	35	3	0	38
Left/left	4	3	0	7
Left/indetermate	7	2	1	10
Indeterminate/right	5	0	0	5
Indeterminate/left	0	2	0	2
Indeterminate/indeterminate	1	0	0	1
Total	117	18	5	140

*True right-sided: N=52; mixed or true nonright-sided: N=88.

RESULTS

Primary tooth crossbite appeared in 172 cases (9% of the total material of 1,835 cases), right-side crossbite appeared in 65 of the unilateral cases (4%), and left-side crossbite in 75 (4%). The functional laterality proportions were:

1. 54% right, 41% left, and 5% indeterminate for the eye laterality;
2. 78% right, 8% left, and 14% indeterminate for the hand laterality;
3. 83% right, 12% left, and 5% indeterminate for foot laterality (Table 1).

The laterality examinations failed to yield a complete set of results in only a few cases.

The comparisons between RRR and NRS children showed variable proportions of unilateral right/left crossbites (Table 2, Figures 2, 3, and 4). Right-side unilateral crossbite appeared in 17 cases among the true right-sided children, while left-side unilateral crossbite was more frequent (35 cases). In the NRS children the proportions were 48 cases with right-side unilateral crossbite and 40 with left-side unilateral crossbite. This difference was statistically significant (chi-square value=6.3; $P<.01$; Table 2). A clear difference between the true RRR and NRS individuals also appeared in the proportions of bilaterally symmetric occlusions, which were more common in true RRR children (Figure 5).

The unilateral crossbite comparisons performed using each functional laterality as a confining factor showed no clear difference in crossbite frequencies between RRR and NRS individuals (Table 2), although right-eyed children had a tendency to have more left-side crossbites and left-eyed children more

Table 2. Numbers of Cases of Primary Dentition Unilateral Crossbite in Functional Lateralities (All Cases) and in Combinations (n=140) of True Right-sidedness (RRR) and Mixed or True Nonright-sidedness (NRS)*

	Eye dominance	Right	Left	Indeterminate	Chi-square	P
Unilateral crossbites						
Right		29	32	4		
Left		48	24	4	5.0	.08
	Hand dominance	Right	Left	Indeterminate	Chi-square	P
Right		49	5	13		
Left		55	8	14	0.4	.8
	Leg dominance	Right	Left	Indeterminate	Chi-square	P
Right		55	9	3		
Left		65	9	2	0.5	.8
	Combinations	RRR	NRS			
Right		17	48			
Left		35	40		6.3	.01†

*The number of teeth in crossbite varies from 1 to 4 per case.
†Statistically significant difference $P<.01$.

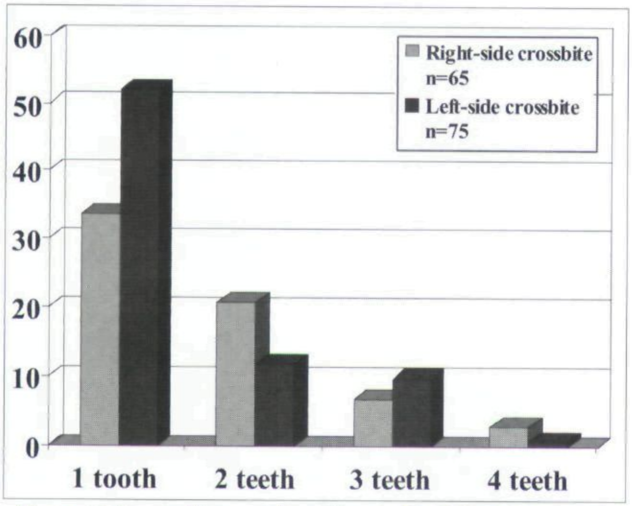

Figure 2. Proportions and numbers of unilateral crossbites with variable degrees of severity on both sides of the primary dentition.

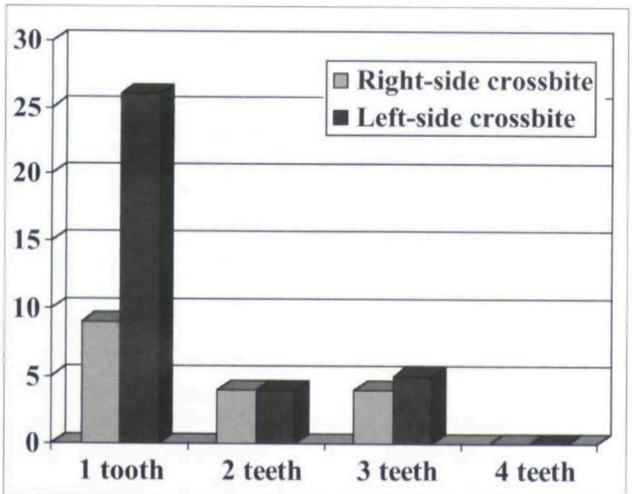

Figure 3. Proportions and numbers of unilateral crossbites with variable degrees of severity on the right or left side of the primary dentition in functionally true right-sided children (N=52).

right-side crossbites. These differences, however, were not statistically significant (*P*<.08).

DISCUSSION

The present results suggest that true RRR children, being the largest uniform group in human populations, are more symmetric in their transversal occlusion and have significantly less right-sided unilateral crossbite than those who are NRS in their functional lateralities. The result is quite the opposite of the hypothesis formed on the basis of earlier laterality evidence. One example is the evidence that human functional lateralities, such as handedness, footedness, and eyedness, are related to the brain's anatomical laterality. Hence, right-handedness, for instance, is associated with a larger left side of the brain, while NRS is associated with increased symmetry of the head and body halves. Similarly, it is thought that asymmetric development in some brain regions may be responsible for or associated with the development of asymmetric facial regions.[22]

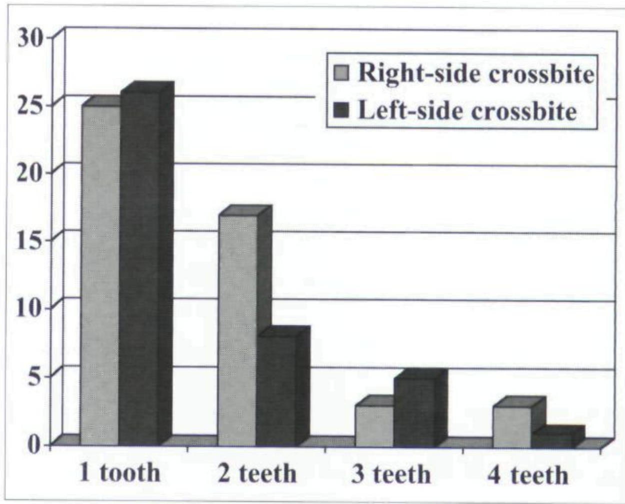

Figure 4. Proportions and numbers of unilateral crossbites with variable degrees of severity on the right or left side of the primary dentition in functionally nonright-sided children (N=88).

The development of bilaterally symmetric occlusion in transversal sagittal and vertical dimensions is not a straightforward matter, and the etiologies of the recent findings should also be explored from a functional point of view regarding the orofacial region, in which the maturation of laterality in the chewing function is apparently important.[23] Unilateral angle II malocclusion has been shown to vary in terms of functional lateralities, with unilateral right-side angle II occurring significantly more frequently in functionally NRS children than in their true RRR controls in the authors' material.[24]

It is not known whether these well-lateralized true RRR children also chew more on their right-side primary teeth, allowing the cuspal guidance function during extra-alveolar eruption of the teeth to produce more favorable results there (a normal transversal occlusal relationship). Occlusal functional laterality has rarely been studied in the dental literature and has been regarded as a habit formed on the basis of the masticatory force exerted on the right or left side of the apparatus, influenced by the quality of occlusal contacts or resulting from a malocclusion rather than being induced by a stimulus.[25,26,27]

In the developmental sense, the order of teeth emergence and the small difference in timing between the left and right sides may be important in the initial chewing habit.[20,21,35] Significant variation has been found to occur in the emergence of the upper jaw's first permanent molar, with true RRR children having earlier eruption of the left first permanent molar,[21] which may stimulate an immature unilateral chewing habit followed by unilateral growth up to 5 to 6 years of age. Emergence of the primary teeth occurs between 6 months and 2 years. During that time, the dentition—like many other systems—is under the influence of neurophysiological and systemic processes involving inequalities between the left and right sides. African American children precede Caucasian children in motor development, tooth mineralization, and eruption.[20,36]

The rate of various malocclusions differs between races, but the prevalence of crossbite in primary dentition is similar, with the occurrence ranging from 5% in Caucasian children to 6% in African American children. It is important to also observe that unilateral crossbite is actually a bilateral maxillary constriction and that the child shifts the mandible to one side or the other to establish occlusal contacts. This cannot be determined, however, using static models.

The observations on brain unilateral maturation suggest that the human cerebral hemispheres develop postnatally at different rates, which is chronologically comparable to the occurrence of "stages" in perceptual and cognitive development.[27] Left side dominance has been found in most of the craniofacial structures regardless of sex, which may indicate functional or genetic left side dominance during development and during the structures' early growth periods.[28-30] Left cerebral dominance exists for specific human skills such as language, but the right hemisphere is more active at times of emotion. Furthermore, facial movements are better controlled on the face's left side, which results in a simultaneous increase in right brain hemisphere activity.[31] Annett has proposed that 15% to 20% of the human population displays an absence or only weak manifestation of "right shift," the common lateralizing influence, perhaps because of the presence of a recessive genetic allele.[32] Different manifestations of laterality are dictated independently and at random among this minority.

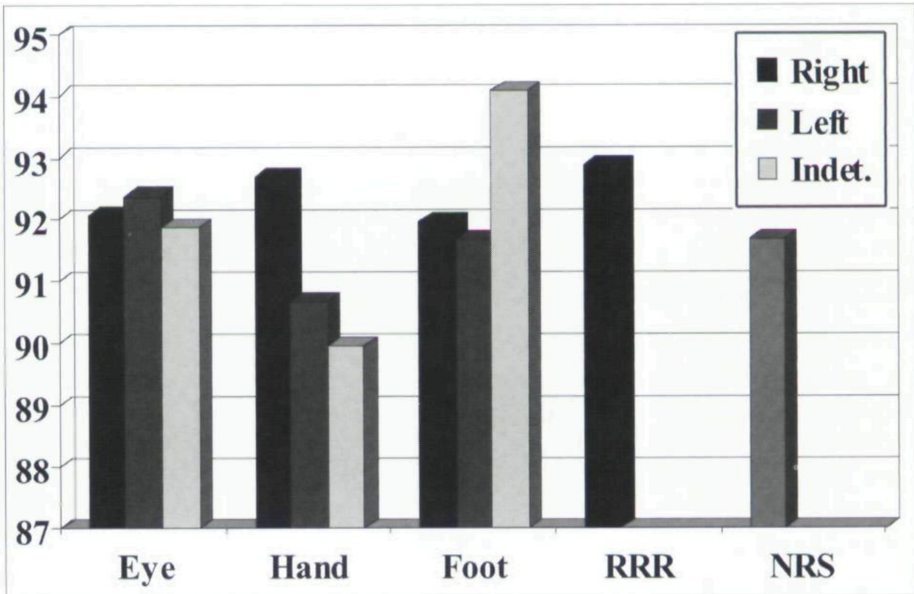

Figure 5. Percentages of symmetric occlusions, either transversally normal or bilateral crossbites, in each category of functional lateralities (right and left-sided or indeterminate handedness, footedness, and eyedness; N=1,672). RRR=true right-sidedness (N=680). NRS=mixed or true nonright-sidedness (N=985).

Left/right symmetry in tooth eruption has been poorly studied, but the timing of the general developmental "right shift" from 6 months to 2 years of age may interfere with this eruption or with chewing preferences, thus warranting further study. It is not well documented whether these associations between nervous and functional systems:

1. are genetic or environmental;
2. form a basis for the commencement of function during gestation;
3. are later formatted during the "training" period.

Digit-sucking is an important aetiological factor in the development of posterior crossbite in the dentition,[32] and handedness may well be of aetiological importance in the difference in the rate of right-side crossbite between true RRR and NRS children. Digit-sucking is common in fetuses. A right-side preference has even been found in preterm babies,[33,34] which, interestingly, have more NRS in functional lateralities and more symmetric sagittal occlusal relationships than full-term babies. In digit-sucking during the preterm period, the head is, in most cases, turned toward the right side. In addition to the mechanical pressure of the digit against the alveolar wall, the tongue is easily forced into a lower position, which can widen the lower arch. This may cause interferences and forced lateral guidance after the eruption of teeth.[35]

Unilateral digit-sucking can sometimes create prominent open-bite effects on the alveolar processes and dentition. Digit-sucking has decreased from 50% in the 1940s and 1950s to 15% in the 1990s, and it has been replaced by a pacifier—which is easier to give up and less effective in the aetiology of unilateral crossbite.[32] Nevertheless, the sidedness of digit-sucking is not a straightforward matter either, as it depends on which hand the finger belongs to—the dominant one or the other. Unfortunately, neither the frequency nor the duration of the oral habits were documented in this population.

Low proportions of depth and height of the face are established at birth relative to the width, so that most of the transversal relationship has to be determined earlier than in the other dimensions. Moreover, the role of largely unknown gestational and early postnatal factors will be of greater importance in the aetiology of transversal malocclusions than in sagittal and vertical ones.

CONCLUSIONS

True RRR children were found to have a bilaterally symmetric transversal occlusal relationship more frequently and unilateral right-sided crossbite significantly less often than children with functional nonright-sidedness. This may be related to the degree of normal skull asymmetry in these children. Additionally, it may be a consequence of developmental lateralization during initial occlusal establishment (ie, the tooth emergence period and early unilateral occlusal function); although, the laterality of digit-sucking, tongue posture, etc may also be involved.

Due to cranial and skull base transversal asymmetry, which are normal situations, the development of an ideal transversal occlusion may require directional asymmetric growth and/or directional unilateral occlusal function to maintain a symmetric occlusal relationship. This implies that most individuals with a strong lateralization process (right-sided eye, hand, foot; unilateral chewing) will have a favorable result in occlusal development, despite the fact that their skull is asymmetric. This topic is a relatively unknown one, however, and requires further studies before any clinical applications can be contemplated.

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