European Journal of Orthodontics 26 (2004) 93–98

European Journal of Orthodontics vol. 26 no. 1

Unilateral Angle II in functional lateralities

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SUMMARY The aim of this study was to explore unilateral Angle II-type malocclusion prevalences in functionally true right-sided (TRS) and non-right-sided (NRS) children having one or more left-sided functions (eye, hand, foot). A half cusp sagittal relationship of the upper and lower M1 and Dm2 was determined on dental casts of 1423 young American black and white children in a cross-sectional sample with the mean age of 8.5 years (range 6–12 years). Hand, foot and eye preferences were recorded at the age of 4 years during the Collaborative Perinatal Study. The prevalences of symmetric bilateral Angle I and II and asymmetric unilateral Angle II right and Angle II left cases were compared between TRS and NRS children using Chi-square analysis.

In general, unilateral Angle II right occurred in 9 per cent of the population and Angle II left in 6.5 per cent. In moderate non-right sideness (two-thirds of left dominant functions), these proportions were 17 and 3 per cent, respectively, and in true right sidedness 8 and 6 per cent, respectively. TRS subjects were more symmetric (bilateral Angle I or II in 85 per cent of cases) than NRS children (80 per cent), and the differences were statistically significant ($P < 0.02$).

These results highlight the anatomical relationships of structures supporting the occlusion and the symmetry/asymmetry of the neurocranium, cranial base, masticatory apparatus, and probably also the sidedness and the growth-stimulating effect of lateralized jaw function. Based on the results and considering earlier observations on brain asymmetry in functional lateralities, it can be hypothesized that a normal symmetric sagittal occlusal relationship is based on unilateral sagittal compensatory growth to maintain optimal bite, challenging early preventive orthodontic treatment in suspect unilateral Angle II cases.

Introduction

In dental clinical practice it is very common to see contralateral differences between the right and left sides of the occlusion, and an asymmetric sagittal molar relationship often results in an unbalanced occlusion, difficult mechanical problems and unilateral extractions in orthodontic treatment. The aetiologies of this type of occlusal disorder often remain unexplored and it is difficult to determine whether these asymmetries are related to genetic or selected environmental backgrounds. It is commonly assumed for many paired structures that the genetic information is identical for each side, and the interpretation of small differences in an individual depends on whether or not environmental conditions are the same on each side (Smith and Bailit, 1979).

Surprisingly little has been discussed in the orthodontic literature on human cranium natural asymmetry and on the balance between a normal symmetric ideal occlusion and a normal asymmetric skull. On the other hand, in the field of anthropology, the human dental occlusion has been regarded as a relatively poorly canalized system and over the last several hundred years it has become more variable due to decreased function and has expressed fluctuating asymmetry (Waddington, 1957).

The asymmetry of the skull is directional, and appears as larger left occipital, malar and sphenoid bones compared with the right side, while the frontal, temporal and parietal bones show an opposite difference, and the internal length of the skull is larger on the right side than on the left (Woo, 1931; Lundström, 1961). It has been hypothesized that human functional laterality, i.e. handedness, footedness and eyedness, is related to this anatomical laterality of the brain and, for example, right handedness is associated with a larger left side of the brain, whereas non-right sidedness (NRS) is associated with increased symmetry of the head and body halves, and asymmetric development in some brain regions may be responsible for the development of asymmetric facial regions (Keles *et al.*, 1997). Normal asymmetry is greater in males compared with females, but left side dominance has been found in most of the craniofacial structures regardless of sex, which may indicate functional or genetic dominance on the left during development and early growth periods of the structures (Chebib and Chamma, 1981). Left cerebral dominance exists for human-specific skills, such as language, but the right hemisphere is more active during emotion, and facial movements, for example, are better controlled on the left side of the face, which means a simultaneous increase in the activity of the right brain hemisphere (Chaurasia and Goswami, 1975).

In general, a strong trend towards a genetic background in human laterality exists, focusing on the so-called 'right shift' factor (Annett, 1981), and the conclusions of reviews, such as those of Corballis (1983) and Geschwindt and Galaburda (1985), focus on the largely unknown role of embryonic and gestational development in human laterality determination. Recently, data from different vertebrates have resulted in a model of genetic interactions that explains how asymmetric patterns of gene expression and 'nodal flow' in the early embryo are translated into spatial patterns of asymmetric organ development (Capdevila and Belmonte, 2000). Annett (1981) proposed that in a minority of 15–20 per cent of the human population, the common lateralizing influence, the 'right shift', is absent or a weak manifestation, perhaps because of the presence of a recessive genetic allele. Among this minority, different manifestations of laterality are dictated independently and at random. The great majority of right handers are right footed and right eyed and they have their language and skills represented in the left cerebral hemisphere, whereas left handers show much more varied and unpredictable patterns of asymmetry, and have less anatomical symmetry in the brain, testes, and skin (Geschwind and Galaburda, 1985). It is not well documented whether these associations between nervous and functioning systems could be genetic or environmental, forming a determined basis for the start of the function, or later, formatting during the 'training' period.

The aims of this study were to explore the symmetry and asymmetry of the occlusion in the sagittal plane according to Angle's classification in categories I and II and to verify the suspected role of skull asymmetry in the aetiology of such occlusal disorders by comparing functionally true-right-sided (TRS) versus more or less NRS individuals.

Subjects and methods

The dental study subjects were 1423 children from the approximately 60 000 pregnancies that comprised the Collaborative Perinatal Study of the National Institute of Neurological Disorders and Stroke carried out in the 1960s. The dental examinations (casts and photographs included) were performed at six of the collaborating medical centres (Buffalo, NY; Richmond, VA; Portland, OE; Philadelphia, PA; Providence, RI; Johns Hopkins, MD) in the early 1970s in a cross-sectional manner at ages varying in 95 per cent of cases from 6.9 to 12.7 years. The mean ages in years at the time of the dental examination were 7.9 for Caucasoid boys, 7.8 for girls, 8.9 for Afro-American boys and 9.3 for girls (40 per cent white and 60 per cent black children), facilitating the comparison of representative numbers of occlusions in the primary, early and late mixed dentition phases.

At each co-operating institution alginate impressions were taken and trimmed dental casts were then made as soon as practicable. The casts were checked and compared with oral photographs taken from every child in the study. Teeth with heavy attrition, decay, restorations, orthodontic appliances, etc. on the surfaces were not studied. Angle's classification with half cusp precision was made by one observer (MG) on casts according to a normal wax bite taken in the intercuspal position (Figure 7a–c). The classification procedure was repeated in 90 cases to determine the intra-examiner methodological error, which was set at the 5 per cent level (Pirttiniemi *et al.*, 1994; Chatzistavrou *et al.*, 1998; Grön, 1999). Neurological and other medical background data were obtained from the records from the first registration of the pregnancy (Niswander and Gordon, 1972), i.e. during the first and second trimesters, up to the child's 7th year of age. Carefully performed hand, eye and leg laterality examinations were recorded at each centre according to uniform manual instructions used in the Collaborative Perinatal Study. The test battery evaluated gross and fine motor skills, a behaviour profile, and psychological and physical characteristics. Hand preference was evaluated by placing coloured pencils directly in front of the child who was asked to make an 'X' on a piece of paper with each pencil. If the same hand was not used with each of the three pencils the test was repeated twice more. Any preference less than four out of five was coded as indeterminate (i.e. 'immature' laterality). Eye preference was detected by asking the child to look through a kaleidoscope and the examiner noted which eye was used. Foot preference was determined by using a ball placed in front of the child. The child was asked to kick the ball three times, each time from a stable initial standing position. The examiner noted whether there was a consistent preference in the three trials. If two right and one left (or *vice versa*) responses were obtained, two more trials were undertaken and any preference fewer than four out of five was coded as indeterminate. Patterns of lateral preferences, interrelationships, sex and racial differences in functional lateralities, etc. in the Collaborative Perinatal Study children have been presented and discussed elsewhere (Nachson *et al.*, 1983; Heikkinen *et al.*, 1999, 2001).

Right sidedness was compared with non-right sidedness using the combinations constructed from all three functional categories. Children with a complete set of right handedness, right footedness and right eyedness (RRR or TRS, n = 471) were compared with children with variable amounts of NRS (n = 868). This group consisted of mild (RRL, n = 754), moderate (RLL, n = 88) and complete (LLL, n = 26) left sidedness. Children with an Angle Class III malocclusion and those with any functional laterality regarded as indeterminate were excluded. Statistical testing was performed by evaluating the equality of the occlusal symmetry/asymmetry proportions (2 × 3 tables and Chi-square tests) in each non-right sidedness group against true right sidedness. $P < 0.05$ was taken as significant.

Results

Unilateral Angle II occlusion appeared in 220 cases, 15 per cent of the total material (1423 cases). In unilateral cases, the proportions of right and left sides of the dentition were not equal; right side Angle II appeared in 128 cases (9 per cent), and left side Angle II in 92 cases (6 per cent) (Figure 1). For functional lateralities, the proportions were 54 per cent right, 41 per cent left and 5 per cent indeterminate for the eye; 78, 8 and 14 per cent, respectively, for the hand; and 83, 12 and 5 per cent, respectively, for the foot (Figures 2–4).

The final comparisons, performed between TRS and NRS children, which were mild (RRL), moderate (RLL) and complete (LLL) (Figure 5), showed variable proportions of bilateral Angle I and II, unilateral Angle II right and unilateral Angle II left occlusions (Figure 6).

A statistically significant difference was found between moderate non-right sidedness (RLL, two-thirds of left dominant functions) and true right sidedness ($P < 0.02$), TRS subjects being more symmetric (bilateral Angle I or II in 85 per cent of cases) than NRS RLL children (80 per cent). For RLL the proportions of unilateral Angle II were 17 per cent right and 3 per cent left, and for TRS children, 8 and 6 per cent, respectively. A similar trend was also found in mild (RRL) and complete (LLL)

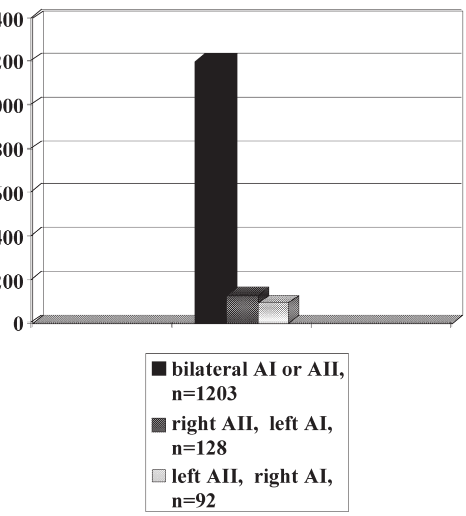

Figure 1 The numbers and proportions of subjects with bilateral Angle I, Angle II and unilateral Angle II occlusions in the study (n = 1423).

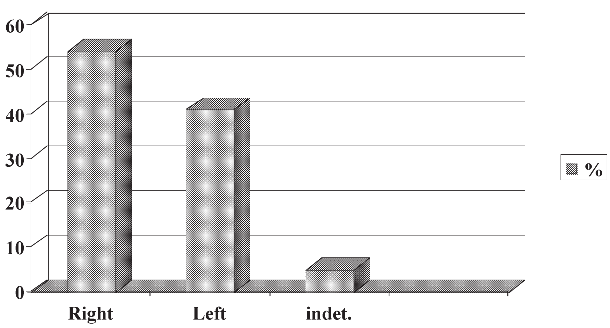

Figure 2 The proportions of right, left and indeterminate eyedness in the Collaborative Perinatal Study children at 4 years of age.

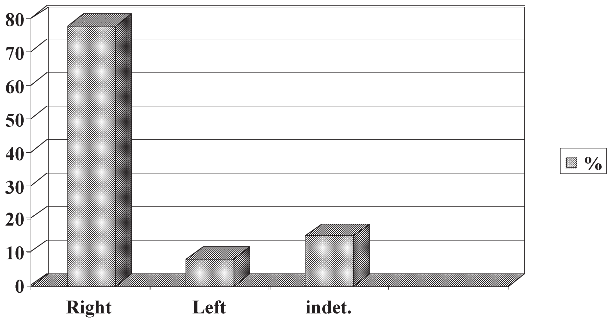

Figure 3 The proportions of right, left and indeterminate handedness in the Collaborative Perinatal Study children at 4 years of age.

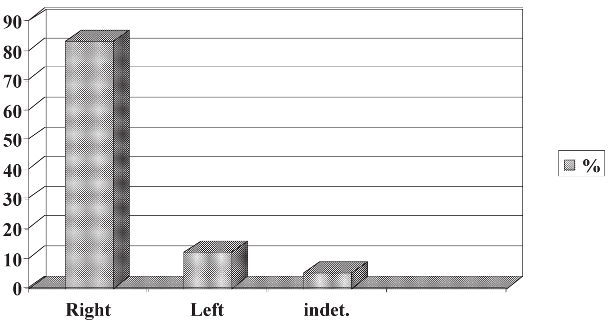

Figure 4 The proportions of right, left and indeterminate footedness in the Collaborative Perinatal Study children at 4 years of age.

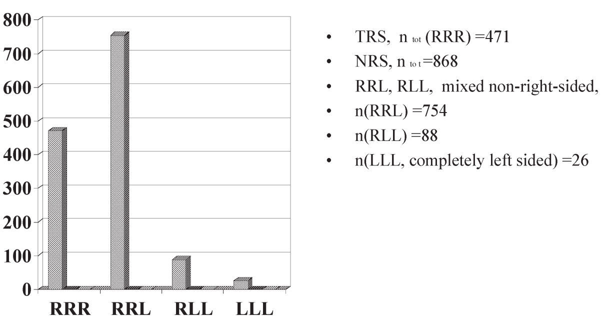

Figure 5 Combined functional lateralities (hand, foot and eye), true right sidedness (TRS) and non-right sidedness (NRS).

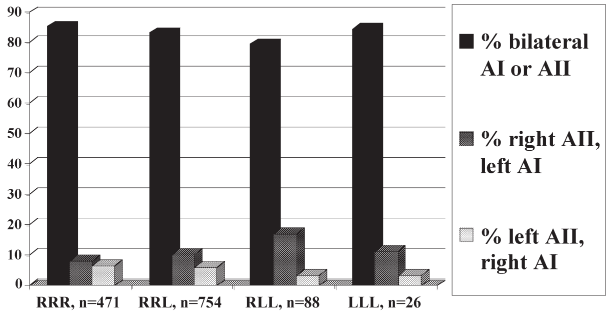

Figure 6 Unilateral Angle II in functional non-right sidedness. True right-sided (RRR) versus non-right-sided (NRS) children. There was a statistically significant difference between mild left sidedness (RLL) and right handedness, right footedness and right eyedness (RRR) ($P < 0.02$).

NRS, but the difference compared with TRS was not statistically significant (Figure 6).

Discussion

The results of this investigation are not in agreement with the hypothesis formed on the basis of earlier findings published on symmetry in the literature (Geschwind and Galaburda, 1985), where structural head and body symmetries are frequently associated with functional NRS. The results show significant differences in the proportion of bilaterally symmetric occlusions, which was smaller in children with NRS compared with those being functionally TRS. Functional TRS is associated with bilaterality in occlusions and NRS with an increased number of unilateral right Angle II occlusions. The excess of unilateral right-sided Angle II occlusions in moderate NRS (RLL) is also confusing, when compared with other groups with mild (RRL) or complete (LLL) NRS. The number of LLL children, however, was relatively low in comparison, and a larger sample will be needed for re-evaluation.

The symmetry of development and growth is not straightforward and differential growth of the two sides of the stomatognathic system is quite a rare topic in the literature. In spite of the decreased importance of jaw function for the survival of mankind, it is widely thought that midline symmetry is advantageous for occlusion. According to Melnik (1992), for example, the left side of the mandible is larger than the right side until puberty, after which the right side is larger. To match an asymmetric skull, jaw bones and ideal symmetric occlusion, there is a need for a balancing system, which should be active before the occlusion is complete; in the primary dentition before 3 years of age, and in the permanent dentition before the end of the second phase of the mixed dentition at approximately 12 or 13 years of age, i.e. the time of accelerated skeletal growth in most cases.

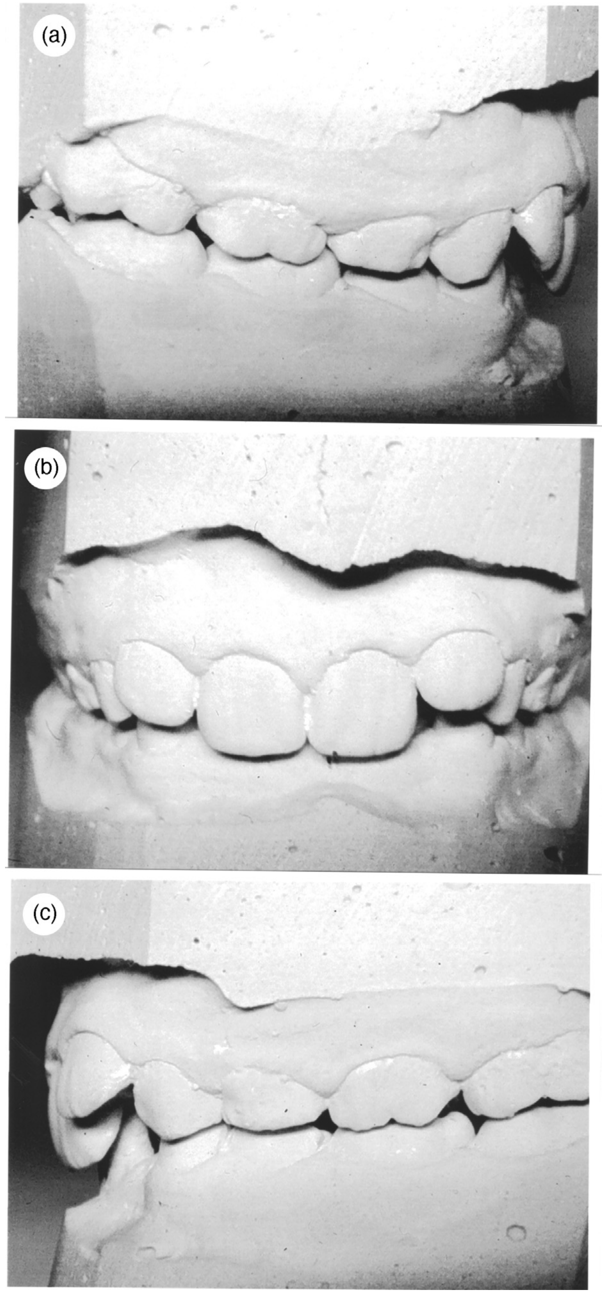

Figure 7 Unilateral Angle II in the mixed dentition.

There is evidence to suggest that some of the anatomical differences between the left and right sides result from unbalanced foetal midline growth, and that asymmetry in the human skull originates in the prenatal period (Trenouth, 1985). It has been reported that upper facial malformations are more common on the left side of the face (cleft lip), and lower facial malformations on the right side, such as hemifacial microsomy (Schnall and Smith, 1974), both of which have early embryonic backgrounds. The maxillary complex forms boundaries between the orbital, nasal, oral and pharyngeal cavities, and it represents adaptation to the demands of functions related to respiration, digestion and vision. The opening movements of the mandible occur in the early phases of foetal life (more than 12 gestational weeks), but occlusal function is established post-natally after the emergence of the teeth, e.g. primary incisors during the first year, molars and canines soon after.

The temporomandibular joint develops during the eight to ninth gestational week from two blastemas, condylar and temporal, which are independent of mechanical stimulation in the early phase of development. Asymmetry of the glenoid fossa position relative to the skull base structures has been found in adult human skull material; right-sided structures are more laterally and distally positioned than left-sided structures (Pirttiniemi and Kantomaa, 1992), and a larger left side of the mandible has been reported by Huggare and Houghton (1995). In the brain, the left planum temporale is larger than the right pre-natally, and a long frontal lobe is more common on the right than on the left. Some of these asymmetries are significant in right-handed subjects but less marked in functionally NRS individuals (Foundas *et al.*, 1995).

Unilateral brain maturation has been explored by Thatcher *et al.* (1987), suggesting that post-natally human cerebral hemispheres develop at different rates, which are chronologically comparable with the 'stages' in perceptual, cognitive development. The results of a previous study suggest that symmetry of tooth eruption varies in terms of functional NRS (Heikkinen *et al.*, 2001). Significant variation occurs in the emergence of the first upper permanent molar. TRS children have earlier eruption of the left side M1, which might stimulate a unilateral chewing habit and unilateral growth during 5–6 years of age. Primary tooth eruption left/right symmetry has been poorly studied, but the timing of the 'right shift' during 1–3 years of age might interfere with the primary tooth eruption/chewing preferences, and requires further investigation.

It should be noted that the relatively small proportions of depth and height, compared with the width of the face, are established at birth and, thus, a major part of sagittal growth occurs post-natally. Occlusal development, lasting a relatively long time, is sensitive, not only to the original placement of sharp guiding cuspal elements during the first and second post-natal years, but also to functional factors, of which the laterality of chewing function may be of great importance (Poikela, 2000). In unilateral chewing, the working side condyle remains static compared with the non-working side, which moves forward stimulating sagittal growth. Functional laterality seems to be stronger in hands and feet than in eyes and chewing, which is influenced by the quality of occlusal contacts (Nachshon *et al.*, 1983; Hoogmartens and Caubergh, 1987), and apparently also in the developmental sense by the emergence order and final success or result of the eruption of the teeth on the left and right sides (Heikkinen *et al.*, 1999, 2001).

Dental asymmetries, resulting from differences in the metric dimensions and the morphology of antimeric teeth, have been used to estimate the effects of genetic or environmental disturbances on developmental homeostasis (Osborne *et al.*, 1958; Sofaer *et al.*, 1971; Perzigian, 1977; DiBennardo and Bailit, 1978; Mayhall and Saunders, 1986; Siegel and Mooney, 1987). The asymmetry of tooth dimensions is said to be, in general, randomly distributed with respect to side, being generally called fluctuating asymmetry, and it is a common finding, for example, in Down syndrome (Barden, 1980; Townsend, 1983). Random discrepancies may indicate an inability of the individual to buffer against developmental disturbances or developmental 'noise', and an increased sample size seems to have profound effects of negating the existence of fluctuating asymmetry in statistical comparisons, as shown by Smith *et al.* (1982). The evidence from directional size asymmetry in the dentition is not clear, but there are reports of differences between earlier and later developing dentitions in this sense, primary teeth being more directional (Hershkovitz *et al.*, 1987).

Conclusions

Children with moderate NRS in functional lateralities have more unilateral right-sided Angle II malocclusions compared with functionally TRS children. This may be related to the degree of normal skull asymmetry and a consequence of the developmental 'right shift' factor during the first years of post-natal life, and early unilateral occlusal function may be involved.

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Acknowledgements

This work was supported by contract no. 1-NS-2-2302 from the National Institute of Neurological Disorders and Stroke. We wish to thank Richard H. Osborne, Russel Spry, Helen Bennet, Gisela Nass, Sirkka Alvesalo, Heikki Könönen, Esko Vakkilainen, Pertti Pirttiniemi, Aila Poikela, Jouko Remes and Päivi Laukkanen for their co-operation.

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