Associations between orthopaedic disturbances and unilateral crossbite in children with asymmetry of the upper cervical spine

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SUMMARY The objective of the present study was to detect possible associations between unilateral crossbite and orthopaedic disturbances in children with asymmetry of the upper cervical spine.

Fifty-five children aged 3–10 years (22 girls and 33 boys) with a unilateral crossbite and 55 gender- and age-matched children with a symmetric occlusion but no crossbite, who served as the control group, were selected from an orthopaedic cohort of 240 patients. In all children, asymmetry of the upper cervical region was confirmed by radiographs and palpation. The following orthopaedic aspects were investigated: oblique shoulder and pelvis, scoliosis, functional leg length difference, and laxity of ligaments of the foot. The differences between the groups were analysed by means of an unpaired t-test.

An increased occurrence of orthopaedic parameters in the frontal plane was observed in children with a unilateral malocclusion. A unilateral crossbite was not necessarily combined with a pathological orthopaedic variable, but statistically, children with a unilateral malocclusion showed more often an oblique shoulder ($P = 0.004$), scoliosis ($P = 0.04$), an oblique pelvis ($P = 0.007$), and a functional leg length difference ($P = 0.002$) than children with symmetry.

The results suggest that a unilateral crossbite in children with asymmetry of the upper cervical spine is associated with orthopaedic disturbances. There is no evidence of a causal link.

Introduction

Although the question of correlations occurring between posture, locomotion apparatus, and dentition has been debated since the beginning of the 20th century, ‘this issue has gained only scant attention in subsequent research’ (Huggare, 1998).

The results from experimental animal studies suggest that alterations in the occlusion evoke changes in many other regions of the body (Festa et al., 1997; Azuma et al., 1999; D’Attilio et al., 2005). Occlusion has an impact on head position, spinal column alignment, and masticatory muscles which control posture and modulate cardiac function via the trigeminal system. After unilateral occlusal destruction, a postural abnormality in terms of inability of head maintenance, T-wave inversion on electrocardiograph, hair loss, changes in tongue mobility, and eating disorders as well as pathologies of the eye have been observed (Festa et al., 1997; Azuma et al., 1999). Recently, a scoliotic curve has been developed after insertion of a unilateral bite plane in rats (D’Attilio et al., 2005). In all the studies, the evoked changes were observed within 1 week of unilateral manipulation and normalized after harmonization of the occlusal plane.

In order to investigate the possible effects of orthopaedic asymmetric disorders on dentofacial development and head posture, interdisciplinary clinical studies have been conducted on patients with scoliosis or torticollis. The statistically elevated prevalence of a unilateral crossbite in those subjects amounted to 26–55 per cent (Pirttiniemi et al., 1989; Huggare et al., 1991; Pećina et al., 1991). Prager (1980) interpreted the crossbite as a transmission of the asymmetry of the body, whereas Hirschfelder and Hirschfelder (1983) considered, although they had not yet clarified transmission, the crossbite to be a new compensatory curvature. Independent of the different offered explanations of the high prevalence of crossbite in those patients, an interdisciplinary treatment approach to alleviate facial asymmetry and to stabilize head posture, initiated as early as possible, has been unanimously recommended (Müller-Wachendorff, 1961; Pirttiniemi et al., 1989; Pećina et al., 1991).

It has been demonstrated in patients, without evident orthopaedic disorders, that craniofacial growth is associated with cervicovertebral anatomy (Huggare and Cooke 1994; Solow and Siersbæk-Nielsen, 1992). It has been shown that the upper cervical region reveals a high potential for adaptation (Huggare, 1998). This may possibly be due to its important role—the cervical spine provides the morphological basis for an extensive freedom of head movement; it serves as a bridge for numerous blood and lymphatic vessels and nerves, linking head, trunk, and upper limb. In this respect, it is important to point out the intimate developmental relationship between the atlas and the cranial base (Ludvig, 1957).

The intention of this study was to investigate the effects of a unilateral crossbite on orthopaedic asymmetries in the
frontal plane. It has been shown that cervical morphology, and particularly that of the upper cervical spine, is linked to dentofacial morphology (Solow and Siersbæk-Nielsen, 1992). As the causes of the observed associations still remain unclear, all participating children suffered from an asymmetric upper cervical spine. Within this sample, children with a unilateral crossbite were compared with children revealing a symmetric occlusion but no crossbite.

Materials and methods

The present investigation was based on data obtained from an interdisciplinary study of 240 children referred to an orthopaedic centre. In all children, an asymmetric upper cervical spine was radiologically and palpatorily confirmed as follows. Anatomical asymmetries (Figure 1) were studied on the basis of an analysis of two radiographs according to Gutmann (1981). The manual palpation of atlas (c1) and axis (c2) was conducted according to Dvorak and Grob (1999). Asymmetric radiographic findings and palpation of the upper cervical spine were classified into the following categories: right-sided asymmetry of the atlas in relation to the cranial base; right-sided asymmetry of the axis in relation to the cranial base; right-sided asymmetry of the atlas and axis in relation to the cranial base, the same classification for the left side (l); and right-sided asymmetry of the atlas and left-sided asymmetry of the axis in relation to the cranial base.

Children with acute inflammation, neurological disorders, and tumours or syndromes were not included in this cohort.

Fifty-five patients (22 girls and 33 boys) between 3 and 10 years of age (mean 7.0 years, standard deviation 2.08 years) with a unilateral crossbite of at least three lateral teeth were selected. Fifty-five gender- and age-matched subjects from the same sample group but without a crossbite of any tooth and coincident midlines served as the control.

Orthopaedic examination

All patients were examined by the same physician, a specialist in manual medicine for children. He was ‘blinded’ with regard to whether or not the children had a unilateral malocclusion.

The clinical orthopaedic examination was based on standardized methods described in the literature (Buckup, 2005). The parameters were graded either as normal or abnormal, as described below.

1. Examination of the shoulder (Nicolakis et al., 2000):
   Visual judgement of the height of the shoulders from the dorsal. Differences between the sides exceeding 5 mm were diagnosed as an oblique shoulder.

2. A scoliosis was determined by the forward-bending test according to Adams (Fairbank, 2004; Buckup, 2005). In the Adams forward-bending test, the patient bends forward at the waist with the knees straight and the arms together and hanging downward, and the back parallel to the floor. The examiner looks along the axis of the spine for rotatory asymmetry of the trunk. A difference in height of 8 mm between the sides is considered abnormal.

3. Using the spine test (Grieve, 1988), the sacroiliac (SI) joint was examined for hypomobility and asymmetry (Figure 2A). In addition, the position of the spina iliaca superior was analysed. Differences between the sides of more than 3 mm were interpreted as asymmetric.

4. Functional leg length difference: The Derbolowski’s test (Colliton, 1997) screens for asymmetric movement of the two SI joints (Figure 2B).

5. Laxity of ligaments in both feet was analysed when the patient was standing on both feet. A flattening of the medial longitudinal arch of the weight-bearing foot was considered as a flexible flat foot (Jackson and Stricker, 2003). The clinical diagnosis was confirmed by means of a gait analysis.

The intra-observer reproducibility of the assessment parameters was tested by evaluating 25 children three times within a 3-week period. The intra-examiner reliability was computed using weighted kappa for the clinician. The values were as follows: shoulder 0.95, forward-bending test according to Adams 0.86, spine test 0.89, analysis of the position of the spina iliaca 0.87, Derbolowski’s test 0.92, and diagnosis of a flexible flat foot 0.81, indicating good correspondence.

Orthodontic examination

The orthopaedic data were not available during the orthodontic examination which was conducted by one orthodontist (HK). No prior orthodontic treatment had been undertaken for any of the children. A unilateral crossbite affecting at least three lateral teeth was diagnosed in the study group, whereas there was no crossbite or midline deviation in the controls. The findings were recorded on extra- and intraoral photographs and study models.

Statistical analysis

Statistical analysis of data was performed using SPSS 12.0 for Windows (SPSS, Chicago, Illinois, USA). A Student’s t-test for unpaired samples was used to compare the differences in orthopaedic disturbances between the subjects with and without an asymmetric occlusion. The level of significance was set at 95 per cent.

Results

The results of palpation and the analysis of the radiographs revealed an uneven lateral distribution of left to right = 3:1.
In the crossbite group, 33 children (60 per cent) had a right-sided crossbite and 22 children (40 per cent) a left-sided crossbite. No correlation was found between the laterality of the asymmetric occlusion and palpation or radiographic diagnosis.

When the differences between the children with and without a crossbite were recorded, an increased occurrence of orthopaedic parameters in the frontal plane was observed in children with a unilateral malocclusion (Figure 3). An asymmetric occlusion was not necessarily combined with a pathological orthopaedic variable, but children with a unilateral crossbite had statistically more often, an oblique shoulder (\( P = 0.004 \)), an oblique pelvis (\( P = 0.007 \)), functional leg length differences (\( P = 0.002 \)), and a scoliosis (\( P = 0.04 \)) than children with dental symmetry. An oblique shoulder was diagnosed in 30.9 per cent of the total study group, and in 70.6 per cent of them a unilateral crossbite was observed. Similar findings applied to a functional difference in leg length which was recorded in 25.5 per cent of the total group, while 75 per cent of them had a unilateral malocclusion. Thirty per cent of all subjects were found to have an oblique pelvis, whereas 69.6 per cent also had a crossbite. A scoliosis was diagnosed in 9.1 per cent of the children, 80 per cent of them revealed a unilateral crossbite.

No correlation was found between the laterality of the crossbite side and any orthopaedic asymmetry.

Figure 1  Cephalometric landmarks and lines used for analysis of the posteroanterior and lateral radiographs according to Gutmann (1981): McG = palato-suboccipital line according to McGrecor; CD = clivus dens angle (angle between a tangent to the dorsal surface of the clivus and a tangent to the dorsal surface of the dens axis); \( H_0 \) = horizontal line zero (connecting the line of the right- and left-sided base of the occipital condyles); \( L_{om} \) = rectangular line to \( H_0 \) (crossing the midpoint of the foramen magnum); \( K \) = condyla, cross-angle (angle between two lines that are drawn from the lateral and caudal tip of the massa lateralis atlantis through the right- and left-sided base of the occipital condyles); \( d \) = lower caudal triangle of the massa lateralis atlantis; \( L_1 \) = line parallel to \( L_{om} \) (crossing the deepest point of the occipital condyle).

Discussion

The investigation techniques of manual therapy have been repeatedly criticized as being unreliable. However, a number of studies have proved that the conducted tests possess sufficient specificity and sensibility (Jull et al., 1988, 1997; Sandmark and Nisell, 1995).

All studies dealing with functional asymmetry have the difficulty of determining the exact contribution of each factor involved. Therefore, an orthopaedic sample was chosen and the effect of the additional diagnosis ‘unilateral crossbite’, which is presumably skeletal in origin, was investigated.

The finding of a left-sided dominance of the asymmetric cervical spine in this study is in accordance with a detected pattern of trunk asymmetry: there is a tendency to the right on the thoracic level and to the left on the lumbar and cervical level (Nissinen et al., 2000). The investigated predominance of right-sided midline deviation was in agreement with the results of Ze'pa et al. (2003).

The results of the present study suggest that dental asymmetries correlate with orthopaedic asymmetries in the frontal plane. Of the children who revealed an asymmetric upper cervical spine, those with a unilateral crossbite had, significantly more often, an oblique shoulder, an oblique...
pelvis, functional leg length differences, and scoliosis compared with children with a symmetric occlusion.

The association of crossbite with scoliosis is in agreement with other interdisciplinary studies on scoliotic patients (Prager, 1980; Hirschfelder and Hirschfelder, 1983; Huggare et al., 1991) where no lateral correlation was found between crossbite and curvature of the spine (Huggare et al., 1991; Prager, 1980).

The close interrelationship between the masticatory muscles and the muscles supporting the head has been demonstrated in patients requiring stomatognathic treatment (Huggare and Raustia, 1992). Apart from distinct cephalometric characteristics, such as an extended head posture, a flattened cranial base, and a smaller size of the upper cervical vertebrae, after stomatognathic treatment a straightening of the lordosis of the cervical spine was observed. Recently, it has been shown that occlusal interference can cause dysfunction of both the cervical spine and the SI joint (Fink et al., 2003). Those authors recommended that the cervical spine and lumbar and pelvic regions should also be investigated in patients with craniomandibular dysfunction.

Only a few studies have investigated the possible relationship of an asymmetric occlusion and trunk asymmetry in patients without pathological orthopaedic conditions (Lippold et al., 2000; Düffler et al., 2002; Zepa et al., 2003). They reported deviating findings: Lippold et al. (2000) also found a statistically significant correlation between midline deviation and oblique pelvis as well as leg length differences. The other two studies (Düffler et al., 2002; Zepa et al., 2003) showed that moderate trunk asymmetry did not affect facial asymmetry or vice versa. With regard to the study design and the investigated patients, the three studies can hardly be compared: one (Düffler et al., 2002) compared 29 children with a right-sided midline shift with 28 children with a symmetric occlusion, Lippold et al. (2000) investigated midline discrepancies in 50 patients, aged 4–55 years, who were recruited from physiotherapy appointments, while Zepa et al. (2003) analysed frontal cephalograms and compared them with rib hump or lumbar prominence and spinal posture.

Clinical and experimental studies (Poikela et al., 1997) on dental asymmetries revealed a high level of asymmetry in craniofacial or temporomandibular structures and muscle function. In patients with a unilateral malocclusion, asymmetric condylar position with an asymmetric condylar path (Pirttiniemi et al., 1990; Nerd er et al., 1999), reduced condylar growth (Tadej et al., 1998), and an asymmetric mandibular ramus length shorter on the crossbite side (Schmid et al., 1991; Santos Pinto et al., 2001) have been observed. Based on the findings that asymmetric structures can be corrected only after early correction of a unilateral crossbite (Mimura and Deguchi, 1994; Pirttiniemi et al., 1991; Santos Pinto et al., 2001), it is suggested that a persisting asymmetric occlusion results in growth restriction that leads to mandibular and facial asymmetry (Schmid et al., 1991; O’Bryrn et al., 1995; Hesse et al., 1997; Langberg et al., 2005).

Conclusions

The observed associations between unilateral crossbite and orthopaedic disturbances in the frontal plane in this young orthopaedic group suggest a possible link between the occlusion and the locomotor orthopaedic system in the frontal plane.

It is important to stress that these findings were observed in children with asymmetry of the upper cervical spine. Further studies are required on children without any orthopaedic disturbances in order to clarify the effect of a unilateral crossbite on the locomotor system and vice versa.

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