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Quantitative evaluation of lip symmetry in skeletal asymmetry

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SUMMARY The objective of this study was to investigate whether skeletal mandibular asymmetry associated with unilateral and anterior crossbite will lead to lip asymmetry.

The subjects were 26 females, 13 controls and 13 true skeletal asymmetric age-matched patients (24–50 years). The study group was diagnosed as asymmetric according to visual and panoramic radiographic examination and exhibited a unilateral anterior crossbite, an asymmetric mandible, and a deviation of the chin. The control group was visually symmetric and exhibited all forms of tooth malalignment without the presence of a crossbite. Digitized images of the frontal facial photographs of all the subjects, taken in an intercuspal contact position, were analysed for upper and lower lip symmetry pre- and post-orthodontic treatment. The upper and lower lips were subdivided into two quadrants each and the surface area of each quadrant was measured and expressed as a percentage of the total surface area of the relevant lip. The degree of lip asymmetry was obtained by calculating the difference in percentage area between the two quadrants of each lip.

In the study group, the lower lip quadrant on the crossbite side was increased pre-treatment (56.85 ± 1.75 per cent), while the contralateral side was reduced (43.15 ± 1.75 per cent, $P < 0.005$), resulting in 13.7 per cent asymmetry. After treatment, the respective lip areas were 52.12 ± 0.64 and 47.88 ± 0.64 ($P < 0.01$) and asymmetry was significantly reduced (4.25 ± 1.29 per cent). In the control group, the differences between the lower lip quadrant areas (range 48.5–51.5 per cent) were small (less than 3 per cent asymmetry) and did not change post-treatment.

The findings demonstrate that in this study group, lower lip symmetry was mainly controlled by the support provided through the dental interarch relationships and less by skeletal factors.

Introduction

Many attempts have been made to discern facial asymmetries in objectively and various techniques have been used in order to analyse and quantitate them. Postero-anterior (PA) cephalometric analysis that has been used utilized midsagittal and transverse linear and angular measurements (Chebib and Chamma, 1981; Grummons and Kappeyne van de Coppello, 1987). A triangulation method has also been described (Hewitt, 1975), and was recently used by Langberg *et al.* (2005) in an attempt to study 'overall facial asymmetry by comparing the cranial base, maxilla, mandible, and dentoalveolar areas of the facial complex'.

The accuracy of these analyses is problematic since it has been shown that many landmarks are difficult to reproduce and identify (Proffit and White, 1991; Athanasiou and Van der Meij, 1995; Pirttiniemi *et al.*, 1996; Athanasiou *et al.*, 1999). The use of the submentovertex radiograph has also been shown to be unsatisfactory due to the difficulty in point location (Peck *et al.*, 1991). It also projects the mandibular corpus and does not allow full-face skeletal visualization. It has been tried in combination with PA cephalometry (Grayson *et al.*, 1983) but the added radiation and the same disadvantages in reference point location with both methods did not result in the widespred use of the last technique.

Three-dimensional methods have also been described but they necessitate complex and expensive equipment, which is seldom available for a clinician in a private office who has to make a diagnosis. They are applicable mainly when orthognathic surgery is required (Edler *et al.*, 2001).

Soft tissue analyses for the study of facial asymmetry from standardized frontal photographs and PA radiographs have also been used. Measurements from photographs are non-invasive, inexpensive, and reliable and take soft-tissue appearance into account (Edler *et al.*, 2003). In addition, the soft tissues may compensate the underlying skeletal asymmetry and should be the baseline for treatment decisions in asymmetrical subjects (Masuoka *et al.*, 2004).

The curve analysis approach compares the difference in outline areas when one side is flipped contra-laterally (Schmid *et al.*, 1991).

Within the context of facial symmetry, the presence of a unilateral crossbite is of interest (Pirttiniemi, 1994; O'Byrn *et al.*, 1995; Brin *et al.*, 1996; Santos Pinto *et al.*, 2001). Many of these studies involve skeletal asymmetry, temporomandibular joint (TMJ) problems, reverse chewing cycles, muscle body, etc., but none have examined lip symmetry. In a previous investigation on symmetric young adolescents with a functional shift leading to a unilateral crossbite involving the canine (Gazit-Rappaport *et al.*, 2003), a quantitative method for evaluation of lip asymmetry was described. In order to examine the relative contribution of a unilateral crossbite, including the canine, to the lip asymmetry in subjects with an obvious skeletal asymmetry. In order to assess the relative contribution of dental relationships to lip asymmetry, the vertical component and lip competence should be taken into account. Patients with long faces and related lip incompetence are unlikely to have the same degree of lip asymmetry.

The aims of the study were (1) to perform a quantitative evaluation of lip symmetry/asymmetry in patients with visual skeletal asymmetry and a unilateral crossbite, including the canine or an additional incisor; (2) to measure the degree to which orthodontic correction of the crossbite will reduce or possibly eliminate lip asymmetry; and (3) to measure the degree of skeletal asymmetry contribution to the lip asymmetry.

Subjects and methods

Patient selection

Twenty-six patients were recruited for this study from an orthodontic practice. All were adult females between 20 and 50 years of age. The study group comprised 13 females (mean 33.2 years, median 30.5 years) recruited retrospectively after completion of orthodontic treatment and prospectively prior to treatment with the following inclusion criteria:

1. Visual skeletal asymmetry at rest and in the intercuspal contact position of the lower third of the face,
2. anterior unilateral crossbite including the canine,
3. no functional shift,
4. competent lips,
5. non-surgical treatment.

Subjects with condylar hypertrophy and facial deformities including severe Class III malocclusions were excluded from the study since these patients need orthognathic surgery. Also progressive or chronic diseases such as various types of TMJ arthritis were excluded.

The control group comprised 13 age-matched adult females (mean age 31.3 years, median 28 years), without any visual asymmetry, who sought orthodontic treatment for a variety of reasons and were recruited retrospectively from the same practice.

Visual assessment of the skeletal asymmetry

Visual assessment of the asymmetry was performed clinically by all three authors. In addition, the 26 patient's photographs (13 symmetrical and 13 asymmetrical) were projected in a randomized order in front of 12 orthodontic graduate students (9 males, 3 females between 24 and 32 years of age) and two male specialists (42 and 50 years of age). They were requested to identify the following:

1. The asymmetrical patients among the projected faces ;
2. the direction of chin deviation.

Photographic procedure

The photographic procedure was identical to that described previously (Gazit-Rappaport *et al.*, 2003). An experienced photographer (TGR) took all photographs in the same room using the same camera (Nikon Coolpix 4500 4.0 Mega pixels ×4 zoom).

The patients, seated on a chair, were requested to look straight at the camera, and were positioned with their visual axis horizontal to the floor with no side rotation around the vertical axis of the head. The distance of the patient's forehead to the camera lens was 140 cm. Glasses were removed and the patients were asked to close the posterior teeth and lightly close the lips. The photographs were taken pre- and post-treatment.

Orthodontic treatment

The patients in both groups received full orthodontic treatment with fixed appliances for 8–12 months. In the study group, the crossbite in the anterior/posterior region was eliminated successfully either by interproximal reduction in the lower anterior region, by extraction of a lower incisor, by expansion of the upper arch, or by a combination of the above. At the end of the orthodontic treatment, normal anterior overjet and overbite relationships were achieved, but the upper and lower midlines never coincided. The control group had a variety of treatments for the correction of crowding, spacing, mesially inclined molars, etc. On completion of treatment, a bonded lingual retainer was utilized for retention of the lower and upper anterior segments and a Hawley retainer was used during the night.

A frontal view of one subject pre- and post-treatment and the measurement technique are shown in Figure 1.

Data collection

The frontal photographs were imported into Microsoft PowerPoint and the lower half of the face was enlarged and saved. A vertical line from the midpoint of the base of the nose (the mid-distance between the inner outline of the nostrils) through the midpoint of the filtrum of the upper lip towards the chin was superimposed on the images. The midpoint of the chin did not fall on this line in the study group. The lip outline and the transverse line at the merging of the two lips were carefully drawn to create (together with the vertical line) four quadrants, two making up the upper lip and two the lower lip. The surface area of each quadrant was measured with the Bioquant Nova Software (R&M Biometrics, Nashville, Tennessee USA). Data from each of the lower lip quadrants were expressed as a percentage of the total surface area of the lower lip.

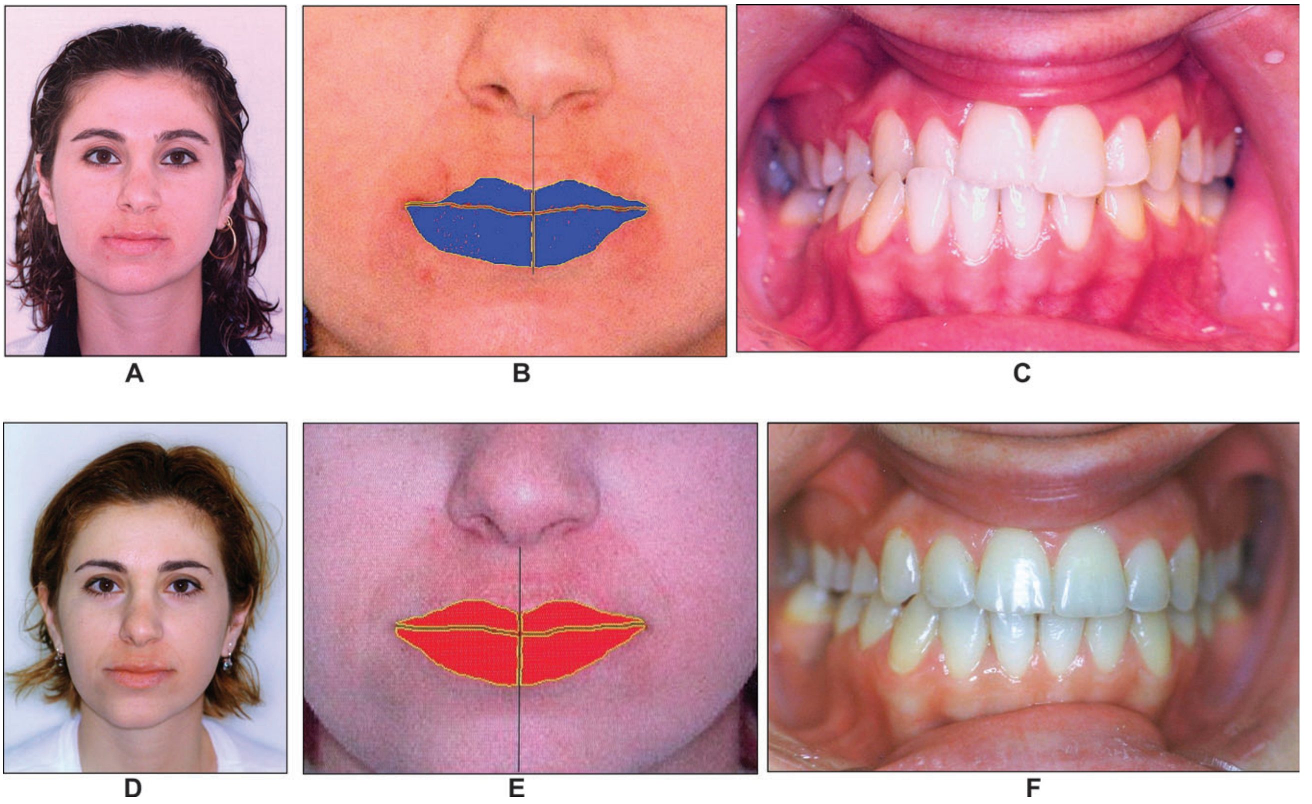

Figure 1 A frontal view of one asymmetric subject. (A) Face pre-treatment, (B) measurement technique dividing the lips into four quadrants, (C) occlusion pre-treatment, (D) face post-treatment, (E) measurement technique dividing the lips into four quadrants (note improvement in lip symmetry after orthodontic treatment), and (F) occlusion post-treatment.

Additionally, lip asymmetry was calculated as the absolute value of the difference in the percentage of area between the two quadrants of each lip according to the formula: asymmetry = (right segment value − left segment value) × 100/(right segment value + left segment value). This calculation used the sum of the right and left values (which varied between patients). Thus, perfect symmetry would result in a zero value. The absolute value was used as patients in the control group had slight lip asymmetry to either the right or the left side. This measurement technique has been described previously (Gazit-Rappaport *et al.*, 2003).

Lip quadrant area was measured on three occasions for six patients (three from the controls and three from the study group) to determine the reproducibility of the measurements by calculating the coefficient of variation for each patient.

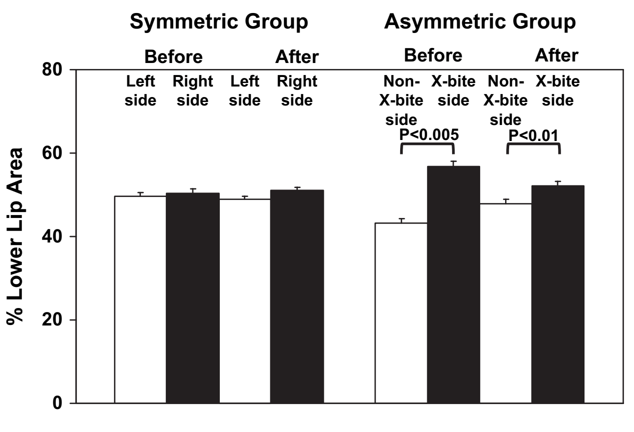

Figure 2 Mean percentage surface area of each of the two halves of the lower lip before and after treatment in both the study and the control groups.

Results

Figure 2 shows the mean percentage surface area of each of the two halves of the lower lip before and after treatment for both the study and the control groups. In subjects with a complete symmetry, each half of the lip should occupy 50 per cent of the total lip area.

In the control group, the differences between lower lip quadrant areas (range 48.5–51.5 per cent) were small (less than 3 per cent asymmetry) and did not change post-orthodontic treatment. The difference in lip symmetry among the study group prior to the orthodontic treatment was significant. The lower lip quadrant on the crossbite side was enlarged pre-treatment (56.85 ± 1.75 per cent), while the contralateral side was reduced (43.15 ± 1.75 per cent, $P < 0.005$), resulting in a 13.7 per cent asymmetry.

On completion of orthodontic treatment, the respective lip mean percentage areas were 52.12 ± 0.64 and 47.88 ± 0.64 ($P < 0.01$) and asymmetry was significantly reduced (4.25 ± 1.29 per cent). These results show that the surface area of the lower quadrants post-treatment approached 50 per cent, similar to the controls.

The percentage of the surface area of the left and right lower lip quadrants before and after orthodontic treatment for each subject in the control and study group is shown in Figure 3. Lip surface area in the study group at the completion of orthodontic treatment approached 50 per cent in each subject. In the control group, the changes were subtle and varied slightly around 50 per cent. The upper lip in both groups demonstrated negligible differences both pre- and post-treatment (data not shown).

Figure 4 shows the absolute values of lip area asymmetry. In the control group, the differences between the lower lip quadrant areas were small (3 per cent), while in the study group they were much larger (13.7 per cent).

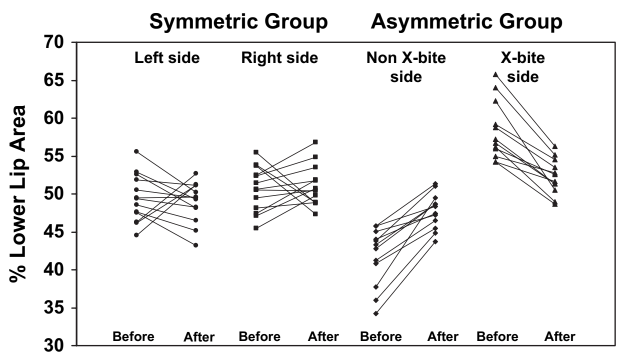

Figure 3 Percentage of the surface area of the left and right lower lip quadrants before and after orthodontic treatment for every patient individually in the control and the study groups.

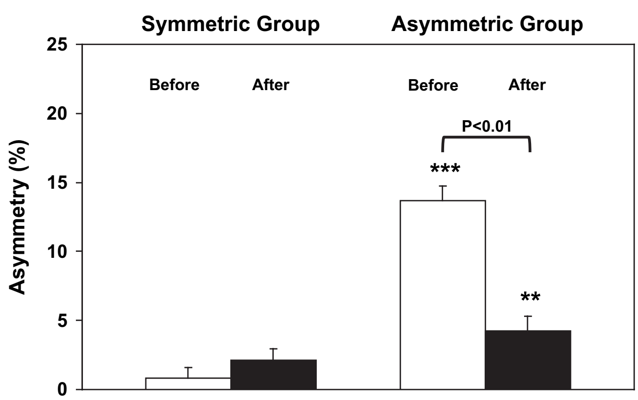

Figure 4 Absolute values of lip area asymmetry in the control and study groups.

The study group comprised eight patients with a tendency to right asymmetry (crossbite and chin deviation is to the right) and five with a tendency to left asymmetry.

Discussion

It is well established that facial asymmetry may be present in three planes of space but the horizontal plane is the most perceptive to the eyes of the patient and the observer (Proffit *et al.*, 1990).

When discussing horizontal asymmetry, the most discernable facial structure of the asymmetry is the mandible or, more specifically, the midpoint of the chin. There is no reference in the literature regarding lip asymmetry in facial asymmetric subjects.

In this study group, the mandibular ramus and body were shorter on the crossbite side and longer on the crossbite side. This finding is in agreement with previous research (Chebib and Chamma, 1981; Mongini and Schmid, 1987; Santos Pinto *et al.*, 2001). Santos Pinto *et al.* (2001) observed positional changes of the mandible and differential joint spaces in the presence of a crossbite in children. After treatment the crossbite side developed faster to correct the asymmetry. If these crossbites had not been treated, it is possible that there would be no compensatory growth to re-establish symmetry. Asymmetry might have developed due to adaptive remodelling changes in the TMJ with age in the presence of a long-standing crossbite (Kantomaa, 1988; O'Byrn *et al.*, 1995; Lam *et al.*, 1999) or during pubertal growth.

The aetiological factors involved in the development of the asymmetry in the subjects were not addressed in this study.

In all facial structures, soft tissue symmetry is dictated by the underlying muscular and skeletal structures and lip symmetry by the underlying dental units. Gazit-Rappaport *et al.* (2003) showed that correction of a unilateral anterior crossbite due to a functional shift re-established lip symmetry in young patients. In the present investigation, the aim was to evaluate the relative contribution of the underlying dental units in subjects with skeletal asymmetry by crossbite correction without addressing the skeleton. The results demonstrate the key role of dental support for lip outline and symmetry in this study group.

In a recent investigation (Van Keulen *et al.*, 2004), chin movement on a computer-designed perfectly symmetrical face tested the observer's detection of the asymmetry by visual scoring. The lips were not moved. Most of the observers recognized a 4-mm chin deviation. If, however, the side slide of the chin had included the lower lip, it is reasonable to assume that detection of the asymmetry would have been more sensitive and recognized earlier. In the present investigation, most of the study group's asymmetric females complained that they were aware of the asymmetry whenever they applied lipstick. Correction of the crossbite was responsible for the less noticeable asymmetry, although the basic skeletal outline did not change.

The analysis of the lip asymmetry utilized only a vertical line of reference; thus, lip measurement was independent of the horizontal planes. These observations cannot be made and quantified if the lips are incompetent or very thin because of the small differences in surface area of each half of the lips.

Conclusions

1. In subjects with mild to moderate skeletal facial asymmetry associated with unilateral anterior crossbites, there is marked lip asymmetry.
2. Correction of the dental crossbite without addressing the skeletal asymmetry (orthognathic surgery) improved lip symmetry visually and quantitatively to a significant degree. Thus, lip symmetry is mainly controlled by the support provided through the dental interarch relationships and less by skeletal factors.

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