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Is unilateral posterior crossbite associated with leg length inequality?

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SUMMARY It has been suggested that malocclusions may influence whole body posture, including leg length, but the current scientific evidence to support this statement is poor. The aim of the present study was to investigate a possible association between leg length inequality (LLI) and unilateral posterior crossbite.

A survey was carried out in young adolescents recruited from three schools. The sample included 1159 subjects (633 males and 526 females) with a mean age of 12.3 years (range 10.1–16.1 years), who underwent an orthodontic and orthopaedic examination performed independently by orthodontists and orthopaedists. The data were analysed by means of logistic regression analysis.

One hundred and twenty subjects (10.3 per cent) were diagnosed as having LLI. A unilateral posterior crossbite was found in 142 of the 1159 subjects (12.2 per cent). Logistic multiple regression analysis, controlling for potential confounding variables, failed to reveal a significant association between LLI and unilateral posterior crossbite (odds ratio = 1.0, confidence limits = 0.6–1.9). A unilateral posterior crossbite does not appear to be associated with LLI, at least in young adolescents.

Introduction

During the last decades, it has been suggested that disorders of the masticatory system can influence whole body posture (Zonnenberg *et al.*, 1996; Gangloff *et al.*, 2000; Milani *et al.*, 2000; Bracco *et al.*, 2004). A number of studies, for instance, support a potential association between the way in which the teeth fit together (i.e. dental occlusion) and spinal curvatures (i.e. kyphosis, scoliosis, lordosis; Huggare, 1998; Festa *et al.*, 2003; D'Attilio *et al.*, 2005). It has also been suggested that an altered position and contact of the maxillary and mandibular teeth influence the distal musculature including leg muscles, which in turn may result in a leg length inequality (LLI; Gole, 1993; Valentino *et al.*, 2002).

These arguments are gaining increasing public awareness through magazines, television programmes, and web sites. As a consequence, a growing number of patients are seeking concomitant treatment for dental malocclusions and postural disorders, who firstly address questions to orthopaedists and general physicians and thereafter are referred to dentists. Unfortunately, most clinicians are often unacquainted with this topic and the current scientific evidence of causality between the two conditions is weak or absent.

The malocclusion that has the potential to strongly influence spinal curvatures and leg length is a unilateral posterior crossbite, which is defined as an irregular bucco-lingual or bucco-palatal relationship between opponent teeth (Daskalogiannakis, 2001). A unilateral posterior crossbite has a strong impact on correct functioning of the masticatory system (Troelstrup and Möller, 1970; Ingervall and Thilander, 1975; Michler *et al.*, 1987; Ferrario *et al.*, 1999; Alarcon *et al.*, 2000) and may induce asymmetrical mandibular growth (Mongini and Schmid, 1987; Lam *et al.*, 1999; Pinto *et al.*, 2001).

The aim of this study was to investigate the potential association between LLI and posterior crossbite by means of a survey carried out in a large sample of young adolescents. The null hypothesis to be tested was that the association between the two conditions would not exceed that expected by mere chance.

Subjects and methods

The subjects were recruited from secondary schools by means of two-stage cluster sampling. Three schools were first randomly selected from among the nine schools found in the surroundings of the Dental Clinic, University of Naples Federico II. In each school, students were selected from name lists using an inclusion probability (80 per cent) related to the school size. Details of the recruitment process are given in Table 1.

The selected students (n = 1680) received an informed consent form to be signed by the parents. Informed consent was obtained only for 1291 (76.8 per cent) students. The following were considered as exclusion criteria: facial trauma, acute or chronic orofacial or vertebral inflammatory

Table 1 Details of the sampling procedure used. The numbers represent absolute frequencies.

	School A	School B	School C	Overall
Eligible students	619	759	722	2100
Students selected by randomization	495	607	578	1680
Parents' refusals to informed consent	121	138	130	389
Students excluded from the study	25	46	61	132
Students included in the study	353	425	381	1159

diseases, spinal or lower limb fractures, and neurological diseases.

According to these criteria, 132 subjects, 75 (56.8 per cent) males and 57 (43.2 per cent) females, were excluded from the study. The remaining subjects included 633 (54.6 per cent) males [mean age ± standard deviation (SD): 12.3 ± 1.2] and 526 (45.4 per cent) females (mean age ± SD: 12.2 ± 1.2). The age range, the 10th, and the 90th percentiles of the whole sample were 10.1–16.1, 11.0, and 13.8, respectively. All subjects underwent an orthodontic and an orthopaedic examination, which were performed independently by two dentists (AM and MF) and two orthopaedic surgeons.

Agreement between examiners was assessed by calculating kappa (κ) coefficients (Cohen, 1960) from duplicate measurements obtained for a subgroup of 60 subjects. The κ coefficients between the two dentists for posterior crossbite assessments was 0.95 (standard error = 0.07) and between the two orthopaedists for LLI 0.80 (standard error = 0.03). These κ values indicated good to excellent agreement.

The subjects first underwent an orthodontic examination. A posterior crossbite was diagnosed when at least one tooth of the posterior dentition (from canine to second molar) was in an irregular (at least one cusp wide) bucco-lingual or bucco-palatal relationship with one or more opponent teeth (Daskalogiannakis, 2001). Following the orthodontic examination, the subject was asked to undress for the orthopaedic examination.

LLI was assessed using a specially designed device, which consisted of two opposite free-standing metal frames 130 cm high welded to a metal platform (Figure 1). This device was developed to reduce measurement errors which might have been introduced by body contours if a traditional tape measure had been used (Grundy and Roberts, 1984). The subject was asked to stand erect on the metal base with the feet almost together and the knees at full extension. The anterior spines were then identified and their cutaneous tips marked with a pen. Therefore, the two horizontal laser points were positioned level with the marked tips and the distance from the anterior superior iliac spine to metal base was read directly from the vertical rule. A difference equal to or greater than 10 mm between leg length was considered as the threshold being clinically relevant for a diagnosis of LLI. This threshold was slightly greater than the mean error resulting from duplicate measurements obtained from a pilot study carried out in 60 subjects (6.1 ± 2.4 mm).

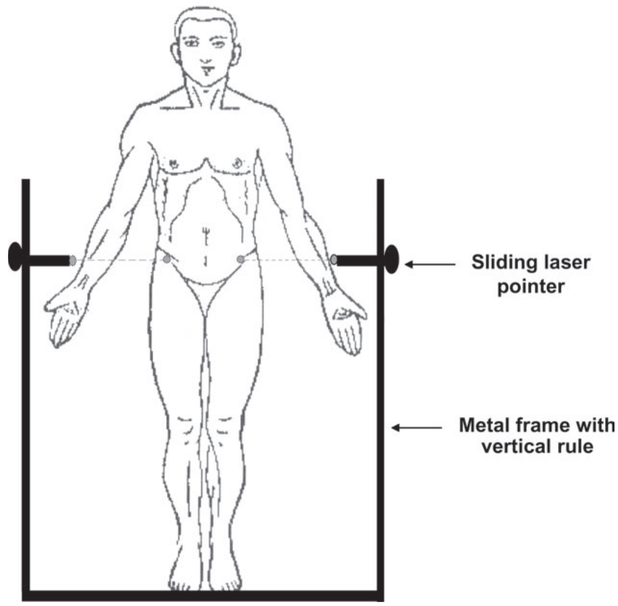

Figure 1 Schematic drawing of the custom-made device used to assess leg length inequality. The device consisted of two opposite free-standing metal frames welded to a metal platform. Attached to each frame, there is a vertical rule showing measurements in millimetres. For each subject, the two sliding laser pointers were adjusted at the level of the cutaneous tips corresponding to the left and the right anterior iliac spines. Then measurements were taken by visual reading of the rule on the frames.

The collected data were firstly analysed by means of conventional descriptive statistics. Chi-square tests and multiple logistic regressions were used for subsequent statistical analyses. Age, gender, and self-report of current or previous orthodontic treatment were entered into the multiple logistic model as potential confounding variables. Statistical analyses were carried out using the Statistical Package for Social Sciences (Release 12.0, SPSS Inc., Chicago, Illinois, USA), with a probability level of 0.05 considered as statistically significant.

Results

Distribution of subjects by LLI, unilateral posterior crossbite, gender, age, and orthodontic treatment for each school is given in Table 2.

One hundred and twenty subjects (10.3 per cent) out of 1159 were diagnosed as having LLI. LLI was found in 60 of the 633 males (9.5 per cent) and in 60 of the 526 females (11.4 per cent). The proportion of LLI did not differ significantly between genders (chi-square = 1.15, df = 1, $P = 0.28$). A unilateral posterior crossbite was found in 142 of the 1159 subjects (12.2 per cent), 73 (51.4 per cent) males

Table 2 Distribution of subjects* among schools by leg length inequality (LLI), unilateral posterior crossbite, gender, age, and orthodontic treatment.

	School A	School B	School C	Overall
LLI				
No	310	389	340	1039
Yes	43	36	41	120
Unilateral posterior crossbite				
No	316	359	342	1017
Yes	37	66	39	142
Gender				
Males	198	234	201	633
Females	155	191	180	526
Age (years)				
<11.6	94	132	146	372
11.6–12.7	144	120	142	406
>12.7	115	173	93	381
Orthodontic treatment				
No	266	328	296	890
Yes	87	97	85	269

*Number of observations, 1159.

Table 3 Results of multiple regression analysis using leg length inequality as the dependent variable and posterior crossbite, gender, age, and orthodontic treatment as independent variables.

Independent variable	Odds ratio	95% Confidence interval		*P*
		Lower	Upper	
Posterior crossbite				
No†	—	—	—	—
Yes	1.0	0.6	1.9	0.85, NS
Gender				
Males†	—	—	—	—
Females	1.2	0.8	1.7	0.40, NS
Age				
<11.6†	—	—	—	—
11.6–12.7	1.2	0.8	2.0	0.40, NS
>12.7	1.1	0.7	1.8	0.60, NS
Orthodontic treatment				
No†	—	—	—	—
Yes	1.6	1.1	2.4	0.02*

†Reference group number of observations, 1159.
*$P < 0.05$; NS, not significant.

and 69 (48.6 per cent) females. The proportion of subjects with a unilateral posterior crossbite did not differ significantly between genders (chi-square = 0.64, df = 1, $P = 0.42$). The association between LLI and a posterior crossbite was not statistically significant (chi-square = 0.00, df = 1, $P = 0.93$), and only 15 subjects (1.3 per cent) were found to have concurrently LLI and a unilateral posterior crossbite. A multiple logistic regression analysis was performed considering the LLI diagnosis as the response variable (two modalities: present, absent) and a unilateral posterior crossbite (two modalities: yes, no), age (three modalities: upper, middle, and lower tertile), gender (two modalities: males, females), and orthodontic treatment (two modalities: yes, no) as independent variables. The results of the logistic regression analysis are summarized in Table 3. No odds ratio (OR) was statistically significant with the exception of that for previous or current orthodontic treatment.

Neither the magnitude (OR = 1.2, confidence limits = 0.6–2.3) nor the level of significance ($P = 0.56$) of the adjusted OR for unilateral posterior crossbite changed noticeably when the subjects with previous or current orthodontic treatment were excluded from the sample investigated.

A *post hoc* power analysis, setting the alpha error at 0.05 and using a prevalence estimate of posterior crossbite at 12.2 per cent, revealed that the power of the main statistical test in detecting an OR equal to 2 or higher was 84 per cent.

Discussion

The relative frequency of LLI found in the present sample (approximately 10 per cent) is lower than that reported in other studies (Guichet *et al.*, 1991; Specht and De Boer, 1991; Brady *et al.*, 2003; Vitale *et al.*, 2006). This discrepancy may be partly ascribed to the different threshold for definition of LLI across studies and partly to the young age of subjects in the present investigation. On the other hand, the relative frequency of a posterior crossbite found in the present study is in agreement with previous prevalence estimates obtained in unselected subjects of a similar age (Thilander and Myrberg, 1973; Helm and Prydsö, 1979).

The findings suggest that in young adolescents, a unilateral posterior crossbite is not a risk factor for LLI as both chi-square testing and multiple logistic regression analysis failed to demonstrate a significant association between this factor and LLI, showing an OR very close to 1.

A sensitivity analysis was carried out excluding subjects with previous or current orthodontic treatment. The results of this analysis suggested that LLI and a unilateral posterior crossbite were still not significantly associated. An interesting finding, obtained with the regression model that included the report of previous or current orthodontic treatment as a covariate, was that orthodontic treatment was possibly associated with LLI (OR = 1.6, confidence limits = 1.1–2.4). This might indicate that orthodontic treatment is a risk factor (rather than a protection). However, this result may be more simply ascribed to a referral bias due to the fact that many children are more likely to be referred to orthodontists from orthopaedists or other general practitioners evaluating postural disorders.

The evidence arising from this study is in contrast with the common belief of many dental and medical practitioners, who recommend dental or orthodontic treatment for correction of a unilateral posterior crossbite to prevent or to treat so-called 'postural imbalances'. In these cases, the treatment decision need is mainly based on anecdotal or case reports rather than on scientific evidence. Well-designed studies therefore appear necessary to support clinical decision making. The present report would appear to be the first study investigating the relationship between LLI and a unilateral posterior crossbite, therefore the findings cannot be compared with previous investigations. However, the present results are, to some extent, in agreement with those of Ferrario *et al.* (1996) and Michelotti *et al.* (2006) showing that different occlusal conditions do not influence postural stability as assessed by means of a stabilometric platform.

The main strengths of this study are the population-based sampling, the use of independently measured exposure and outcome variables, the demonstrated reliability of assessments, and the control for potentially confounding variables. It must be emphasized, however, that the findings have been obtained from a sample of young adolescents. It cannot be excluded that a unilateral posterior crossbite may become a significant risk factor for LLI with increasing age. Future longitudinal studies might help to clarify this point. However, the strength of association between a unilateral posterior crossbite and LLI found in the present study was so low (OR =1.0, $P = 0.85$) that is unlikely that any future research will find a strong association between the two conditions.

Conclusions

A unilateral posterior crossbite is not a risk factor for LLI. A possible cause–effect relationship between these two conditions is therefore not supported by the findings. Based upon these observations, clinicians should be cautious in recommending early orthodontic or dental treatment in unilateral posterior crossbite patients aiming only to prevent or to treat LLI as it seems unrelated to this occlusal condition.

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