Posterior Crossbite and Functional Changes

A Systematic Review

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ABSTRACT

Objective: To assess, by systematically reviewing the literature, the functional changes of the masticatory muscles associated with posterior crossbite in the primary and mixed dentition.

Materials and Methods: A literature survey from the Medline database covering the period from January 1965 to February 2008 was performed. Randomized controlled trials, controlled clinical trials, and clinical trials that evaluated bite force, surface electromyography, and signs and symptoms of temporomandibular disorders (TMD) were included. Two reviewers extracted the data independently and assessed the quality of the studies.

Results: The search strategy resulted in 494 articles, of which 8 met the inclusion criteria. Children with posterior crossbite can have reduced bite force and asymmetrical muscle function during chewing or clenching, in which the anterior temporalis is more active and the masseter less active on the crossbite side than the noncrossbite side. Moreover, there is a significant association between posterior crossbite and TMD symptomatology.

Conclusion: The consequences of the functional changes for the growth and development of the stomatognathic system deserves further investigation. (*Angle Orthod.* 2008;79:380–386.)

KEY WORDS: Crossbite; Bite force; Surface EMG; TMD; Masticatory muscles; Systematic review

INTRODUCTION

Posterior crossbite is one of the most prevalent malocclusions in the primary and early mixed dentition and is reported to occur in 8% to 22% of the cases.[1,2] It is defined as any abnormal buccal-lingual relation between opposing molars, premolars, or both in centric occlusion.[1] The most common form is a unilateral presentation with a functional shift of the mandible toward the crossbite side, which occurs in 80% to 97% of cases.[3,4] The etiology of posterior crossbite can include any combination of dental, skeletal, and neuromuscular functional components, but the most frequent cause is reduction in width of the maxillary dental arch. Such a reduction can be induced by finger sucking,[3,5,6] certain swallowing habits,[5] or obstruction of the upper airways caused by adenoid tissues or nasal allergies.[6,7]

Because spontaneous correction is rare,[1] posterior crossbite is believed to be transferred from primary to permanent dentition, with long-term effects on the growth and development of the stomatognathic system.[8,9] The condyles on the crossbite side are positioned relatively more superiorly and posteriorly in the glenoid fossa than those on the noncrossbite side.[10] Since skeletal remodeling of the temporomandibular joint (TMJ) can occur over time, the condyles become more symmetrically positioned in their fossa, and facial asymmetry and mandibular midline deviation toward the crossbite side might persist. Subsequent adaptation of the neuromusculature to the acquired mandibular position can cause asymmetric mandibular growth, facial disharmony, and several functional changes in the masticatory muscles and TMJ.[11–14]

Previous studies have found associations between crossbite and parameters related to the masticatory muscle performance, such as asymmetric electromyo-

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Table 1. Initial Inclusion and Exclusion Criteria for the Retrieved Studies

Inclusion Criteria	Exclusion Criteria
• Human studies • Primary and early mixed dentition with posterior crossbite • Randomized controlled trials, controlled clinical trials, and prospective studies • Articles written in English	• Case reports and case series • Review articles and abstracts • Permanent dentition, adults • Angle Class III • Cleft lip and/or palate or other craniofacial syndrome diagnosis

graphic (EMG) activity,[15,16] different thickness of the elevator muscles on each side of the jaw,[17] different bite force magnitude, and more TMJ symptomatology in crossbite subjects.[14,16,18] Disparate outcomes have been produced from a considerable variety of diagnostic approaches, study designs, sample sizes, and research approaches.

Therefore, a systematic review was warranted, focusing on the functional changes associated with posterior crossbite in children, based on the evaluation of EMG activity of masticatory muscles, bite force, and signs and symptoms of temporomandibular disorders (TMD). Furthermore, a quality analysis of the methodological soundness of the studies in the review was performed.

MATERIALS AND METHODS

Search Strategies

The strategy for this systematic review was based on the National Health Service Center for Reviews and Dissemination.[19] A literature survey was done by applying the Medline database (www.ncbi.nim.nih.gov) in the period from January 1965 to February 2008, using the Medical Subject Headings terms "crossbite" and "bite force," which were also crossed with various combinations of the following terms: "surface EMG" and "TMD."

Selection Criteria

The inclusion and exclusion criteria are given in detail in Table 1.

Data Collection and Analysis

Data were collected on the following items: author, year of publication, study design, study groups, methods/measurements, and outcome measurements. In addition, to document the methodological soundness of each article, a quality evaluation was performed with respect to preestablished characteristics[20,21] evaluating eight variables: (1) study design (randomized clinical trials [RCT], prospective [P] or controlled clinical trials [CCT] = 3 points; clinical trials [CT] = 1 point); (2) adequate sample size = 1 point; (3) adequate selection description = 1 point; (4) valid measurement methods = 1 point; (5) use of method error analysis = 1 point; (6) blinding in measurement = 1 point; (7) adequate statistics provided = 1 point; and (8) confounders included in analysis = 1 point. Each study was categorized as low (0–5 points), medium (6–8 points), or high (9 or 10 points).

The data extraction and quality scoring from each article were assessed independently by two researchers who selected the articles by reading the title and abstracts. All of the articles that appeared to meet the inclusion criteria were selected. A 100% agreement was obtained in this phase between the two researchers. The reference lists of the selected articles were also searched manually for additional relevant publications that might have been missed in the database searches.

RESULTS

The search strategy resulted in 494 articles. After selection according to the inclusion/exclusion criteria, eight articles qualified for the final analysis.

Quality of the Studies

The research quality and methodological soundness were high in one study,[15] medium in six,[16,18,22–25] and low in one[14] (Tables 2 and 3). The most serious shortcomings were the CT design with small sample size and inadequate description of selection. Problems of confounding variables, lack of method error analysis, and the absence of blinding in measurements were other examples of shortcomings. Furthermore, the choice of statistical methods was not explained. Considering the confounding variable facial pattern, only one study selected subjects with a Class I malocclusion and a mesiofacial growth pattern in order to avoid the influence of sagittal and vertical anomalies in the neuromuscular systems.[15] The other seven studies did not comment or consider this matter at all.

DISCUSSION

This systematic review aimed to select all RCTs, CCTs, and all P and retrospective observational studies with concurrent controls as well as observational studies verifying the functional changes in masticatory

Table 2. Summarized Data of the Eight Studies Included in the Review

Author (Year)	Study Design	Study Groups	Sample	Age, y	Methods/ Measurements	Outcome Measurements: Statistically Significant Difference Between Groups	Outcome Measurements: Statistically Significant Difference Between Sides
Alarcón et al [15] (2000)	CCT	I: Unilateral posterior crossbite	n = 30 (17 girls, 13 boys)	10–14	EMG	↑ EMG on ipsilateral AT and on both sides of AD during swallowing; ↑ EMG on ipsilateral AD and ↓ EMG on ipsilateral MM during chewing	↑ EMG on contralateral PT than ipsilateral PT during rest and swallowing
		II: Control normocclusive	n = 30 (16 girls, 14 boys)	10–14			
Kecik et al[16] (2007)	P, CCT, L	I: Unilateral functional posterior crossbite	n = 35 (20 girls, 15 boys)	10.6 (mean)	EMG and joint vibration analysis	↑ EMG on ipsilateral AT and MM than contralateral ones during rest; ↑ EMG on ipsilateral AT and ↓ EMG on ipsilateral MM than contralateral ones during clenching	↑ EMG on ipsilateral AT and MM than contralateral ones during rest; ↑ EMG on ipsilateral AT and ↓ EMG on ipsilateral MM than contralateral ones during clenching
		II: Control (without malocclusion)	n = 31 (18 girls, 13 boys)	9.8 (mean)			
Sonnesen et al[25] (2001)	CCT	I: Unilateral posterior crossbite	n = 26 (13 girls, 13 boys)	9.35 (mean)	Bite force determination and evaluation of TMD signs and symptoms (clinical examinations and questionnaire)	Crossbite group showed lower bite force than control group; MM and AT had more sensibility in crossbite group	No significant differences in bite force between sides
		II: Control (with neutral occlusion or minor malocclusion)	n = 26 (13 girls, 13 boys)	9.35 (mean)			
Rentes et al[22] (2002)	CCT	I: Normocclusion	n = 10	3–5.5	Bite force determination	No differences	Not evaluated
		II: Crossbite	n = 10				
		III: Openbite	n = 10				
Sonnesen and Bakke[23] (2007)	P, L	I: Unilateral posterior crossbite	n = 19 (7 girls, 12 boys)	7–11	Bite force determination	Immediately after treatment↓ bite force on ipsilateral than on contralateral side	No differences
Castelo et al[24] (2007)	CCT	I: PNO	n = 15 (5 girls, 10 boys)	PNO = 58.67 months	Bite force, muscular thickness, and occlusal contacts	MCB↓ bite force than in the MNO group; no differences between PNO and PCB groups	↑ AT (muscular thickness) in the crossbite side than the normal side in the MCB group
		II: PCB	n = 10 (4 girls, 6 boys)	PCB = 60.50 months			

Table 2. Continued

Author (Year)	Study Design	Study Groups	Sample	Age, y	Methods/ Measurements	Outcome Measurements: Statistically Significant Difference Between Groups	Outcome Measurements: Statistically Significant Difference Between Sides
		III: MNO	n = 13 (6 girls, 7 boys)	MNO = 72.85 months			
		IV: MCB	n = 11 (8 girls, 3 boys)	MCB = 71.91 months			
Vanderas and Papagiannoulis[18] (2002)	RCT	. . .	n=314 (153 girls, 161 boys)	6–8	Clinical examination and evaluation of TMD signs and symptoms by an interview	Posterior crossbite had a significant impact on TMJ tenderness	
Sonnesen et al[14] (1998)	CT	. . .	n=104 (56 girls, 48 boys)	7–13	Bite force determination, clinical examination and evaluation of TMD signs and symptoms by an interview	Crossbite group showed lower bite force than control group and the malocclusion was significantly associated with signs and symptoms of TMD	

CCT indicates controlled clinical trials; RCT, randomized clinical trials; CT, clinical trials; L, longitudinal; P, prospective; MM, masseter; AT, anterior temporalis; PT, posterior temporalis; AD, anterior digastric; EMG, surface electromyography; TMJ, temporomandibular joint; TMD, temporomandibular disorders; ↑ EMG, higher electromyographic activity; ↓ EMG, lower electromyographic activity; PNO, primary normal-occlusion; PCB, primary-crossbite occlusion; MNO, mixed-normal occlusion; MCB, mixed-crossbite occlusion.

muscles associated with posterior crossbite in children. No retrospective study could be found. Eight studies were retrieved.

From a methodological point of view, it was notable that all the studies used examination methods without blinding design. However, this could be explained by the difficulty in having an observer be blind to the presence of posterior crossbite. In all studies, the methods used to detect and analyze the functional changes associated with posterior crossbite were valid and well known. However, different experimental designs and sample selection were used, which caused difficulties in comparing the results.

Crossbite and Bite Force

Five articles evaluated the bite force in children with unilateral posterior crossbite.[14,22–25] Maximum bite force and numbers of teeth in contact were significantly lower in children with unilateral crossbite when compared with control groups having a similar number of teeth. In addition, there were no significant differences in maximum values between sides of the jaw in the groups with and without posterior crossbite. These findings suggest that children with unilateral crossbite can present a reduced bite force when compared with children with neutral occlusion and more tooth contacts.[14,25]

In a prospective, longitudinal study,[23] bite force in children with a unilateral posterior crossbite before orthodontic treatment did not differ significantly between sides, but immediately after orthodontic treatment, bite force was significantly lower on the ipsilateral side (crossbite side) than on the contralateral one.[23] The reason could be due to transient changes in occlusal support, periodontal mechanoreceptors, and jaw elevator muscle reflexes, but the bite force increased again after retention and approached the mean level in children with neutral occlusion.[23]

Nevertheless, in the primary dentition, no significant differences in bite force values were found between children with normal occlusion and posterior unilateral crossbite,[22,24] whereas in the early mixed dentition, the level of maximum bite force was significantly lower for children with this malocclusion than controls.[24]

Bite force can be influenced by the size of the bite gauge, and in a young age group, the size might be beyond their optimal vertical jaw separation, which in turn might reduce the bite force.[26] Therefore, the reduced bite force associated with crossbite seems to become apparent from the time that the mixed dentition starts.

Muscular Activity at Rest Position

After evaluating muscular activity at rest position, two studies reported EMG differences during swallowing and mastication[15] and during maximum clench[16] as a result of a posterior crossbite in children. Alarcon et al[15] compared the normocclusive and right posterior

Table 3. Quality Evaluation of the Retrieved Studies

Author (Year)	Study Design	Sample Size	Selection Description	Valid Measurement Methods	Method Error Analysis	Blinding in Measurements	Adequate Statistics Provided	Confounding Factors	Judged Quality Standard
Alarcón et al[15] (2000)	CCT[a]	Adequate	Adequate	Yes	Yes	No	Yes	Yes, facial pattern considered	High
Kecik et al[16] (2007)	CCT	Adequate	Adequate	Yes	Yes	No	Yes	ND	Medium
Sonnesen et al[25] (2001)	CCT	Adequate	Adequate	Yes	Yes	No	Yes	ND	Medium
Rentes et al[22] (2002)	CCT	Inadequate	Adequate	Yes	No	No	Yes	ND	Medium
Sonnesen and Bakke[23] (2007)	P, L	Adequate	Adequate	Yes	Yes	No	Yes	ND	Medium
Castelo et al[24] (2007)	CCT	Inadequate	Adequate	Yes	Yes	No	Yes	ND	Medium
Vanderas and Papagiannoulis[18] (2002)	RCT	Adequate	Adequate	Yes	Yes	No	Yes	ND	Medium
Sonnesen et al[14] (1998)	CT	Adequate	Inadequate	Yes	Yes	No	Yes	ND	Low

[a] CCT indicates controlled clinical trial; RCT, randomized clinical trial; CT, clinical trial; L, longitudinal; P, prospective; ND, not declared.

crossbite subjects and found no significant differences in any of the tested muscles (anterior and posterior temporalis, masseter, and anterior digastric) at rest position. Moreover, the right anterior temporal demonstrated a higher EMG activity than the left anterior temporal in the normocclusive group, and the study's authors suggested that some degree of muscular asymmetry could be considered as physiological and compatible with normal function. In the right posterior crossbite subjects, the left posterior temporal showed higher EMG activity than the right posterior temporal, suggesting that this asymmetry could be due to the functional mandibular shift. Such a shift could act as a mechanism for reaching a certain degree of occlusal stability.[15] Kecik et al[16] showed that the anterior temporal and masseter muscle activity at rest position differed significantly between the crossbite and control groups, and higher muscle activity was found on the crossbite side, but the respective differences were eliminated after maxillary expansion.

Muscular Activity During Swallowing

EMG activity of the left anterior temporal and both left and right anterior digastric muscles was higher in the right posterior crossbite group than in the normocclusive group, whereas the left posterior temporal showed a higher peak of EMG activity than the right.[15] The increased activity of the anterior digastric muscles in the crossbite subjects could be the result of the higher frequency of atypical deglutition found in this group.[15] In contrast, Kecik et al[16] did not find significant differences in masticatory muscle activities between the right and left sides and crossbite and normocclusive groups. The differences could be attributed to a different sample selection and experimental design (Table 2).

Muscular Activity During Chewing and Clenching

Subjects with a posterior crossbite could have a masticatory pattern that is unique and different from normocclusive subjects.[15,16] The anterior temporalis muscles were the most active in crossbite subjects during chewing[15] and demonstrated significantly higher activity on the crossbite side than the noncrossbite side; a similar comparison was made between the crossbite and control subjects.[15,16] Conversely, the right masseter (ipsilateral to the crossbite) was less active in the crossbite group than in the normocclusive group.[16] These findings could indicate that the sequence of the neuromuscular system priorities during mastication is different in the crossbite subjects; the most important role is to position the mandible correctly in order to reach higher occlusal stability, and once this is attained, to generate the necessary power to chew.[15,16] This could be the reason why the anterior temporal is the most active muscle. On the other hand, the lower EMG activity of masseter muscles in the crossbite group than in the normocclusive group could be due to an inhibitory-protective reflex to avoid injury or pain in the structures of the stomatognathic system; thus, the capacity of the masseter muscles to generate contraction could be diminished.

Crossbite and TMD Signs and Symptoms

Four studies evaluated the TMD signs and symptoms associated with posterior crossbite in children.[14,16,18,25] Headache several times a week occurred more frequently in children with unilateral crossbite.[14] Moreover, headache at least once a week and tenderness of the anterior temporal and superficial masseter muscles were the most prevalent signs and symptoms of TMD.[25] Furthermore, tenderness of the anterior temporal and superficial masseter muscles occurred more frequently in the crossbite group than in the control group.[25]

In a multifactorial analysis of TMD signs and symptoms, Vanderas and Papagiannoulis[18] reported that posterior crossbite with lateral shift significantly affected the probability that children would develop deviation of the mandible on opening, which would have significant impact on TMJ tenderness. They also found a significant correlation between epinephrine levels and TMJ tenderness, suggesting that emotional stress should not be neglected even in the presence of malocclusion traits.

The surface vibrations of the bilateral TMJs have been studied with electrovibratography in children with and without posterior crossbite.[16] The TMJ vibration was significantly higher on the crossbite side compared with the noncrossbite side before treatment, and the differences between the crossbite and the control groups were also significant. After maxillary expansion, both sides had similar values, and there was no significant difference between the treatment and control groups. It is important to point out that some studies included in this review[15,22,23] established the absence of TMJ disorders as an inclusion criterion, and this could underestimate the TMJ problems found in children with posterior crossbite in this research.

CONCLUSIONS

- Altered muscle function associated with posterior crossbite can reduce the bite force in mixed dentition.
- According to EMG analysis, children with posterior crossbite have asymmetrical muscle function during chewing or clenching, that is, the anterior temporalis is more active and the masseter less active on the crossbite than on the noncrossbite side. The EMG data of muscular activity during rest and swallowing were not conclusive.
- Posterior crossbite may increase the probability of children developing signs and symptoms of TMD.

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