

Original Article

Early Orthodontic Treatment of Skeletal Open-bite Malocclusion: A Systematic Review

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Abstract: The aim of this study was a systematic review of the literature to assess the scientific evidence on the actual outcome of early treatments of open-bite malocclusions. A literature survey was done by applying the Medline database (Entrez PubMed). The survey covered the period from January 1966 to July 2004 and used the MeSH, Medical Subject Headings. The following study types that reported data on the treatment effects included: randomized clinical trials (RCT), prospective and retrospective studies with concurrent untreated as well as normal controls, and clinical trials comparing at least two treatment strategies without any untreated or normal control group involved. The search strategy resulted in 1049 articles. After selection according to the inclusionary/exclusionary criteria, seven articles qualified for the final review analysis. No RCTs of early treatment of anterior open bite have been performed. Two controlled clinical trials of early anterior open bite have been performed, and these two studies indicated the effectiveness of treatment in the mixed dentition with headgears or functional appliances (or both). Most of the studies had serious problems of lack of power because of small sample size, bias and confounding variables, lack of method error analysis, blinding in measurements, and deficient or lack of statistical methods. Thus, the quality level of the studies was not sufficient enough to draw any evidence-based conclusions. (*Angle Orthod* 2005;75:707–713.)

Key Words: Early treatment; Open bite; Systematic review; Quality analysis

INTRODUCTION

Open bite must be considered as a deviation in the vertical relationship of the maxillary and mandibular dental arches, characterized by a lack of contact be-

tween opposing segments of teeth.¹ In a study by Kelly et al,² the prevalence of open bite in US children was reported as 3.5% in the white population and 16.5% in the black population. Proffit et al³ recorded a prevalence of approximately 3.5% in patients from eight to 17 years of age.

Open bite develops because of interaction of many etiologic factors, both hereditary and environmental in nature. Environmental factors include variations in dental eruption and alveolar growth;^{4–8} disproportionate neuromuscular growth or aberrant neuromuscular function related to malfunctions of the tongue^{9–16} or oral habits or both.^{17–19}

Pure dental open bite has to be distinguished from open bites that involve the morphology and position of the maxilla or the mandible (or both).^{4,5,7} Dental open bites are either self-correcting or respond readily to myofunctional treatment and mechanotherapy.^{5,20,21} Open bites associated with craniofacial malformations are much more difficult to treat and tend to relapse.^{21,22}

Early treatment of vertical dysplasia during the primary or the mixed dentition period has been advocated to reduce the need of treatment in the permanent

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dentition,^{23–26} when surgery becomes a viable option. A series of treatment approaches can be found in the literature regarding early treatment of open bite. These treatment modalities include mainly functional appliances, multibracket techniques, headgears, and bite blocks.

The goal of this review is to analyze the scientific evidence on the actual outcomes of early treatment of open-bite malocclusions as derived from the existing literature on peer-reviewed orthodontic journals according to Cochrane Collaboration's principles.²⁷ This systematic review was undertaken to answer the following important questions: (1) Is early treatment of skeletal open-bite malocclusion effective? (2) Which treatment modality is the most effective? (3) Is the treatment result stable?

MATERIALS AND METHODS

Search strategy

The strategy for performing this systematic review was influenced mainly by the National Health Service (NHS) Center for Reviews and Dissemination.²⁸ To identify all the studies that examined the relationship between early orthodontic treatment and skeletal open bite, a literature survey was done by applying the Medline database (Entrez PubMed, www.ncbi.nlm.nih.gov). The survey covered the period from January 1966 to July 2004 and used the Medical Subject Headings (MeSH) terms: "early treatment" and "dentition, mixed," which were crossed with combinations of the MeSH term "open bite". In addition, a search in the Cochrane Controlled Clinical Trials Register was performed.

Selection criteria

Early treatment of open bite was defined as treatment in the mixed dentition. The following study types that reported data on the treatment effects were included: randomized clinical trials (RCT), prospective and retrospective studies with concurrent untreated as well as normal controls, and clinical trials comparing at least two treatment strategies without any untreated or normal control group involved. No restrictions were set for sample size. The main reasons for exclusion were the technical and clinical presentation of appliances, trials not comparing at least two treatment strategies (case series), descriptive studies, case reports, studies concerning treatment in the permanent dentition/adult patients, surgically assisted treatment, treatment combined with extractions, or full-fixed appliances and discussion or debate articles.

TABLE 1. The Articles Included in the Review

Articles	Study design ^a
R. Fränkel and C. Fränkel ³²	R, L, CCT, UC
Kiliaridis et al ³³	P, CT
Isçan et al ³⁴	R, L, CT
Arat and Iseri ³⁵	R, L, CT
Kuster and Ingervall ³⁶	R, L, CT
Weinbach and Smith ³⁷	R, L, CT
Ngan et al ³⁸	R, CCT, UC

^a P indicates prospective study; R, retrospective study; L, longitudinal study; CCT, controlled clinical trial; CT, clinical trial, ie, comparison of at least two treatment modalities without any untreated or normal group involved; and UC, untreated control group.

Data collection and analysis

According to the recommendations by Petrén et al²⁹ data were collected on the following items: year of publication, study design, materials, dropouts, measurements, treatment time, success rate, decrease of open bite and divergency, side effects, costs, and author's conclusions. In addition, to document the methodological soundness of each article, a quality evaluation modified by the methods described by Antczak et al³⁰ and Jadad et al³¹ was performed with respect to preestablished characteristics. The following characteristics were used: study design, sample size and previous estimate of sample size, selection description, withdrawals (dropouts), valid methods, method error analysis, blinding in measurements, and adequate statistics. The quality was categorized as low, medium, and high. Two independent reviewers assessed the articles separately (Dr Mucedero, Dr Franchi). The data were extracted from each article without blinding to the authors, and interexaminer conflicts were resolved by discussion on each article to reach a consensus. One author (Dr Baccetti) performed the quality evaluation of the statistical methods used in the articles.

RESULTS

The search strategy resulted in 1049 articles. After selection according to the inclusionary/exclusionary criteria, seven articles^{32–38} qualified for the final review analysis.

Study design and treatment modalities

The study design of the seven articles is shown in Table 1, and the results of the review are summarized in Tables 2 and 3. No RCTs had been performed. The effects produced by functional appliances were examined in two studies.^{32,37} Three studies described the effects of functional appliances in association with high pull headgear^{37,38} or with high pull headgear and vertical chin cup (VCC).³⁵ The results of posterior bite

TABLE 2. Summarized Data of the Seven Studies Included in the Review^a

Article Material	Methods/ Measurements	Treatment Duration/ Retention Duration	Success Rate	Reduction of Open Bite and Divergency	Side Effects/ Stability	Authors' Conclusion
Fränkel and Fränkel ³²						
30 (FR)	Cephalometric analysis	No treatment and retention durations information	Not declared	Yes open bite	Relapse rate not declared	Correct function to correct form
11 (uCG)	Pre- and post treatment	8-y follow-up		Yes divergency		
Kiliaridis et al ³³						
10 (MBB)	Cephalometric analysis	6 mo	100%	Yes open bite	Lateral crossbite (MBB)	MBB faster and more effective
10 (PBB)	Study casts photos	No retention		Yes divergency	Effect declined with time (PBB) No stability information	
Isçan et al ³⁴						
11 (SLBB)	Cephalometric analysis	SLBB 6 mo	100%	Yes open bite	No stability information	Both therapies are effective
12 (PBB-VCC)		PBB 8 mo No retention		Yes divergency		
Arat and Iseri ³⁵						
11 (BT)	Cephalometric analysis	BT 2.3 y	Not declared	Yes open bite	Increase divergency (BT, ET)	Skeletal response to early treatment
2 (ET) + 8 (ET-hpHG)		ET 2.2 y		Yes divergency (A)	No stability information	
8 (A-hpH-VCC) + 3 (A-hpH)		A 1y No retention		No divergency (BT, ET)		
Kuster and Ingervall ³⁶						
22 (SLBB)	Cephalometric analysis	SLBB 1y	Not declared	Yes open bite	No side effects	Retention is necessary (MBB)
11 (MBB)	Electromyography	MBB 3 mo		Yes divergency	Tendency to relapse (MBB) No stability information (SLBB)	
	Bite-force	4 MBB patients 1y retention 9 MBB patients 1-y follow-up				
Weinbach and Smith ³⁷						
26 (B)	Cephalometric analysis	1y 8 mo	67%	Yes open bite	No stability information	hpH not useful
13 (B-hpH)	Pre- and post treatment	No retention		Yes divergency		B useful for open bite—Class II
	Cephalometric standards					
Ngan et al ³⁸						
8 (A-hpH)	Cephalometric analysis	1y 2 mo	100%	Yes open bite	No stability information	Therapy effective for open bite—Class II
8 (uCG)	Study casts	No retention		Yes divergency		

^a A indicates activator; B, Bionator; BT, Begg therapy; magnetic splint; ET, edgewise therapy; FR, Fränkel; hpH, high-pull headgear; MBB, magnetic bite blocks; PBB, posterior bite blocks; SLBB, spring-loaded bite blocks; uCG, untreated control group; and VCC, vertical chin cup.

block (PBB) alone³³ or in combination with VCC (PBB/VCC),³⁴ spring-loaded bite block (SLBB),^{34,35} and magnetic bite block (MBB)^{33,35} were compared in three studies.

Success rate

A 100% success rate was reported in three studies^{33,34,38} and 67% rate in one study.³⁷ The success rate was not declared in three studies^{32,35,36} (Table 2).

TABLE 3. Quality Evaluation of the Selected Studies

Article	Sample Size	Previous Estimate of Sample Size	Selection Description	Withdrawals	Valid Method	Method Error Analysis	Blinding in Measurements	Adequate Statistics Provided	Judge Quality Standard
Fränkel and Fränkel ³²		No/not known	Adequate	None	Yes	No	No	Yes	Medium
Kiliaridis et al ³³		No/not known	Adequate	Four	Partly	Yes	Yes	Absent	Low
Isçan et al ³⁴		No/not known	Adequate	One	Yes	Yes	No	Inadequate ^a	Low
Arat and Iseri ³⁵		No/not known	Adequate	Not known	No	Yes	No	Inadequate ^a	Low
Kuster and Ingervall ³⁶		No/not known	Adequate	Not known	Yes	Yes	No	Yes	Medium
Weinbach and Smith ³⁷		No/not known	Adequate	Not known	Partly	No	No	Inadequate ^{a,b}	Low
Ngan et al ³⁸		No/not known	Adequate	Not known	Yes	Yes	No	Inadequate level of significance ($P < .1$)	Low

^a Use of parametric tests in insufficient sample size.

^b Comparison with cephalometric standards.

Treatment duration and open-bite reduction

The treatment duration varied significantly among the treatment modalities (Table 2). The treatment duration for bite-block therapy varied between three months and one year^{33,34,36} and for functional appliances between one year and one year eight months.^{35,37,38}

Treatment in skeletal open-bite patients with an activator in combination with a high pull headgear or a high pull headgear and VCC produced an average 5.2 mm increase in overbite.³⁵ The use of high pull headgear during Bionator therapy had no significant effect on dentoskeletal changes during treatment.³⁷ Mean open-bite reduction was 2.0 mm for the headgear/Bionator group and 1.0 mm for the Bionator group. In patients with Class II skeletal open-bite malocclusion, the combination of an activator with a high pull headgear induced a reduction in the amount of forward and downward movement of the maxilla and maxillary molars and an increase in mandibular alveolar height, leading to a correction in open bite and molar relationships.³⁸

Open-bite correction with the MBB ranged from 2.0 mm, Kuster and Ingervall,³⁶ to 2.4 mm, Kiliaridis et al,³³ on an average. For the PBB,³³ the mean change in overbite was 2.2 mm when used alone,³³ whereas it was 4.6 mm when used in PBB/VCC.³⁴ The SLBB group showed an average open-bite correction ranging from 1.3 mm, Kuster and Ingervall,³⁶ to 3.6 mm, Isçan et al.³⁴ These bite-block appliances caused an intrusion of the posterior teeth, generated by the masticatory muscles, and an anterior rotation of the mandible that produced bite closure. The functional appliances depressed the vertical growth of the posterior upper and lower dentoalveolar heights, and the mandible rotated in a forward and upward direction. Adequate follow-up time was analyzed in only one study.³²

Comparison of open-bite reduction between the treatment strategies

The effect between bite-block appliances in open-bite reduction was compared in three studies^{33,34,36} (Table 2). Kuster and Ingervall³⁶ reported a greater effect with MBB when compared with SLBB, whereas Isçan et al³⁴ reported greater open-bite reduction in subjects treated with a PBB/VCC when compared with subjects treated with SLBB. One study reported equivalent effect between MBB and PBB.³³ Three studies reported that functional therapy with Fränkel,³² Bionator³⁷ or activator^{35,38} was successful during the mixed dentition.

Side effects and costs

One study³³ reported that unilateral crossbite occurred in four out of 10 patients treated with MBB in the mixed dentition and who wore the appliance for virtually 24 hours a day (Table 2). The disadvantage of the PBB is that its treatment effects declined with time, possibly because of a decrease in the force applied to the antagonist teeth by the elevator muscles of the mandible.³³ No side effects were reported for functional therapy.

In five studies, there were no information regarding treatment stability.^{33–35,37,38} One study³² reported that when open bite was associated with an hyperdivergent skeletal pattern, relapse occurred in all treated cases unless a competent anterior oral seal had been achieved. Another study³⁶ reported a tendency to relapse in patients treated with MBB after a one-year follow-up. No studies performed a cost analysis.

Quality analysis

Research quality or methodological soundness was low in five studies^{33–35,37,38} and medium in two^{32,36} (Table 3). The most recurrent shortcomings were small

sample sizes implying low power, problems of bias and confounding variables, lack of method error analysis, blinding in measurements, and deficiency or lack of statistical methods. Furthermore, no study declared any power analysis or discussed the possibility of a type-II error occurring.

Only one study³² was judged to have an adequate sample size, whereas the other studies had partly sufficient or insufficient sample sizes, implying low power with high risk to achieve insignificant outcomes. The selection description was adequate or fair in all studies. Withdrawals (dropouts) were declared in three³²⁻³⁴ of the seven studies, and in these studies, the number of dropouts was generally low. No study declared the presence of ethical approval.

The methods used to detect the treatment effects were valid in five studies.^{32-34,36,38} In one study,³⁵ the method used was not valid because the skeletal open-bite group treated in the mixed dentition (11.2 years) with an activator in combination with a high pull headgear or a high pull headgear and VCC was compared with two groups of subjects treated in the permanent dentition (16.1 years Begg group and 14.8 years edge-wise group) with extractions and fixed appliances. Two studies^{33,37} were considered as partly valid. In the first one,³³ the age range was too wide (9–16 years) with subjects treated in the permanent dentition, whereas in the other study,³⁷ the treatment effects in subjects treated with Bionator alone or in combination with high pull headgear were compared with cephalometric standards derived from Riolo et al.³⁹ Five studies^{33-36,38} included a method error analysis, and one study³³ used blinding in measurements. Only two studies^{32,36} used proper statistical methods. In the remaining studies, one study did not report any statistics,³³ whereas in the others the choice of test method was inadequate.

DISCUSSION

Effectiveness and long-term effects of early treatment of open bite

In this systematic review, the literature search was aimed to select all RCTs and controlled clinical trials (CCTs) and all prospective and retrospective observational studies with concurrent controls as well as observational studies comparing different treatment modalities for early treatment of anterior open bite. No RCT could be found. Seven studies were retrieved, and they showed some consistent results. Two CCTs^{32,38} evaluated the effects of functional appliances vs no treatment, and both studies came to the conclusion that it was beneficial to perform early functional therapy of dentoskeletal open bite.

The analysis of the results suggests that an early

treatment of dentoskeletal open bite (9–11 years of age) was able to intercept the malocclusion to reduce the need of treatment at an adolescent age. This was particularly true in the cases of open bite caused by an altered function, such as oral habits. Different studies^{32,34,35,38} suggested that the appliances were very effective and produced faster response in younger subjects. The control of the skeletal vertical dimension is considered the most important factor in successfully treated individuals.

The analysis of the seven studies suggested that the combination of treatment modalities was very effective, for instance, the use of a functional appliance associated with high pull headgear in younger subjects.³⁸ Repelling MBBs were highly effective in producing rapid and extensive control of the vertical dimension,^{33,36} although therapy was associated with some negative side effect on the transverse dimension.³⁶

Other results were controversial. A combined therapy with a high pull headgear and Bionator did not seem to be effective for the treatment of skeletal Class II and open bite when compared with Bionator alone,³⁷ as opposed to Ngan et al,³⁸ who recommended the use of high pull activator in subjects with the same malocclusion. The Fränkel appliance was able to induce clinically significant favorable changes in the vertical skeletal relationships.³²

Was the treatment result stable and long lasting? Unfortunately, there was no adequate literature available to answer this question. Only in one study³² were the subjects controlled for a sufficient period after the treatment, although the relapse rate was not reported. The authors³² reported that relapse tended to occur in those cases that had not been able to achieve a competent oral seal.

Quality of the studies

RCTs have been used rarely in orthodontics, and this systematic review shows that analysis of investigations on early treatment of open bite is no exception. The results show that only a few retrospective studies were available, probably because of the difficulty in gathering many patients with a certain occlusion deviation. Furthermore, several items required in quality reviews^{30,31} clearly were not applicable eg, patients blinded or observer blinded to treatment. Moreover, as in previous reviews on orthodontic problems,²⁹ one item of the classical scales^{30,31} (retrospective analysis) could not be used because its definition did not state clearly what was meant with the retrospective analysis. Therefore, it was decided not to use the suggested scoring system in this review. Instead, as proposed by

Petrén et al,²⁹ the quality of the articles was judged as low, medium, or high.

In most of the studies, there were serious shortcomings, such as small sample sizes, no previous estimate of sample size, or no discussion on the possibility of type-II error occurring. Problems of bias, lack of method error analysis, blinding in measurements, and deficient or lack of statistical methods were other examples of drawbacks in most of the studies. Withdrawals (dropouts) were well declared in only three of the seven studies.

A very serious limitation of most studies was the lack of an adequate untreated control group, which is a group of subjects with the same type and severity of malocclusion as the treated group and who were left untreated. The causes for that could be the practical difficulty in gathering many patients with open-bite malocclusions or an "ethical" reason.

The methods used to detect and analyze the treatment effects were not valid in one study³⁵ and partly valid in two studies.^{33,37} Five studies^{33–36,38} included a method error analysis, whereas only one study³³ declared the use of blinding in measurement or analysis. Many studies were defective according to statistical quality or did not use statistics at all. This might influence the outcome reliability of the studies.

CONCLUSIONS

After assessing the quality of the retrieved articles, it may be concluded that:

- No RCTs of early treatment of anterior open bite have been performed.
- Two CCTs of early anterior open bite have been performed, and these two studies indicate the effectiveness of treatment in the mixed dentition with headgears or functional appliances or both.
- Most of the studies have serious problems of lack of power because of small sample size, bias and confounding variables, lack of method error analysis, blinding in measurements, and deficient or lack of statistical methods. Thus, the quality level of the studies was not sufficient enough to draw any evidence-based conclusions.
- To obtain reliable scientific evidence, RCTs with sufficient sample size are needed to determine which treatment is the most effective for early correction of skeletal open bite. Future studies should also include assessment of long-term stability as well as analysis of cost and side effects of the interventions.

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