Cephalometric evaluation of mandibular changes following orthodontic treatment with preformed appliances on Class II patients: A Meta-analysis

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Abstract

Aim: The purpose of this study is to conduct a systematic review and meta-analysis of studies on treatment with preformed appliances in the mixed dentition period.

Methods: The effectiveness of treatment was evaluated on two mandibular cephalometric variables: SNB° and Co-Gn. The research made use of the following electronic databases: Medline, Scopus, Scirus, Lilacs, Cochrane Database, and Google Scholar, without any date restriction. A manual search of references was also performed. For statistical analysis, the fixed effects model was used. Heterogeneity has been assessed by the Q-test and I² indices.

Results: We identified 397 studies, and we included only 6 studies in the meta-analysis (4 about Occlus-o-guide and 2 about Trainer For Kids), covering 506 subjects in mixed dentition, having Class II, division 1, and deep-bite. All data have been annualized. Results show a significant increase of Co-Gn (1.17mm/year).

Conclusions: This meta-analysis shows statistically significant changes in total mandibular length (Co-Gn), compared to untreated subjects.

Introduction

Preformed orthodontic appliances are born relatively recently, as an alternative to functional appliances and as interceptive orthodontics. They are mainly used for the correction of minor misalignments and dental crowding in Class I or II patients, or in case of increased overjet and/or overbite.

Many preformed appliances share some aspects with functional appliances, from which they derive. They are, in fact, considered as functional orthopedic devices and myofunctional regulators: they guide the proper dental and craniofacial growth, restores the physiological growth direction, free from any interference or influence.
5. patients in mixed dentition, with Class I or Class II (Division 1) and/or anterior crowding, and/or deep bite, and compared with untreated subjects having same age and malocclusion.
6. studies based on cephalometric measurements (values before and after the treatment/observation period, or the difference between these two values), both in the experimental and in the control group;
7. studies reporting the standard deviations, both in the experimental and in the control group;
8. studies in English, Italian and Portuguese.

**Exclusion criteria:**

1. studies not concerning the preformed appliances;
2. non-experimental studies (case reports, descriptive studies, etc.);
3. studies about Nite-guide appliance;
4. insufficient number of patients (less than 13), or studies without a control group;
5. experimental studies not related (for example evaluating the muscular effects of the treatment, by electromyography);
6. association or pretreatment with other devices (expander, fixed appliance, etc.);
7. studies evaluating the effects of preformed devices through clinical measurements or models, not supported by cephalometric data;
8. studies showing incomplete cephalometric data;
9. studies not reporting the standard deviations;
10. studies in language other than English, Italian and Portuguese.

To provide a quantitative assessment of mandibular changes induced by treatment, compared to untreated subjects, we extracted all the data related to the two cephalometric variables considered in this meta-analysis. For each variable, we collected the mean values measured at the beginning and at the end of the treatment/observation period (or the difference between these two values), in order to calculate the change that occurred during this period, for both the experimental and the control group. Then, we proceeded to annualize all the data, to statistically compare the cephalometric changes occurred in studies having different treatment/observation periods. For each of the six studies included in the meta-analysis, we calculated the average annualized changes in the two cephalometric variables, obtained from the difference between the values of the treated and those of the control group.

For the statistical analysis (1) (2), the fixed effects model was used. For each cephalometric variable we also calculated the heterogeneity indices, with the Q-test (considering significant a value of \( p<0.01 \)), and also with the I\(^2\) index (considering as substantial a value of I\(^2\) >50).

The search was performed using the following electronic databases: Medline, Scopus, Scirus, Lilacs, Cochrane Database of Systematic Reviews, and Google Scholar.

The keywords used were: "Eruption Guidance Appliance", "Occlus-o-guide", "Preformed appliance", "Trainer For Kids", "Preorthodontic trainer", "Myofunctional trainer." We selected the studies without limitations on date of publication, but we included only studies in English, Portuguese and Italian languages. The details of the electronic search are shown in Table I.

A manual search of all references was also performed, to identify any items not found in electronic databases. Articles not available online, have been searched at the Interdepartmental Library of Sense Organs and Dental Sciences of University of Rome "La Sapienza", and at the National Central Library of Rome. The items not included in these archives, have been requested at other Italian libraries through the Interlibrary Loan Service of University of Rome "La Sapienza".

The research initially focused on all the studies about treatment with preformed appliances. Items not related to this topic or inadequate were initially excluded on the basis of the title or abstract, and, when this was unsatisfactory, by reading the full text. Then, the review was focused only on the two most known and studied devices: Occlus-o-guide (G series) and Trainer For Kids (T4K) (Fig.1 and 2).

All these studies have been read in full-text.

**Results**

Initially, we identified a total of 397 studies. Then, not relevant studies were excluded based on the title or abstract, and, when these were not clear, after viewing the full-text. Of the remaining 193 potentially appropriate articles, 105 were duplicates, and consequently we identified in total 88 articles useful to the search. They have been read in full-text version. At this point, we excluded other 42 articles, because purely descriptive, case reports, or about Nite-guide appliance.

The selection process has finally led to the identification of 6 experimental studies (4 about Occlus-o-guide, and 2 about Trainer For Kids), which included all the eligibility criteria. The selection process is summarized in the Flow Chart (Fig. 3).

The main data from the six studies included in the meta-analysis (3) (4) (5) (6) (7) (8) are reported in Table II.

The total number of subjects analyzed was 506: 275...
treated with preformed appliances, and 231 untreated (control group). They all were in mixed dentition, most of them having a Class II division 1 malocclusion, with increased Overjet and deep-bite. None of the studies included patients with Class II division 2.

The number of treated and untreated subjects ranged from 13 to 115, and from 13 to 104, respectively. None of the studies made reference to biological indicators to determine the development stage of the subjects analyzed, except Kesky-Nisula’s study, which specified that the treatment covered the pubertal growth peak (vertebral maturation at stage C3-C4).

The appliance application was homogeneous. Occlus-o-guide daily application provided the execution of active exercises of "biting"; instead, Trainer For Kids was always applied in a passive way by the patient.

The treatment/observation period ranged from a minimum of 10 to a maximum of 39 months.

### SNB\(^{\wedge}\) angle

We evaluated four studies (3) (4) (5) (8), reporting the changes in the cephalometric variable SNB\(^{\wedge}\), occurred during the observation/treatment period, both in the experimental and in the control group.

The results of the statistical analysis are shown in Table III.

The results (overall) of the meta-analysis (Table III and Fig. 4) showed a not completely significant increase in SNB\(^{\wedge}\) angle (0.54 °/year) in the treated group, compared with the control group (confidence interval 95% CI -0.14 to 1.21).

### Co-Gn (Condylion-Gnation)

We evaluated six studies (3) (4) (5) (6) (7) (8), reporting the changes in the cephalometric variable Co-Gn, occurred during the observation/treatment period, both in the experimental group and in the control group.

The results of the statistical analysis are shown in Table IV.

The results (overall) of the meta-analysis (Table IV and Fig. 5) showed a significant increase in Co-Gn (1.17 mm/year) in the treated group, compared with the control group (confidence interval 95% CI 0.53 to 1.81).

### Discussion

The aim of the present study is to quantify the mandibular skeletal effects of treatment with two types of preformed appliances (Occlus-o-guides and Trainer For Kids), on two cephalometric variables, compared to untreated subjects.

Many studies have shown that mandibular growth can be influenced by functional appliances in the mixed dentition (9) (10) (11) (12) (13) (14) (15) (16), but other studies have reported an increase in mandibular growth comparable to untreated patients (17) (18) (19) (20). These differences could be due to the different selection criteria of the patients, or to the different reference points used to assess the mandibular length.

The most interesting result of this meta-analysis is a significant increase on total mandibular length (Co-Gn: 1.17 mm/year), when the preformed device is applied during skeletal development, for a sufficient period, and when treatment coincides with the pubertal growth peak (21) (22) (8).

All the six studies considered for Co-Gn showed significant results: a rather important additional increase in total mandibular length (Co-Gn), with values between 0.75 and 1.71 mm per year. It’s also important to note that the larger value has been obtained in Oliveira’s study (6), using Trainer For Kids (see Table IV and Fig. 5). The results of this meta-analysis confirm that the effect on skeletal jaw obtained with these appliances is similar to other functional appliances, and that the best response is obtained at or near the pubertal growth peak (23) (24). However, it is obvious that you can get a clinically significant orthopedic effect, that contributes to the correction of a molar Class II, also in other age groups, provided children are growing.

A previous study (4) about Occlus-o-guide showed that it’s possible to obtain a similar value of additional mandibular lengthening (about 1.2 mm per year), provided that the average duration of therapy is at least 26 months (approximately two years), arguing that a treatment of 10 months is not sufficient to obtain a significant skeletal growth (3). However, there are also studies that deny the existence of significant mandibular skeletal changes after one year of therapy with Occlus-o-guide (3) (25) (26), so there is not a unanimous opinion in literature.

Regarding the Trainer For Kids, the two studies included in this meta-analysis (6) (5) showed a significant mandibular elongation, with its forward rotation. According to previous studies, Trainer For Kids is able to stimulate the mandibular anteroposterior and transverse growth through the correction of dysfunctional habits: mouth breathing, finger sucking or lip, atypical swallowing, muscle hyperactivity mental (5) (27). These studies have
focused primarily on the dentoalveolar changes, after a treatment of about 1 year. A recent study (28), however, state that there aren’t significant differences between treated and untreated subjects for the parameter Co-Gn.

The additional mandibular lengthening contributes in part to the correction of Class II malocclusion, that is expected from the preformed devices studied. In subjects with untreated Class II, however, the mandibular growth, which could bring the lower teeth forward, seems to be lost by the “block effect”, given by intercuspidation and the resulting adaptive movements of the dentoalveolar complex (29).

It is conceivable that this mandibular elongation is associated also with its active protrusion, without alteration of mandibular morphology, as shown in previous studies (4) (30), which would contribute to the correction of most Class II malocclusions (due to mandibular retraction).

Many authors (13) (31) also agree to say that the degree of mental prominence and, therefore, the degree of correction of mandibular retraction, is inversely proportional to the vertical growth of the lower anterior face. According to these authors, in fact, the mandibular growth, induced by the treatment, occurs in a horizontal vector, leading to an improvement in the facial profile and to a resolution of the intermaxillary discrepancy. So, there isn’t a rotation of the mandible, that would increase the anterior facial height, tending to disguise the Class II correction.

It is also necessary to emphasize that the cephalometric parameter used in this meta-analysis for evaluating mandibular elongation is Co-Gn, and not Ar-Gn, widely used in literature, but much criticized (32). In fact, the latter is not determined by two anatomical landmarks, but from one anatomical (Gn), and one (Ar) that depends on the patient’s position during the teleradiography. This is, therefore, susceptible of possible errors and artifacts. The parameter Co-Gn, considered in this study, however, is determined by two anatomical and clearly identifiable points, that don’t depend by the patient’s posture.

This meta-analysis, however, does not show a significant improvement in SNB° value (increase of 0.54 °/year), despite the good clinical correction. This could be due to the inadequacy of the S-N plane as a cephalometric reference plane, due to its considerable variability during child’s development.

All the 4 studies included in the meta-analysis for SNB° showed an increase in this parameter, though slight (see Table III and Fig. 4). These results are in agreement with many previous studies, which showed an increase of SNB° after treatment with Occlus-o-guide (33) (34) (22), and Trainer For Kids (27) (35).

The normal growth of the mandible contributes to the correction of Class II, and we know that when the lower anterior facial height decreases, SNB° angle is reduced. Every time the active mandibular elongation is accompanied by an increase in anterior lower facial height, this is not represented by SNB°. For this reason, it’s more appropriate to assess the mandibular growth using Co-Gn, rather than SNB° (3).

This meta-analysis have also some limitations: all the studies included have not a skeletal accurate diagnosis, and any reference to biological indicators, which are essential to determine the patients’ developmental stage, with the exception of the Palone’s study (8). In fact, growth does not occur at a constant speed, especially in children: subjects with the same chronological age may not have an equivalent skeletal maturity or the same growth potential. Therefore, when the studies don’t refer to the biological age, it can be difficult to determine the amount of growth or skeletal modification induced by the treatment.

Furthermore, the treatment/observation period in the six studies considered were different (Table II), so it was necessary to annualize all the data. However, if the skeletal changes do not occur uniformly during the entire treatment or observation period, this could alter the analysis of the results (36).

Conclusions

The preformed orthodontic appliances Occlus-o-guides and Trainer For Kids represent a valid therapeutic device for the resolution of Class II, Division 1 malocclusions, during the mixed dentition stage. However, the effectiveness of these devices depends on some variables, such as the patient’s compliance and the treatment period, which should last about two years and cover the subject’s growth peak.

The results of this meta-analysis, about mandibular changes induced by orthodontic preformed appliances treatment on Class II patients, show:

- a not completely significant increase in SNB° (0.54 °/year);
- a significant skeletal effect on the mandible, in particular a considerable additional elongation of Co-Gn (1.17 mm/year).
Further investigations are needed to verify the long-term stability of the results obtained, and to determine any differences between the effects of the two appliances studied.

References


Illustrations

Illustration 1

Table I: search results from various electronic databases (EGA: Eruption Guidance Appliance)

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<th>Database</th>
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T4K

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</table>

Illustration 2

Fig.1: Occlus-o-guide appliance (G series)
Illustration 3

Fig. 2: Trainer For Kids appliance

Illustration 4

Fig. 3: Flow chart illustrating the selection process of the studies in this meta-analysis
Illustration 5

Table II: main data from the six studies included in the meta-analysis. Studies about occlus-o-guides are in green, those about Trainer For Kids in blue (NS = not specified).

Illustration 6

Table III: Analysis of mean change in the cephalometric variable SNB^ (in degrees)
Illustration 7

Fig. 4: Forest plot representing the results of the meta-analysis for the variable SNB^®

Illustration 8

Table IV: Analysis of mean change in the cephalometric variable Co-Gn (in mm)

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<th>Comb. C</th>
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<th>SE</th>
<th>VAR</th>
<th>W</th>
<th>VP</th>
<th>VPbias^®</th>
<th>VP</th>
<th>CI lower</th>
<th>CI upper</th>
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Results of the test for cumulative

\[ Q = 9.007 \text{ (p=0.0001)} \]

G-test: p = 0.0001

\[ Q = 0.967 \] (p-test > 0.50)
Illustration 9

Fig. 5: Forest plot representing the results of the meta-analysis for the variable Co-Gn