Early vs late orthodontic treatment of deepbite: A prospective clinical trial in growing subjects

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Introduction: The aim of this prospective clinical trial was to compare the outcomes of prepubertal vs pubertal treatment of deepbite patients with a protocol including biteplane and fixed appliances. **Methods:** A sample of 58 subjects with deepbite completed the study. A total of 34 subjects received treatment with removable biteplane appliances in the mixed dentition at a prepubertal stage of skeletal maturation (early treatment group), and 24 subjects were treated at a pubertal stage of skeletal maturation in the permanent dentition (late treatment group). All subjects of both groups were reevaluated after an average period of 15 months after the completion of fixed appliance therapy. Treatment outcomes were assessed statistically after a phase with removable biteplane appliances and at the posttreatment observation. **Results:** Treatment duration was significantly shorter in the early treatment group than in the late treatment group. Overbite reduction was significantly greater in the late treatment group (−3.1 mm) than in the early treatment group (−1.4 mm). In the late treatment group, 92% of the patients had a corrected overbite 1 year after therapy. **Conclusions:** Treatment of deepbite at puberty in the permanent dentition leads to significantly more favorable outcomes than treatment before puberty in the mixed dentition. (Am J Orthod Dentofacial Orthop 2012;142:75-82)

Clinical trials reporting the results of orthopedic or orthodontic treatment specifically aimed at deepbite correction are scarce in the literature, and they usually lack comparisons between different treatment approaches or modalities.[1-4] The general outcome of these investigations is that active treatment can induce a moderate improvement of the overbite followed usually by a relapse tendency.

No definitive information can be derived when evaluating the possible effects of treatment timing on deepbite treatment results. Tulloch et al[5] found no significant impact on overbite change of phase 1 therapy followed by phase 2 treatment vs a single-phase orthodontic approach. However, they did not investigate deepbite treatment specifically. The long-term stability of deepbite treatment results was good for the sample studied more recently by Schütz-Fransson et al[3]; their subjects had started treatment in the early permanent dentition at a mean age of 12.2 years. Simons and Joondeph[1] found that "deep bite patients of either sex in whom overbite reduction was accomplished during their respective pubertal growth spurt periods maintained this correction 10 years post-retention. Thus, it would be advisable for the clinician to be aware of individual differences in the onset of maximum growth velocity and to utilize this information in treatment planning." A specifically designed clinical trial targeting patients with deepbite malocclusions treated at different developmental stages appeared to be required to compare possible outcomes of early vs late treatment of growing deepbite patients.

A classic treatment protocol for the correction of deepbite in growing subjects, especially in those who also have a Class II malocclusion, consists of the use of biteplane appliances, with or without the addition of headgear, followed by fixed appliance therapy to refine the occlusion and maintain the occlusal modifications.[6-9] Therapy with anterior biteplanes is intended to limit the extrusion of the incisors and increase the length of the mandibular ramus relative to the eruption rate of the posterior teeth.[6,8] In general, treatment of a deepbite in growing subjects appears to

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be indicated when they have an "impinging overbite," a situation with overeruption of both the maxillary and mandibular anterior teeth and an accentuated curve of Spee. In this type of deepbite, the mandibular incisors often contact the palatal tissue behind the maxillary anterior teeth, occasionally resulting in a long-term periodontal breakdown.[10] Deepbite, in particular when associated with retroclined maxillary incisors, can also be a risk factor for temporomandibular disorders.[11]

The aim of this prospective clinical trial was to assess the outcomes of early vs late treatment of deepbite patients by means of anterior biteplane appliances followed by fixed appliance therapy. The early treatment approach to deepbite in the mixed dentition at a prepubertal stage of skeletal maturation was compared with a late treatment approach to the malocclusion in the permanent dentition at a pubertal stage of skeletal maturation.

MATERIAL AND METHODS

A total of 58 patients were enrolled for this trial at the Department of Orthodontics of Università degli Studi di Firenze in Florence, Italy. At the initial observation, the subjects had to have a deepbite (overbite, >4.5 mm), fully erupted maxillary and mandibular incisors, no multiple tooth agenesis or agenesis affecting the permanent incisors, and no craniofacial syndromes.[3,4,12-14] The numbers for the sample derived from a previous estimate of sample size based on a power analysis. To achieve a power of the study exceeding 0.9, calculated for an effect size[15] equal to 1.15 at an α level of 0.05, each group of patients under investigation had to include 24 subjects or more.

The early treatment group comprised 34 subjects, and the late treatment group included 24 subjects. The early treatment subjects started treatment in the mixed dentition at a prepubertal stage of individual skeletal maturation (CS 1 or CS 2), and the late treatment patients started orthodontic therapy in the permanent dentition at a pubertal growth stage (CS 3 or CS 4).[16] Table I reports the distribution of the 2 groups for sex, stages of skeletal maturation, and dentoskeletal discrepancies.

In both groups, treatment of deepbite was accomplished with a nonextraction protocol that consisted of removable appliances in the form of anterior biteplane appliances followed by fixed appliance therapy to refine the occlusion.[8,9] The early treatment patients underwent a first phase of treatment with either a removable maxillary plate with an anterior biteplane (26 subjects), or cervical headgear associated with an anterior biteplane (8 subjects). When the patients were showing permanent dentition, the second phase of therapy was accomplished with fixed appliances (0.022-in slot, preadjusted brackets). The duration of active phase 1 treatment was 18 months on average with a retention period before fixed appliances from 10 to 18 months during which the patients wore a removable maxillary plate with an anterior biteplane at night. The duration of active phase 2 treatment with fixed appliances was 18 months on average followed by a posttreatment retention period of 14 months on average. As a retention protocol, all subjects wore maxillary and mandibular Hawley retainers.

In the late treatment patients, orthodontic therapy started with a removable maxillary plate with an anterior biteplane (17 subjects) or with headgear associated with an anterior biteplane (7 subjects), and it was immediately followed by fixed appliances (0.022-in slot, preadjusted brackets). The duration of comprehensive treatment in the late treatment group was on average 31 months, with an initial phase of deepbite treatment of 15 months and a fixed appliance phase of 16 months. An average posttreatment retention period of 15 months followed active therapy in the late treatment group, during which the patients wore Hawley retainers in both arches.

Both treatment groups received a standardized protocol of fixed appliance therapy with the main purposes to level and align the dental arches and refine the occlusion. Treatment was ended when a satisfactory correction of the malocclusion had been reached.

Lateral cephalograms were taken of all patients before treatment (T1), before fixed appliance therapy (T2), and at least 1 year after active therapy with fixed appliances (T3). Most patients were at the end of active circumpubertal growth (CS 6) at T3 (Table I).[16]

Cephalograms were traced by 1 investigator (L.F.) and then verified for landmark location, anatomic contours, and tracing superimpositions by a second (T.B.). Any disagreements were resolved by retracing the landmark or structure to the satisfaction of both observers. A customized digitization regimen and analysis (Viewbox 3.1; dHAL Software, Kifissia, Greece) were used for all cephalograms that were examined in this study.

The magnification of the lateral cephalograms was consistent at 8%. The examiners who analyzed the lateral cephalograms of all patients at T1, T2, and T3 were blinded to the origin of the films and the group to which each subject belonged.

A total of 40 lateral cephalograms randomly chosen from all observations were retraced in random order and redigitized to calculate the method error by means of Dahlberg's formula.[17] The operator (L.F.) who retraced and redigitized the cephalograms was blinded to time period and group. The error for linear measurements ranged from 0.25 mm (overjet) to 0.75 mm (pogonion to nasion perpendicular), and the error for angular

Table I. Demographics of the early and late treatment groups

	Age at T1 (y)		*Age at T2 (y)*		*Age at T3 (y)*		*T1-T2 interval (y)*		*T2-T3 interval (y)*		*T1-T3 interval (y)*	
	Mean	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*	*Mean*	*SD*
Early treatment group (n = 34; 17 girls, 17 boys) Class II Division 1, 14 subjects Class II Division 2, 7 subjects Class I, 13 subjects CS at T1: CS 1, 28 subjects CS 2, 6 subjects CS at T2: CS 3, 23 subjects CS 4, 11 subjects CS at T3: CS 5, 8 subjects CS 6, 26 subjects	10.7	1.6	13.1	1.3	15.4	1.8	2.9	1.3	2.5	1.5	5.6	2.0
Late treatment group (n = 24; 14 girls, 10 boys) Class II Division 1, 8 subjects Class II Division 2, 5 subjects Class I, 11 subjects CS at T1: CS 3, 18 subjects CS 4, 6 subjects CS at T2: CS 4, 10 subjects CS 5, 14 subjects CS at T3: CS 5, 3 subjects CS 6, 21 subjects	12.3	0.9	13.8	0.8	15.7	0.9	1.4	0.9	2.7	0.9	4.3	1.6

CS, Cervical vertebral maturation stage.

measurements varied from 0.55° (Ar-Goi-Me) to 1.40° (interincisal angle).

Statistical analysis

Descriptive statistics of craniofacial measurements in both treated samples at T1, as well as the T1 to T2, T2 to T3, and T1 to T3 changes were calculated. The Kolmogorov-Smirnov test showed normality of distribution for the measurements used in the study. Therefore, parametric statistics (analysis of variance [ANOVA] with Tukey post-hoc tests, $P < 0.05$) were used. The following comparisons were carried out for the dentoskeletal variables: (1) early vs late treatment groups at T1 (comparisons of starting forms); (2) T1 to T2 changes in the groups (effects of deepbite treatment protocols with anterior biteplane appliances); (3) T2 to T3 changes in the groups (effects of treatment with fixed appliances); and (4) T1 to T3 changes in the groups (effects of overall comprehensive treatment including a 1-year posttreatment observation period).

The duration of treatment expressed in months was compared between the groups by means of the Student *t* test for independent samples.

The prevalence rates of subjects showing correction of deepbite at T3 in the early treatment group vs the late treatment group were calculated and compared with a chi-square test. Correction of deepbite was assessed when the overbite value was smaller than 4 mm at T2.[18]

All statistical computations, comparisons, and analyses were carried out with statistical software (version 17.0; SPSS, Chicago, Ill).

RESULTS

No differences were found for the starting forms of the 2 groups, with a few exceptions (Table II). The ANS-Me measurement was greater in the late treatment group, as a consequence of the greater age at T1 in this group, and the mandibular incisors were less retruded to the Point A-pogonion line in the late treatment group as well.

The effects of the first phase of treatment with anterior biteplane appliances (T1-T2 changes) are shown in Table III, with no significant differences between the 2 groups for the sagittal skeletal measures. The length of the mandibular ramus (Ar-Goi) showed increases that were greater in the early treatment group than in the late treatment group.

As for the occlusal changes, overbite showed a 1.2-mm greater reduction in the late treatment group than in the early treatment group (although this difference was not statistically significant). Both the maxillary and mandibular incisors showed significant amounts of extrusion in the early treatment group when compared

Table II. Descriptive statistics and statistical comparisons of the starting forms

	Early treatment group (n = 34)		*Late treatment group (n = 24)*			
Cephalometric measures	*Mean*	*SD*	*Mean*	*SD*	t	*Significance*
Skeletal sagittal						
Point A to nasion perp (mm)	0.3	2.9	1.0	5.0	−0.597	NS
Pg to nasion perp (mm)	−7.1	5.6	−6.4	6.3	−0.453	NS
Wits (mm)	0.8	3.0	−0.1	4.3	0.909	NS
Skeletal vertical						
FH to palatal plane (°)	−1.1	2.7	−2.3	4.0	1.354	NS
FH to mandibular plane (°)	23.2	5.6	23.7	5.0	−0.363	NS
Palatal plane to mandibular plane (°)	24.3	6.6	26.0	5.1	−1.059	NS
Ar to Goi (mm)	41.1	5.0	42.9	3.9	−1.523	NS
ANS to Me (mm)	61.2	4.4	65.0	3.8	−3.365	*
Ar-Goi-Me (°)	124.0	7.3	123.1	6.3	0.481	NS
S-Go/N-Me (%)	62.5	4.5	61.9	3.2	0.591	NS
Interdental						
Overjet (mm)	5.8	2.5	5.9	1.5	−0.308	NS
Overbite (mm)	6.1	1.3	5.9	1.2	0.639	NS
Interincisal angle (°)	138.3	10.2	134.7	7.6	1.452	NS
Molar relationship (mm)	−0.7	1.8	−0.1	2.2	−1.110	NS
Maxillary dentoalveolar						
U1 to Point A vertical (mm)	3.8	2.2	4.4	1.9	−1.775	NS
U1 to FH (°)	108.0	8.6	108.7	5.8	−0.317	NS
Mandibular dentoalveolar						
L1 to Point A-Pg (mm)	−1.8	2.0	−0.1	2.1	−3.161	*
L1 to mandibular plane (°)	90.5	7.2	92.9	5.7	−1.369	NS

NS, Not significant; *Perp*, perpendicular.
*$P < 0.01$.

with the late treatment group, whereas the mandibular molars erupted significantly more in the early treatment group than in the late treatment group.

No significant differences between the groups were assessed as a result of the phase of treatment with fixed appliances followed by retention (T2-T3 changes; Table IV).

The T1 to T3 changes (Table V) included differences between the groups during the overall observation period that replicated the treatment effects recorded during the phase of treatment with biteplane appliances (T1-T2). The only exceptions were the lack of a significant difference in the length of the mandibular ramus between the 2 groups, and the significant reduction in overbite in the late treatment group compared with the early treatment group (1.7-mm difference).

The duration of treatment in the early treatment group, thus including the retention period between the end of treatment with biteplane appliances and the beginning of fixed appliance therapy, was 41 months (SD, 11 months). The duration of treatment for the late treatment group was 30 months (SD, 8 months). The comparison was statistically significant ($t = 4.17$; $P < 0.001$).

The analysis of the correction of deepbite was performed approximately 1 year into retention after the end of comprehensive treatment of the malocclusion in both groups. The prevalence rates for a corrected overbite (overbite, <4 mm) were 64.7% in the early treatment group (22 of 34 patients) and 91.7% in the late treatment group (22 of 24 patients). This difference was highly significant ($P < 0.001$).

DISCUSSION

This clinical trial was designed to compare the effectiveness of therapy with biteplane appliances followed by fixed appliances in growing patients with deepbite malocclusions at 2 periods of dentoskeletal development. The subjects of the early treatment group received the treatment with biteplane appliances aimed to reduce the excessive overbite at a prepubertal period of growth in the mixed dentition. Thereafter, these subjects had a retention period with removable appliances worn at night before completion of therapy with fixed appliances to refine the occlusion. The late treatment group started therapy with the biteplane appliances later at a pubertal stage of skeletal maturation and in the permanent dentition. These subjects underwent the phase with fixed appliances immediately after the deepbite correction phase with the biteplane appliances. All patients in both groups were reevaluated at least 1 year after the end of treatment with fixed appliances, when most of them had completed the active phase of circumpubertal growth.

Table III. Descriptive statistics and statistical comparisons of the T1-T2 changes: effects of therapy with biteplane appliances

	Early treatment group (n = 34)		*Late treatment group (n = 24)*			
Cephalometric measures	*Mean*	*SD*	*Mean*	*SD*	*Net difference*	*Significance*
Skeletal sagittal						
Point A to nasion perp (mm)	0.3	2.7	0.5	2.0	−0.2	NS
Pg to nasion perp (mm)	2.9	3.9	1.8	3.7	1.1	NS
Wits (mm)	−1.4	3.9	0.6	3.9	−2.0	NS
Skeletal vertical						
FH to palatal plane (°)	0.8	2.7	−0.4	2.4	1.2	NS
FH to mandibular plane (°)	−0.8	2.4	−0.1	2.4	−0.7	NS
Palatal plane to mandibular plane (°)	−1.3	2.0	0.5	1.9	−1.6	NS
Ar to Goi (mm)	5.5	2.7	2.8	2.7	2.7	*
ANS to Me (mm)	4.9	3.1	3.3	2.2	1.6	NS
Ar-Goi-Me (°)	−1.0	2.9	−0.4	3.0	−0.6	NS
S-Go/N-Me (%)	1.1	1.8	0.4	1.6	0.6	NS
Interdental						
Overjet (mm)	−1.1	2.3	−1.1	1.5	0.0	NS
Overbite (mm)	−1.1	1.4	−2.3	1.6	1.2	NS
Interincisal angle (°)	−3.4	12.1	−2.6	9.2	−0.8	NS
Molar relationship (mm)	2.6	2.8	1.8	2.4	0.8	NS
Maxillary dentoalveolar						
U1 to Point A vertical (mm)	1.2	2.3	0.3	2.0	0.9	NS
U1 to FH (°)	2.6	8.9	2.0	7.2	0.6	NS
U1 vertical (mm)	1.1	1.8	−0.4	1.7	1.5	*
U6 vertical (mm)	2.7	1.6	1.1	1.3	1.6	*
Mandibular dentoalveolar						
L1 to Point A-Pg (mm)	1.7	2.1	0.7	2.1	1.0	NS
L1 to mandibular plane (°)	1.5	6.0	0.7	4.7	0.8	NS
L1 vertical (mm)	3.0	1.8	1.4	1.5	1.6	*
L6 vertical (mm)	4.1	2.5	2.5	1.4	1.6	NS

NS, Not significant; *Perp*, perpendicular.
*$P < 0.05$.

These findings indicate that treatment of deepbite in the permanent dentition at an advanced stage of pubertal skeletal maturity appears to be significantly more effective than at an earlier stage of development (ie, in the mixed dentition at a prepubertal stage of skeletal maturity). The amount of overbite correction recorded at least 1 year after the end of treatment in late treatment group was twice greater than in early treatment goup (3.1 vs 1.4 mm). In a previous similar investigation that analyzed 2-phase treatment of deepbite independently from the timing of intervention, the amount of overbite correction at the end of comprehensive therapy (2.8 mm) was more comparable with the late treatment group than the early treatment group of our study.[9] The reasons for this finding must be found in various aspects related to growth, with special regard to the following growth changes in deepbite subjects.

1. The use of functional or orthopedic appliances aimed to reduce overbite in growing patients in conjunction with a reduction of the overjet appears to be maximized when it is accomplished during periods of intense growth.[19,20] Simons and Joondeph[1] in 1973 had already stated that the effectiveness and stability of deepbite correction seemed to be greater in patients treated during the pubertal growth spurt.
2. Previous studies on the growth changes in untreated subjects with deepbite malocclusions have shown that a deepbite tends to worsen physiologically during the late mixed dentition, whereas it tends to improve once the permanent dentition has been established.[13,14] Therefore, the smaller amount of deepbite correction in the early treatment group must be related to the fact that these patients finished the active phase of deepbite correction with the biteplane appliances during the mixed dentition. The retention period before the fixed appliance, still occurring during the late mixed dentition, coincided with the period of physiologic increase of the overbite. The natural changes occurring in the overbite worked against

Table IV. Descriptive statistics and statistical comparisons of the T2-T3 changes: effects of fixed appliance therapy

	Early treatment group (n = 34)		*Late treatment group (n = 24)*			
Cephalometric measures	*Mean*	*SD*	*Mean*	*SD*	*Net difference*	*Significance*
Skeletal sagittal						
Point A to nasion perp (mm)	0.1	2.3	0.2	3.3	−0.1	NS
Pg to nasion perp (mm)	1.0	3.8	0.3	5.2	0.7	NS
Wits (mm)	2.9	4.9	0.9	4.4	2.0	NS
Skeletal vertical						
FH to palatal plane (°)	0.0	2.6	0.8	3.1	−0.8	NS
FH to mandibular plane (°)	−1.1	2.6	−0.7	2.5	−0.4	NS
Palatal plane to mandibular plane (°)	−1.1	2.4	−1.5	2.4	0.4	NS
Ar to Goi (mm)	3.6	3.5	3.2	4.6	0.4	NS
ANS to Me (mm)	3.1	2.5	2.9	3.5	0.2	NS
Ar-Goi-Me (°)	−2.2	3.3	−1.9	3.4	−0.3	NS
S-Go/N-Me (%)	1.2	2.2	0.7	2.3	0.5	NS
Interdental						
Overjet (mm)	−0.5	1.6	−0.9	1.6	0.4	NS
Overbite (mm)	−0.3	1.1	−0.9	1.3	0.6	NS
Interincisal angle (°)	−2.4	7.8	−2.1	8.6	−0.3	NS
Molar relationship (mm)	−0.8	2.2	−0.1	2.1	−0.7	NS
Maxillary dentoalveolar						
U1 to Point A vertical (mm)	0.2	1.8	−0.5	1.9	0.7	NS
U1 to FH (°)	1.3	5.4	0.7	5.1	0.6	NS
U1 vertical (mm)	0.6	1.3	0.2	1.8	0.4	NS
U6 vertical (mm)	2.3	1.5	2.1	1.5	0.2	NS
Mandibular dentoalveolar						
L1 to Point A-Pg (mm)	0.5	1.5	0.6	1.8	−0.1	NS
L1 to mandibular plane (°)	2.3	5.1	2.1	5.9	0.2	NS
L1 vertical (mm)	1.7	1.7	1.8	2.5	−0.1	NS
L6 vertical (mm)	1.8	2.1	2.2	2.5	−0.4	NS

NS, Not significant; *Perp*, perpendicular.

the outcomes of deepbite correction accomplished during the first phase of therapy. In fact, the amounts of relative extrusion of the maxillary and mandibular incisors in the early treatment group were greater than in the late treatment group, during both the first phase of treatment and the overall observation period.

The difference in treatment outcomes between the early and late treatment groups is amplified when the prevalence rates of patients showing a corrected overbite (<4 mm) are evaluated rather than analyzing the average effects of therapy in the 2 groups. The prevalence rate of patients with a corrected overbite at T3 in the early treatment group was 64.7%, which is similar to what would be expected from deepbite subjects who had no treatment (62%), as derived from a previous investigation.[14] The impact of therapy on the final amount of overbite was therefore quite minimal in the early treated group. On the contrary, the prevalence rate of patients in the late treatment group who had a corrected overbite at 1 year after therapy was high (91.7%) and definitely significantly greater than in the untreated subjects with deepbite malocclusions.

The phase with fixed appliances (T2-T3 interval) had the main purposes to level and align the dental arches with no overcorrection of the deepbite. No significant changes in the dentoskeletal parameters were found when the modifications in the early treatment group were compared with those of the late treatment group (Table IV). Therefore, a more aggressive therapeutic approach to deepbite with bite-opening biomechanics during the phase with fixed appliances should be recommended. To prevent relapse during the posttreatment period, the use of a Hawley retainer with an anterior bite plane can be also considered.

Our outcomes also confirm previous data by Tulloch et al,[5] who found no significant impact on overbite change of phase 1 therapy followed by phase 2 treatment vs the single-phase orthodontic approach. However, they did not focus their investigation on deepbite treatment specifically. Also, our results add significance to previous observations from longitudinal studies on deepbite treatment.[1,3,4] In these previous studies,

Table V. Descriptive statistics and statistical comparisons of the T1-T3 changes: effects of overall treatment followed by 1 year of retention

	Early treatment group (n = 34)		*Late treatment group (n = 24)*			
Cephalometric measures	*Mean*	*SD*	*Mean*	*SD*	*Net difference*	*Significance*
Skeletal sagittal						
Pt A to nasion perp (mm)	0.4	2.6	0.7	2.9	−0.3	NS
Pg to nasion perp (mm)	3.8	3.6	2.2	4.9	1.6	NS
Wits (mm)	1.4	3.7	1.5	4.4	−0.1	NS
Skeletal vertical						
FH to palatal plane (°)	0.6	2.8	0.2	2.7	0.4	NS
FH to mandibular plane (°)	−1.8	3.1	−0.6	2.7	−1.2	NS
Palatal plane to mandibular plane (°)	−2.3	2.4	−0.4	2.4	−1.9	NS
Ar to Goi (mm)	9.0	3.6	5.9	4.5	2.9	NS
ANS to Me (mm)	8.0	2.7	6.2	3.8	1.8	NS
Ar-Goi-Me (°)	−3.2	3.9	−2.3	3.0	−0.9	NS
S-Go/N-Me (%)	2.3	2.4	1.1	1.7	1.2	NS
Interdental						
Overjet (mm)	−1.6	2.3	−2.0	1.8	0.4	NS
Overbite (mm)	−1.4	1.5	−3.1	1.3	1.7	*
Interincisal angle (°)	−5.8	14.4	−4.7	11.4	−1.1	NS
Molar relationship (mm)	1.9	2.2	1.7	2.6	0.2	NS
Maxillary dentoalveolar						
U1 to Point A vertical (mm)	1.4	2.5	−0.1	2.1	1.5	NS
U1 to FH (°)	3.8	9.9	2.7	6.4	1.1	NS
U1 vertical (mm)	1.5	1.9	0.0	1.8	1.5	*
U6 vertical (mm)	4.9	1.7	3.3	1.9	1.6	NS
Mandibular dentoalveolar						
L1 to Point A-Pg (mm)	2.2	2.3	1.3	2.7	0.9	NS
L1 to mandibular plane (°)	3.8	6.7	2.8	6.0	1.0	NS
L1 vertical (mm)	4.7	1.7	3.2	2.6	1.5	*
L6 vertical (mm)	5.9	2.2	4.7	2.8	1.2	NS

NS, Not significant; *Perp*, perpendicular.
*$P < 0.01$.

a gross determination of treatment timing for deepbite correction based on the patients' ages at the start of treatment indicated better efficacy and greater stability of outcomes in those treated in adolescence (12-13 years) vs preadolescence (8-10 years).

The favorable changes in overbite in patients of the late treatment group occurred through dentoalveolar modifications with no significant skeletal changes. The most relevant mechanism for overbite correction was a more limited eruption of the maxillary and mandibular incisors during the observation periods in comparison with the early treatment group. No effects of treatment timing were found on the eruption of the molars or the vertical growth of the mandibular ramus. Modifications in these dentoskeletal parameters would have affected the vertical dimensions, as suggested in the literature.[13,21,22] During the initial phase of treatment, the early treatment group had an increased amount of maxillary molar extrusion when compared with the late treatment group. However, the early treatment group also had greater vertical growth of the mandibular ramus, thus compensating for the greater extrusion of the maxillary molars, with no residual effect in terms of bite opening.

The limitations of this study derive from the use of removable appliances during the initial phase of deepbite correction, thus requiring the patients' compliance. However, the level of collaboration shown by the subjects in both groups can be considered acceptable. Actually, cooperation appeared to be better for subjects treated at an earlier age; the late treatment group received deepbite treatment during puberty, a time that is associated with decreased compliance due to adolescence. Another limitation of the study included the lack of untreated controls for ethical reasons. Nonetheless, previous studies offered valid reference data to describe the physiologic dentoskeletal changes that occur in subjects with untreated deepbite malocclusions.[13,14]

CONCLUSIONS

This prospective clinical trial showed that 2-phase treatment of deepbite with removable biteplanes in growing subjects leads to relatively unsatisfactory results.

1. At the end of treatment, 2.7 to 4.7 mm of overbite remained, with a significant relapse tendency once retention was discontinued.
2. If this treatment option is undertaken, the issue of treatment timing should be considered. The average amount of deepbite correction 1 year into retention was 2 times (3.1 vs 1.4 mm) that in subjects treated in the permanent dentition than in those who started treatment in the mixed dentition. The prevalence rate of patients with a corrected overbite at the final observation in the early treatment sample was not significantly different from what can be expected in deepbite subjects. On the contrary, patients treated at puberty showed a high prevalence rate of corrected overbite 1 year into retention (about 92%).
3. Correction of overbite occurred through dentoalveolar changes, with no skeletal modifications. Phase 1 therapy had no significant impact on the growth of the mandibular ramus or the vertical dimension of the posterior dentoalveolar sectors of the dental arches.

REFERENCES

1. Simons ME, Joondeph DR. Change in overbite: a ten-year postretention study. Am J Orthod 1973;64:349-66.
2. Uhde MD, Sadowski C, BeGole EA. Long-term stability of dental relationship after orthodontic treatment. Angle Orthod 1983;53: 240-52.
3. Schütz-Fransson U, Bjerklin K, Lindsten R. Long-term follow-up of orthodontically treated deep bite patients. Eur J Orthod 2006;28: 503-12.
4. Berg R. Stability of deep overbite correction. Eur J Orthod 1983;5: 75-83.
5. Tulloch JF, Proffit WR, Phillips C. Outcomes in a 2-phase randomized clinical trial of early Class II treatment. Am J Orthod Dentofacial Orthop 2004;125:657-67.
6. Hellsing E, Hellsing G, Eliasson S. Effects of fixed anterior bite-plane therapy—a radiographic study. Am J Orthod Dentofacial Orthop 1996;110:61-8.
7. Wheeler TT, McGorray SP, Dolce C, Taylor MG, King GJ. Effectiveness of early treatment of Class II malocclusion. Am J Orthod Dentofacial Orthop 2002;121:9-17.
8. Almeida-Pedrin RR, Almeida MR, Almeida RR, Pinzan A, Ferreira FPC. Treatment effects of headgear biteplane and bionator appliances. Am J Orthod Dentofacial Orthop 2007;132:191-8.
9. Franchi L, Baccetti T, Giuntini V, Masucci C, Vangelisti A, Defraia E. Outcomes of two-phase orthodontic treatment of deepbite malocclusions. Angle Orthod 2011;81:945-52.
10. McNamara JA Jr, Brudon WL. Orthodontics and dentofacial orthopedics. Ann Arbor, Mich: Needham Press; 2001. p. 116.
11. Egermark I, Magnusson T, Carlsson GE. A 20-year follow-up of signs and symptoms of temporomandibular disorders and malocclusions in subjects with and without orthodontic treatment in childhood. Angle Orthod 2003;73:109-15.
12. Feldmann I, Lundström F, Peck S. Occlusal changes from adolescence to adulthood in untreated patients with Class II Division 1 deep bite malocclusion. Angle Orthod 1999;69:33-8.
13. Bergersen E. A longitudinal study of anterior vertical overbite from eight to twenty years of age. Angle Orthod 1988;58:237-56.
14. Baccetti T, Franchi L, McNamara JA Jr. Longitudinal growth changes in subjects with deepbite. Am J Orthod Dentofacial Orthop 2011;140:202-9.
15. Cohen J. A power primer. Psychol Bull 1992;112:155-9.
16. Baccetti T, Franchi L, McNamara JA Jr. The cervical vertebral maturation (CVM) method for the assessment of optimal treatment timing in dentofacial orthopedics. Semin Orthod 2005;11: 119-29.
17. Dahlberg G. Statistical methods for medical and biological students. London, United Kingdom: G. Allen & Unwin; 1940. p.124.
18. Bhatia SN, Leighton BC. A manual of facial growth. A computer analysis of longitudinal cephalometric growth data. Oxford, United Kingdom: Oxford University Press; 1993.
19. Petrovic A. Auxologic categorization and chronobiologic specification for the choice of appropriate orthodontic treatment. Am J Orthod Dentofacial Orthop 1994;105:192-205.
20. Johnston LE. Growth and the Class II patient: rendering unto Caesar. Semin Orthod 1998;4:59-62.
21. Bishara SE, Jakobsen JR, Vorhies B, Bayati P. Changes in dentofacial structures in untreated Class II Division 1 and normal subjects: a longitudinal study. Angle Orthod 1997;67:55-66.
22. Nanda SK. Patterns of vertical growth in face. Am J Orthod 1988; 93:103-16.