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Stability of anterior open bite correction of adults treated with lingual appliances

Silvia Geron, Atalia Wasserstein and Zachi Geron
Department of Orthodontics, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel

Correspondence to: Silvia Geron, Department of Orthodontics, The Maurice and Gabriela Goldschleger School of Dental Medicine, Tel Aviv University, Tel Aviv, Israel. E-mail: sigeron@gmail.com

SUMMARY The aim of this study was to evaluate retrospectively the stability of treatment outcomes of adult anterior open bite (AOpB) cases, treated non-surgically, using a conservative approach with lingual orthodontics (LO). Thirty-nine adult AOpB patients consecutively treated by one operator (SG), with Ormco™ Generation 7 LO brackets and a conservative treatment protocol, with or without extractions, were evaluated clinically before treatment, at the end of active orthodontic treatment, and after a follow-up period, divided into a short-term group (ST): 1–2 years post-treatment, and a long-term group (LT): more than 2 years and up to 11 years post-treatment. All patients had a positive overbite at the end of active treatment (T2). Stability of the open bite correction was seen in 87.2 per cent of the patients (T3). Relapse to a negative overbite was seen in one patient (2.5 per cent). Post-treatment improvement of the overbite was demonstrated, with no difference between the ST and the LT groups. Stability of the transverse molar relations was significantly correlated with stability of AOpB correction. The LO appliance with the presented treatment protocol is a viable procedure for AOpB correction in adult patients, who are not suitable for surgical procedures, to improve or to enhance facial aesthetics. Post-treatment improvement of the overbite was observed in patients treated with this treatment approach in this study.

Introduction

The anterior open bite (AOpB) malocclusion can be a severe malocclusion, involving dental, skeletal, facial, functional, and aesthetic discrepancies (Proffit and Fields, 2000). It may derive from undereruption of anterior teeth, overeruption of the posterior teeth, excessive vertical development of the maxilla, or deficiency in mandibular ramus height. AOpB is associated with constricted upper arch and posterior x-bite, and involves functional abnormalities such as tongue interposition, lisping, and involuntary spluttering when speaking. Each type of AOpB has its specific aesthetic features, dental characteristics, and cephalometric findings (Straub, 1960; Brauer and Holt, 1965; Turvey *et al*., 1988; Denison *et al*., 1989; Miguel *et al*., 1995; Lo and Shapiro, 1998; Justus, 2001; Reyneke *et al*., 2007).

Several theories have been proposed for the aetiology of AOpB, including heredity, unfavourable growth, tongue posture, sucking habits, and obstruction of nasal breathing (Solow and Kreiborg, 1977; Proffit *et al*., 1983; Nanda, 1988; Brenchley, 1991; Vig, 1998).

The treatment of AOpB depends on the type of AOpB, the severity of the case, and the age of the patient. For adult patients the main treatment approach for severe AOpB is often surgical. Stability was reported in about 75–85 per cent of the cases treated with different surgical procedures (Bailey *et al*., 2004; Ding *et al*., 2007; Espeland *et al*., 2008; Stansbury *et al*., 2010; Teittinen *et al*., 2012). Despite the relative stability of surgically corrected AOpB, orthodontic camouflage or conventional orthodontic treatment is usually preferred by the patients due to reduced risks. However, the non-surgical approach is considered to be less consistent and predictable. Long-term stability of surgical and non-surgical therapies for AOpB malocclusion was studied in a meta-analysis (Greenlee *et al*., 2011) and indicated moderate stability of both the surgical (82 per cent) and non-surgical (75 per cent) treatments of AOpB, measured by positive overbite (OB) at 12 or more months after the treatment interventions.

The long-term skeletal and dental stability of open bite correction is reported as moderate regardless of the treatment modality, surgical or non-surgical (Lopez-Gavito *et al*., 1985). It was suggested that stability might be complicated because of the influence of the musculature, thus control of tongue habits and muscular training is a major factor in achieving stability after open bite correction. This subject was addressed by Fränkel and Fränkel (1983), who suggested that correction of open bite in children resulted from lip-seal training and improving the postural position of the muscles. It was supported by Huang *et al*. (1990), who showed that crib therapy over a period of several years was helpful in achieving stability of the orthodontic correction of the open-bite malocclusion. When using tongue spur, they observed no indentations of the spur on the tongue, indicating the

establishment of a new tongue posture, probably due to a nociceptive or a proprioceptive reflex (Justus, 2001).

The lingual orthodontic (LO) appliance is postulated to help in eliminating the abnormal tongue posture. According to the authors' experience, when using the 7th generation LO brackets (Ormco Company, Orange, California, USA), which have long hooks projecting towards the tongue, the same spur effect is noticed, with no indentations of the hooks or brackets on the tip of the tongue. After bonding the brackets, the patient is instructed to position his tongue behind the brackets at rest and during swallowing, and few days after bonding, the patients are no longer complaining of tongue irritation at the tip of the tongue, although they may complain of irritation on the back of the tongue, which may indicate the establishment of a more backward tongue posture. Since the treatment duration is at least for 12 months, the patient has the opportunity to practice the new tongue position and strengthen the reflex arc. Therefore, it is expected that the use of the LO appliance may improve the stability of AOpB correction due to its contribution to eliminate abnormal oral functions associated with the open bite.

The objectives of this study were to evaluate the treatment outcomes of adult AOpB cases treated non-surgically with LO conservative open bite protocol, and the stability of the treatment results in the short term and long term.

Subjects and methods

Thirty-nine adult patients, 34 women and 5 men, with AOpB malocclusion, were included in this retrospective study. The age range of the patients was 18–45 years (mean 27.23; SD 6.38).

The patients were consecutively treated by one operator (SG) in a private practice. The inclusion criteria were age above 18 years old, anterior OB of zero or less, and acceptable facial aesthetics that did not indicate the need for orthognathic surgery. The patients had various anteroposterior relations according to Angle classification, Class I (10 patients), Class II (16 patients), and Class III malocclusion (13 patients). They were treated either by extraction of the second premolars (24 patients) or by non-extraction (15 patients), depending on crowding and profile.

All patients received treatment with the Ormco 7th generation (G7). The treatment protocol included a bidimensional bracket system (0.022″ slot for the bicuspids and molars and 0.018″ slot for the anterior teeth, incisors, and canines). The anterior brackets were positioned with the Lingual Bracket Jig (Geron, 1999). Both arches were indirectly bonded together. The patients were instructed to position the tongue behind the brackets at rest and to practice swallowing with that tongue position and lips sealed, 4 times a day for 1 minute. They were also instructed to wear very light vertical elastics from the hooks of the upper to the lower incisor brackets during sleeping hours, to avoid forward tongue posture during sleep. The elastics were used for the purpose of tongue training, from the first day of treatment to 12 weeks by patients who had acceptable vertical incisal exposure at rest and 6 weeks by patients with excessive upper incisor vertical exposure. The patients with excessive incisal vertical exposure were given posterior bite blocks, made of composite material, bonded to the palatal cusps of the upper molars during the bonding appointment. The bite blocks were removed when positive OB was achieved. Nickel Titanium round wires were used for an average period of 3 months for levelling and alignment, followed by rectangular Nickel Titanum wires. Rectangular stainless steel wires were used for space closure. The average treatment duration was 18 months.

The retention protocol included an upper and a lower fixed anterior retainer and a clear plate (including occlusal and incisal coverage) for night wear only, for 2 years post-treatment. After 2 years of retention, the patients were instructed to wear the retainer for 1 night a week.

Anterior OB was measured in millimetre with a ruler on the patients' central incisors before treatment (T1), at the end of the active orthodontic treatment (T2), and after a retention period, which varied between 1 and 11 years post-treatment (T3). The anterior overjet (OJ) was measured at the same location and the posterior overjet (POJ) was measured in millimetre for the first molars, by using a ruler as an indication of the transverse molar relations. Cephalometric parameters: Y-axis and Go–Gn to SN were measured on the initial cephalograms as an indication for the facial vertical skeletal pattern. All the measurements were undertaken by the same practitioner.

The patients were divided into two groups, according to the time of follow-up measurement (T3). Seventeen patients had the follow-up measurements taken 1–2 years post-treatment, and they were defined as the short-term retention group (ST); 22 patients had the follow-up measurements taken more than 2–11 years post-treatment, and they were defined as the long-term retention group (LT). The LT group included 8 patients up to 5 years post-treatment, 8 patients up to 7 years post-treatment, and 6 patients up to 11 years post-treatment. The average follow-up period for this group was 6.09 years. The average follow-up period for both ST and LT groups was 4.01 years.

Data analysis was carried out using the SPSS (version 15) for windows (SPSS, Chicago, Illinois, USA). Data had been tested for normality prior to performing the statistical analyses.

Two-way analysis of variance (ANOVA) with repeated measures was used to evaluate the significance of the anterior OB change in the three-time groups and between the two follow-up periods.

The anterior OB changes in the post-treatment period of the three malocclusion groups, according to Angle classification, were compared by one-way ANOVA.

Differences in the anterior OB changes due to the treatment modality (extracions versus non-extractions) and due to changes in the POJ post-treatment were evaluated with independent *t*-tests.

Two-tailed Pearson Correlations were used to determine the relationship between the changes in the anterior OB and the other variables, and Pearson two-sided chi-square tests were used to find differences between three groups of patients according to the anterior OB change post-treatment from T2 to T3: negative (relapse), positive (deepening of the bite), and no change. The level of statistical significance used was $\alpha < 0.05$.

Results

The results are presented in Tables 1–3 and Figure 1.

All the patients had a positive OB at the end of active treatment (Table 1). Significant increase in OB was noted between T3 and T1 ($P < 0.001$) and between T2 and T1 ($P < 0.001$).

Out of the 39 patients, 5 patients experienced some relapse of the anterior OB in T3 (12.5 per cent). However, only one of them had a negative OB (2.5 per cent). A small, but statistically significant increase was found in the anterior OB from T2 to the follow-up period, T3 ($P < 0.005$) in both, the ST and LT groups, with no statistical significant differences between the groups (Figure 1).

The difference in the transverse molar relations (POJ) post-treatment was significantly correlated with the anterior OB change post-treatment ($P = 0.007/P < 0.05$). Sixty per cent of the patients with anterior OB relapse (3 out of 5) experienced negative change in POJ and 71.4 per cent of the stable OB patients (15 out of 21) had no change in POJ, while all the patients who gained deepening of the OB (13 patients) had stable POJ (Table 2). However, when studying the same data from the opposite direction (Table 3), we see that 50 per cent of the patients with stable POJ (15 out of 30) had no change in the OB post-treatment, 43.3 per cent had deepening of the OB, and 6.6 per cent had relapse of the OB.

The post-treatment changes of the anterior OB were also significantly correlated to the initial anterior OB ($P = 0.020$).

Treatment modality, combined with extraction of teeth or non-extraction treatment, had no effect, according to statistical evaluation of the changes in the anterior OB at T2 compared

Table 1 Descriptive statistics of anterior overbite (OB) at T1, T2, and T3 for the whole group of patients as well as for the ST (short-term follow-up) and the LT (long-term follow-up) groups.

	N	Minimum	Maximum	Mean	SD
OB (T1)	39	−9.00	0	−2.2051	1.97923
ST	17			−2.3824	2.2798
LT	22			−2.068	1.9792
OB (T2)	39	0.50	2.0	0.9872	0.57910
ST	17			0.7353	0.4372
LT	22			1.1818	0.6083
OB (T3)	39	−0.50	2.5	1.1538	0.70854
ST	17			0.9118	0.4414
LT	22			1.3409	0.8221

Table 2 Number and percentage of patients with posterior overjet change in three groups of patients defined by anterior overbite (OB) change: with relapse, stable, or deeper at T3 compared with T2.

Anterior OB T3–T2	Posterior overjet change		Total number of patients
	Negative	No change	
Relapse			
N	3	2	5
%	60	40	
Stable			
N	6	15	21
%	28.6	71.4	
Deeper			
N	0	13	13
%	0	100	
Total N	9	30	39

Table 3 Number and percentage of patients with anterior overbite (OB) change in two groups of patients defined by posterior overjet (POJ) change in the post-treatment period (T3–T2): negative and no change groups.

POJ (T3–T2)	Anterior OB change			Total number of patients
	Relapse	Stable	Deeper	
Negative				
N	3	6	0	9
%	33.33	66.6	0	
No change				
N	2	15	13	30
%	6.66	50	43.33	
Total *N*	5	21	13	39

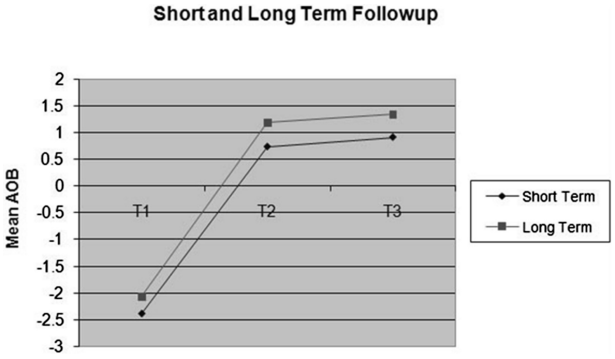

Figure 1 Changes of the mean anterior overbite for the short-term and the long-term follow-up groups of patients at T1, T2, and T3.

with T1. The mean anterior OB increased between T3 and T2 in the extraction group and was almost stable in the non-extraction group. Yet, these changes ($P = 0.151$) were below the level of significance defined for the study. Significant negative correlation was found between the change in the OJ post-treatment and the change in the anterior OB post-treatment ($P = 0.029$, $R = -0.350$). No statistically significant correlations were found between the change in the anterior OB post-treatment and other variables measured in the study: initial vertical cephalometric parameters, Y-axis and Go–Gn to SN, malocclusion according to Angle classification, and age of the patients. Gender differences were not evaluated statistically due to the low rate of males involved in the study (5 out of 39).

Discussion

In this study we found post-treatment stability in 87.5 per cent of the patients. About 12.5 per cent of patients experienced some relapse of the anterior OB and 2.5 per cent (1 out of 39 patients) had a negative OB at the follow-up examination. These results present higher stability than the results presented in the literature for surgical correction of AOpB (Bailey *et al*., 2004; Ding *et al*., 2007; Espeland *et al*., 2008; Stansbury *et al*., 2010; Teittinen *et al*., 2012) or conventional orthodontics with temporary anchorage devices (TADs) (Kuroda *et al*., 2007; Baek *et al*., 2010) and lower stability than the results presented for the crib appliance (Huang *et al*., 1990; Justus, 2001).

By comparing the data of our sample to the data presented in a meta-analysis comparing stability of surgical versus non-surgical AOpB treatment (Greenlee *et al*., 2011), meta-analysis revealed the pre-treatment adjusted means of OB were −2.8 mm for the surgical and −2.5 mm for the non-surgical groups. In our study, the mean anterior OB in T1 was −2.2 mm, ranging from −9 to 0 mm (seven patients had anterior OB of −0.5 and 0 mm, all others had more severe AOpB). In the meta-analysis, anterior OB closure was up to +1.6 mm in the surgical and +1.4 mm in the non-surgical group, whilst in our study, the mean OB achieved at the end of treatment was 0.98 mm (between 0.5 and 2.0 mm). Relapse presented in the meta-analysis in the surgical group during the mean 3.5 years of follow-up reduced the OB to +1.3 mm; the non-surgical group relapsed to +0.8 mm in the mean 3.2 years of follow-up, whilst in our study, the mean OB continued to increase to 1.15 mm, ranging from 0.5 to 2.5 mm in both the short-term and the long-term groups. Therefore, our results indicate good efficiency and stability of this treatment approach for AOpB, with the main strength presented in the follow-up period.

The uniqueness of this study is the sample, which included only adult patients treated non-surgically, and the establishment of a relative stable positive OB, which improved over time, probably due to the establishment of a more backward tongue posture at rest. We hypothesize that the LO appliance contributes to improve tongue posture in several ways: firstly due to the spur effect, and secondly, due to the tongue exercises, by using the lingual brackets as a guide for the tongue. The patient was instructed to practice positioning his tongue behind the brackets at rest during swallowing and speech. He is also instructed to use light vertical elastics at sleeping hours to avoid unintentional forward positioning of the tongue. Vertical elastics from the lingual side are much more effective than from the labial side in avoiding the tongue's forward posture, since the elastics avoid the contact of the tongue with the teeth. We hypothesize that the 7th generation lingual brackets, which are big and have irritating hooks may cause a sudden environmental change for the tongue, which is forced to a more backward position to avoid contact with the brackets. This may contribute to the stability of the open bite correction. When normal OB is created and the anterior oral seal is corrected the tongue has already adapted itself to a normal position and function.

LO treatment offers also effective molar intrusion, incisor extrusion, and lingual tipping of the incisors by using controlled mechanics with LO (Geron and Chaushu, 2002) as was shown previously by a theoretical model (Geron *et al*., 2004). Maxillary expansion is also more easily achieved with LO, and with less tipping compared with labial appliance (Alexander *et al*., 1983).

In our study, the stability of the transverse molar relations (POJ) was significantly correlated with the anterior OB stability. When the transverse molar relationship relapsed, the anterior OB also relapsed in one out of three patients. Hoppenreijs *et al*. (1998, 2001) found a similar correlation between the transverse dimension and anterior OB for surgically corrected AOpB, and they suggested that the relapse of transverse dimension was associated with recurrence of open bite after surgery, irrespective of the surgical procedure.

We also found a significant negative correlation between the relapse of the OJ and the relapse of the anterior OB, expressing the effect of the incisor inclination on the OB. We suggest that preserving the transverse molar relations and the anterior OJ may help the stability of the anterior OB post-treatment.

Conclusions

LO treatment with the protocol presented here appears to be a viable treatment option for the correction of AOpB in adult patients who are not suitable for surgical procedures to improve or to enhance facial aesthetics. Long-term stability and even improvement of the OB was observed in this study in patients treated with this treatment approach, probably due to the tongue crib effect of the appliance. Keeping the transverse molar relations and the OJ may help the stability of the anterior OB post-treatment. Further investigations are needed to establish whether the LO appliance affects tongue position and whether this affects orthodontic stability.

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