

Periodontal status of adult patients treated with fixed buccal appliances and removable aligners over one year of active orthodontic therapy

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ABSTRACT

Objective: To compare the periodontal status of adults treated with fixed buccal orthodontic appliances vs removable orthodontic aligners over 1 year of active therapy.

Materials and Methods: The study population consisted of 42 subjects; 22 treated with fixed buccal orthodontic appliances and 20 treated with removable aligners. Clinical indices recorded included: plaque index (PI), gingival index (GI), bleeding on probing (BOP), and probing pocket depth (PPD). Plaque samples were assessed for hydrolysis of N-benzoyl-DL-arginine-naphthylamide (BANA test). Indices and BANA scores were recorded before treatment and at 6 weeks, 6 months, and 12 months after initiation of orthodontic therapy.

Results: After 6 weeks, only mean PPD was greater in the fixed buccal orthodontic appliance group. However, after 6 months, the fixed buccal orthodontic appliance group had significantly greater mean PI, PPD, and GI scores and was 5.739 times more likely to have a higher BANA score. After 12 months, the fixed buccal orthodontic appliance group continued to have greater mean PI, GI, and PPD, while a trend was noted for higher BANA scores and BOP.

Conclusions: These results suggest treatment with fixed buccal orthodontic appliances is associated with decreased periodontal status and increased levels of periodontopathic bacteria when compared to treatment with removable aligners over the 12-month study duration. (*Angle Orthod.* 2013;83:146–151.)

KEY WORDS: Fixed orthodontic appliances; Orthodontic aligners; Gingival inflammation

INTRODUCTION

The introduction of esthetic orthodontic treatment options has prompted an increasing number of adults to request orthodontic therapy. In contrast to the adolescent patient, in whom caries is the primary dental concern, the adult patient may also present with, or be at risk for, periodontal diseases.¹ Data from NHANES III suggest 14% of the US population over 20 years of age have moderate to severe periodontitis.² Depending upon the criteria used to define periodontal disease status and severity, some epidemiologic studies have reported an even greater prevalence of periodontal diseases.³ Therefore, as more adults enter orthodontic therapy, the practitioner must consider the effects that orthodontic treatment, including appliance type, may have on periodontal health.

The entire periodontium, including osseous and soft tissue components, remodels with orthodontic tooth movement.⁴ However, the presence of periodontal inflammation may inhibit remodeling and compromise the outcome of treatment through the loss of periodontal

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connective tissue attachment.⁵ While some studies have shown periodontal changes induced by orthodontic appliances are transient and do not result in permanent attachment loss,⁶ other studies suggest up to 10% of past orthodontic patients have greater periodontal connective tissue attachment loss than the general population.⁷

Fixed buccal orthodontic appliances have been shown to enhance plaque accumulation⁸ and adversely affect periodontal tissues, as measured by gingival inflammation and probing pocket depths.⁹ Some studies suggest periodontal health improves with removal of fixed buccal orthodontic appliances¹⁰ or with the daily use of dental floss.¹¹ After placement, the subgingival bacterial profile shifts from gram-positive aerobic species, associated with periodontal health, to gram-negative anaerobic or facultative species, associated with periodontitis. Huser et al.¹² reported early increases in anaerobic species, including *Prevotella intermedia*, and a decrease in facultative anaerobic species following initiation of fixed buccal orthodontic appliances in the treatment of periodontally healthy patients. Thornberg et al.¹³ reported that levels of six subgingival, pathogenic periodontal species increased after 6 months of treatment using fixed buccal orthodontic appliances but returned to pretreatment levels by 12 months in an adolescent population. Studies of fixed lingual orthodontic appliances have similarly reported increased plaque,¹⁴ bleeding upon probing, and pocket depths after bracket placement on lingual but not buccal aspects of bracketed teeth.^{15,16}

Conflicting results comparing the periodontal status of subjects treated with fixed vs removable appliances have also been reported. Tuncer and Baylas¹⁷ found significant differences in probing pocket depth between removable and fixed appliances after 1 month of treatment. However, Årtun et al.¹⁸ found no differences in periodontal indices between fixed and removable orthodontic appliances. In addition, Dubey et al.¹⁹ compared subgingival plaque levels in patients using fixed or removable appliances and reported that although plaque levels in both treatment groups were higher than that of controls, no statistically significant differences in the levels of subgingival plaque were found between the treatment groups.

Therefore, to attempt to resolve this inconstancy, the following study was conducted to compare the effects of fixed buccal appliances and removable aligners on periodontal status over 1 year of active orthodontic therapy in an adult population.

MATERIALS AND METHODS

The nonrandomized, two-armed, prospective study design was reviewed and approved by the Institutional

Review Board of New York University School of Medicine. Subjects were recruited from the new patient pool at the New York University College of Dentistry Department of Orthodontics. Patients were invited to participate in the study after a definitive orthodontic treatment plan was agreed upon by both patient and treating clinician following a detailed discussion of all possible treatment options, including the use of removable aligners or fixed buccal orthodontic appliances. Exclusion criteria included: (1) those younger than 18 or older than 60 years of age, (2) prior history of periodontitis as evidenced by the presence of attachment loss, and (3) current cigarette smokers. Twenty subjects were treated with removable aligners (Invisalign, Align Technologies, Santa Clara, Calif), and 22 were treated with fixed buccal orthodontic appliances (In-Ovation-R, GAC, Bohemia, NY).

Periodontal Evaluation

Both groups received a full mouth scaling and prophylaxis 1 week prior to, and full oral hygiene instructions on the day the appliances or aligners were delivered. Immediately prior to placement of the appliances or aligners, the plaque index (PI),²⁰ gingival index (GI),²⁰ bleeding on probing (BOP), and probing pocket depth (PPD) (using a manual North Carolina 15 periodontal probe) were measured at the mid facial, mid lingual, and buccal line angles of the maxillary right first molar, right canine, left lateral incisor, mandibular left canine, right central incisor, and right first molar. These clinical measurements were repeated at 6 weeks, 6 months, and 12 months ($\pm$ 14 days) after initiation of orthodontic therapy. All clinical measurements were performed by three examiners calibrated to a single examiner.

Subgingival bacteria were sampled using a sterile Gracey 11/12 curette from eight sites; the mesial of the maxillary right first molar, lateral incisor, central incisor, left central incisor, lateral incisor, canine, and first molar immediately prior to and at 6 weeks, 6 months, and 12 months after the initiation of active orthodontic therapy. The plaque samples were then assessed for the ability to hydrolyze N-benzoyl-DL-arginine-naphthylamide using a commercially available kit (BANA Test, OraTec Corp, Manassas, Va).

Statistical Analysis

The hypothesis tested was that periodontal status would decrease in the fixed buccal appliance compared to the removable aligner group and that decreased periodontal status would be associated with an increase in BANA scores. The primary outcome measures were clinical measures of periodontal status, specifically PPD, PI, GI, and BOP. The BANA score was a secondary outcome measure.

Table 1. Number of Subjects in Study at 6 Weeks, 6 Months, and 12 Months After Initiation of Orthodontic Therapy

Group	Time After Initiation of Orthodontic Therapy			
	Baseline	6 Weeks	6 Months	12 Months
Fixed buccal appliances	22	21	20	18
Aligners	20	20	19	17

All measurements were summarized using descriptive statistics. Clinical data were analyzed for significance using a repeated measure analysis of covariance (ANCOVA) with adjustment for baseline values. Repeated measure ANCOVA was used to determine the time and group effect for each of the four periodontal indices, with post hoc ANCOVA (using baseline as the covariate) performed to analyze group differences at each time point. BANA scores were analyzed using the generalized linear mixed model implementing an ordered logistic regression with a random intercept for each subject.

RESULTS

The fixed buccal orthodontic appliance group included 16 women and six men with a mean $\pm$ standard deviation age of 34 ± 7.18 years, range of 18 to 44 years. Self-reported ethnicity was one Asian, one Indian, six African-American, one Hispanic, 12 white, and one other. The aligner group included 12 women and eight men with a mean $\pm$ standard deviation age of 28 ± 6.86 years, range of 18 to 44 years. Self-reported ethnicity included five Asian, one Indian, three African-American, three Hispanic, six white, and two other. At the 12-month time point, four subjects in the fixed buccal appliance group and three subjects in the aligner group failed to be examined due to geographic relocation for an 83% retention rate (Table 1).

An increase in PI was noted in the fixed buccal appliance group over time (Figure 1). At 6 weeks, no difference in PI was noted between the fixed buccal appliance and aligner groups ($P = .078$), but by 6 months ($P < .001$) and 12 months ($P < .001$) the PI of the fixed buccal appliance group was significantly greater than the aligner group. In contrast, a slight decrease ($P < .05$) in PI was noted for the aligner group over the 12-month duration of the study.

Associated with the increase in PI was an increase in gingival inflammation (Figure 2). Although both groups had similar GI scores at 6 weeks ($P < .126$), by 6 months ($P < .01$) and 12 months ($P < .01$), the aligner group had significantly lower GI scores. The changes in PI and GI were also associated with changes in BOP. Both groups had similar BOP at 6 weeks ($P = .645$), but by 6 months a trend towards increased differences in BOP ($P = .081$) was observed in the fixed buccal appliance group that attained

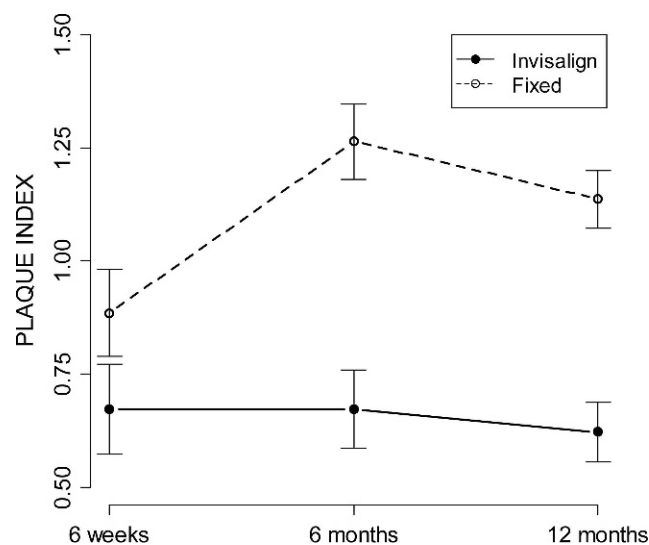


Figure 1. Effect of fixed buccal appliances vs removable aligners on PI after initiation of orthodontic therapy. Values are the mean $\pm$ standard error of the mean PI scores adjusted for differences in starting values for each subject using repeated measures ANCOVA. Significance of differences between fixed and removable groups at 6 weeks, $P = .078$; 6 months, $P < .001$; and 12 months, $P < .001$.

statistical significance by 12 months ($P < .05$) (Figure 3). As shown in Figure 4, an increase in PPD was recorded for the fixed buccal appliance group at 6 weeks ($P = .012$), 6 months ($P = .021$), and 12 months ($P = .003$) (Figure 4).

No differences in BANA scores were found between the fixed buccal appliance and removable aligner groups at baseline or after 6 weeks. However, after

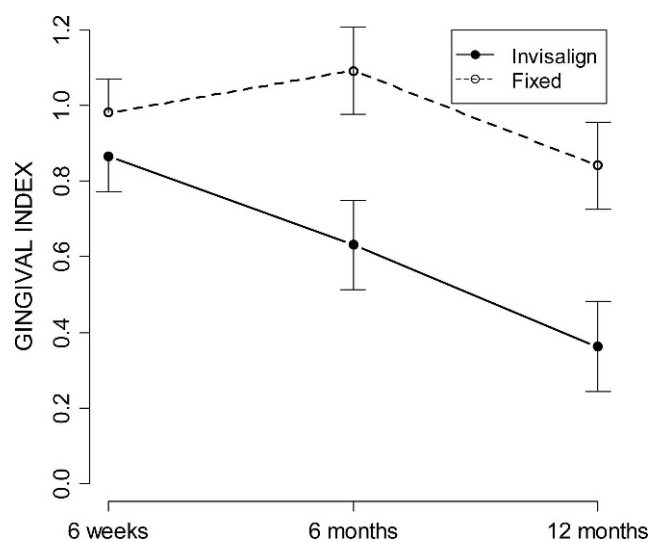


Figure 2. Effect of fixed buccal appliances vs removable aligners on GI after initiation of orthodontic therapy. Values are the mean $\pm$ standard error of the mean GI scores adjusted for differences in starting values for each subject using repeated measures ANCOVA. Significance of differences between fixed and removable groups at 6 weeks, $P = .126$; 6 months, $P < .01$; and 12 months, $P < .01$.

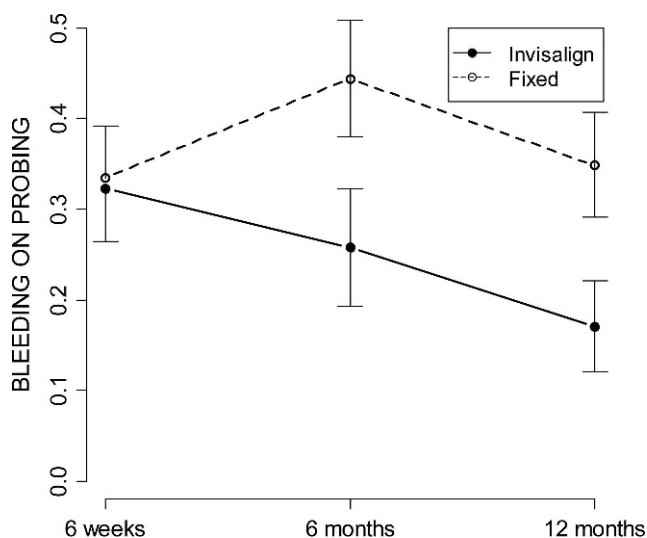


Figure 3. Effect of fixed buccal appliances vs removable aligners on BOP after initiation of orthodontic therapy. Values are the mean $\pm$ standard error of the mean BOP scores adjusted for differences in starting values for each subject using repeated measures ANCOVA. Significance of differences between fixed and removable groups at 6 weeks, $P = .645$; 6 months, $P < .081$; and 12 months, $P < .05$.

6 months, subjects in the fixed buccal appliance group were 5.7 times more likely to have an elevated BANA score than the aligner group. After 12 months, the odds ratio was still elevated in the fixed buccal appliance group but failed to achieve statistical significance (Table 2).

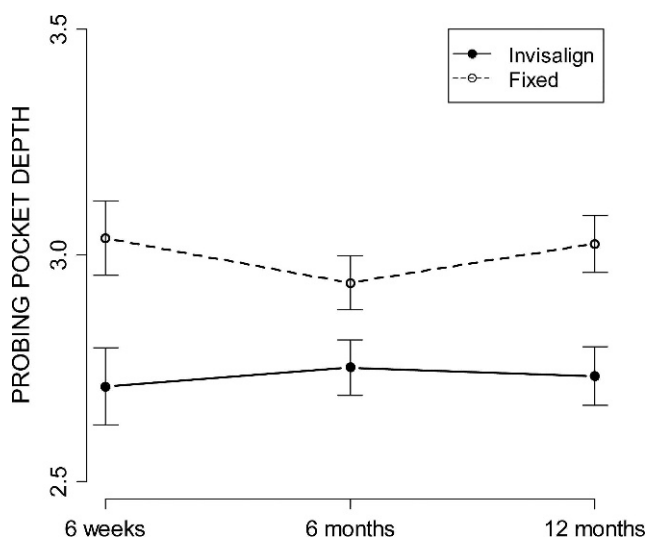


Figure 4. Effect of fixed buccal appliances vs removable aligners on PPD after initiation of orthodontic therapy. Values are the mean $\pm$ standard error of the mean probing pocket depth adjusted for differences in starting values for each subject using repeated measures ANCOVA. Significance of differences between fixed and removable groups at 6 weeks, $P = .012$; 6 months, $P < .021$; and 12 months, $P < .003$.

DISCUSSION

Fixed orthodontic appliances create retention areas for plaque accumulation and impede attempts at oral hygiene, increasing risk for enamel demineralization, caries, gingival inflammation, and decreased periodontal health.^{21,22} However, the results of the present study suggest less plaque accumulation with removable aligners at 6 and 12 months when compared to fixed buccal appliances. In addition, plaque levels did not increase, but slightly decreased, over the 12-month study. Decreased plaque levels were associated with decreased GI and PPD, while a tendency for decreased BOP was found in the aligner group. We interpret these results as an outcome of improved access for oral hygiene in the aligner group.

These findings are similar to those reported by Miethke and Brauner,²³ comparing the periodontal status of patients treated with Invisalign vs fixed lingual orthodontic appliances. They reported that patients treated with removable aligners had significantly better periodontal indices that continued to improve over the course of the study. However, unlike the present study, periodontal indices in the fixed group remained constant. These results contrast with results of recent studies of patients treated with fixed lingual appliances where PI and BOP increased after 4 weeks¹⁶ and 3 months¹⁵ of treatment. In the present study, periodontal indices in the fixed buccal appliance group reached maximal values 6 months after placement of appliances, followed by a decrease at 12 months. A similar result was reported by Ristic et al.^{24,25} who found periodontal indices to increase over the first 3 months followed by a gradual decrease, after placement of fixed buccal appliances. In addition, fixed buccal orthodontic appliances initially increased periodontal indices and stimulated growth of periodontal pathogenic bacteria, but did not result in long-term periodontal connective tissue attachment loss.^{24,25}

Hydrolysis of the BANA substrate by plaque samples was used as a semi-quantitative marker for the presence of *Treponema denticola*, *Porphyromonas gingivalis*, and *Tannerella forsythia*,^{26,27} gram-negative anaerobic bacteria strongly associated with chronic adult periodontitis.²⁸ BANA scores were significantly greater for the fixed buccal appliance group at 6 months but decreased at 12 months. It is uncertain whether this finding was due to an actual decrease in BANA score for the fixed buccal appliance group or to decreased study power due to subject attrition. However, the BANA results support the clinical periodontal results of decreased plaque and attendant gingival inflammation and pocket depth as a result of improved oral hygiene with removable aligners. Our findings agree with a study comparing banded and

Table 2. Comparison of BANA Scores After Initiation of Orthodontic Therapy Using Fixed Buccal Appliances or Removable Aligners. Analysis Using Linear Mixed Model and Ordered Logistic Regression

Time After Initiation of Orthodontic Therapy	Odds Ratio	P Value	95% Confidence Interval
Baseline	1.073	.897	0.369–3.121
6 Weeks	1.943	.307	0.543–6.952
6 Months	5.739	.003	1.801–18.294
12 Months	3.797	.104	0.761–18.949

bracket-bonded teeth with teeth without fixed attachments in 24 adolescent subjects.²⁹ Over the 36-week study, the total anaerobic bacterial species increased in the banded and bonded-bracketed sites in association with increased pocket probing depth, bleeding upon probing, and gingival crevicular fluid flow. Our results also agree with a systematic review that concluded that patients treated with fixed appliances had a slightly decreased periodontal status compared to untreated controls.³⁰

The present study has several limitations. The modest sample size and 17% attrition rate limit conclusions that may be drawn from the 12-month time point. Also, the lack of subject randomization into fixed buccal appliances or removable aligner groups may have introduced a bias in that those subjects selecting orthodontic treatment with the removable aligner may have been more esthetically conscious and therefore more willing to perform oral hygiene procedures. However, that both fixed buccal appliance and aligner groups did not differ with respect to PI, GI, BOP, or PPD at baseline does not support the possibility that subjects in the removable group were more inclined to practice oral hygiene.

To our knowledge, this is one of the few studies to compare periodontal status between fixed buccal appliances and removable aligners over 1 year of active orthodontic therapy in adult subjects. Previous studies comparing the periodontal status of patients treated with removable aligners vs fixed buccal appliances used observation periods of 3 months or less. Miethke and Vogt³¹ reported no differences in periodontal status after 9 weeks of treatment. In a second study, Miethke and Brauner²³ reported improved periodontal indices in patients treated with removable aligners vs fixed lingual appliances.

Although patients treated with fixed buccal appliances demonstrated decreased periodontal status, we do not suggest that fixed buccal or lingual appliances are precluded in the treatment of the adult orthodontic patient. Not all orthodontic treatment objectives are achievable using removable aligners. In addition, the use of fixed appliances ensures treatment compliance. Also, not all adults are susceptible to periodontitis.

Finally, there is little evidence that fixed orthodontic appliances have a long-term negative effect on periodontal tissues in adult patients. This question can only be answered by long-term comparative studies that examine periodontal status after appliance removal.

CONCLUSIONS

- The results of this study suggest that the use of removable aligners facilitates oral hygiene.
- Treatment with removable aligners was associated with improved periodontal status as evidenced by decreased plaque levels, gingival inflammation, bleeding upon probing, probing pocket depths, and BANA scores.
- These results suggest that removable aligners be considered when treatment planning for the adult orthodontic patient at risk for periodontitis.

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