Original Article

Tooth Positioner Effects on Occlusal Contacts and Treatment Outcomes

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ABSTRACT

Objective: To determine if an increase in tooth contacts is the principal effect of tooth positioner wear.

Materials and Methods: Patient charts from a consecutive series were reviewed until a sample of 100 cases that used a tooth positioner was obtained. One hundred control cases were randomly selected from patients treated at the same period. Malocclusion severity and finished occlusion were assessed with the American Board of Orthodontics (ABO) Discrepancy Index (DI) and Objective Grading System (OGS) score, respectively. Finish casts for each patient were mounted on a Galleti articulator. Occlusal registrations were obtained with silicone-based impression material from casts fabricated from impressions taken at the time of fixed appliance removal (control) or at the end of the tooth positioner treatment (experimental). The number of the perforations and transparent areas on the occlusal registrations were quantified.

Results: There was no significant difference ($P = .20$) in the number of total occlusal contacts between the two groups. However, the OGS score of the tooth positioner group (16.7) was significantly ($P = .0009$) better than for the control group (19.9).

Conclusions: Tooth positioners were effective in improving the occlusal finish, but the effects were independent of an increase in occlusal contacts. Positioners primarily improved first order alignment by tipping teeth into an improved intercuspation.

KEY WORDS: Tooth positioner; Orthodontics; Treatment outcomes; Occlusal contacts; ABO OGS scores

INTRODUCTION

During the finishing and retention phase of orthodontic treatment, there are many approaches to establishing an optimal functional occlusion. In the present sample, the most common methods were to finish the occlusion with segmental elastics, make bends in coordinated light round arch wires, and use tooth positioners.

Tooth positioners are routinely prescribed by some clinicians for use immediately after removal of fixed appliances. A tooth positioner, rather than final finishing with archwires, is purported to have three advantages: (1) it allows the fixed appliances to be removed sooner, (2) it improves articulation of the teeth and massages the gingiva, which is usually swollen after comprehensive orthodontic treatment, and (3) it helps develop lip competence and facial muscle tone. On the other hand, a tooth positioner may have a tendency to increase overbite and it requires good patient compliance.[1,2]

Numerous quantitative methods have been proposed for analyzing the functional occlusion, but the most reliable approach is to quantify the actual contacts between teeth.[3] Many studies of orthodontic treatment have investigated the change of occlusal contacts over time.[4–7] Orthodontic therapy may severely alter tooth contacts during early treatment, but after completion of treatment the number of contacts increases with the settling of the occlusion.

The purpose of the present research is to compare the number of occlusal contacts achieved by the use of a tooth positioner to determine if that is the principal mediator for short-term improvement of the occlusion following the removal of fixed appliances. The following hypothesis was offered: tooth positioners significantly increase the number of occlusal contacts as the principal means for improving the American Board of

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Accepted: November 2007. Submitted: July 2007.

 DOI: 10.2319/070307-307.1

Orthodontics Objective Grading System (ABO OGS) score.

MATERIALS AND METHODS

Sample Selection

This is a retrospective study with a sample drawn from a consecutive series of more than 2000 patients who received comprehensive orthodontic treatment in a graduate orthodontics training program from 1997–2007. Beginning at the end of 2006 and working backwards in time, patient charts were reviewed until a sample of 100 tooth positioner patients was obtained. One hundred patients in which no tooth positioner was used were randomly selected from the same time. The control patients were selected by adding one to the chart number of each patient in the tooth positioner sample.

Inclusion Criteria

- Patients were treated by postgraduate orthodontic students under faculty supervision;
- All patients were treated with full fixed banded or bonded edgewise appliances;
- Patients were treated to an optimum occlusion;
- Adequate records were obtained after treatment was completed;
- Patients demonstrated good or at least fair compliance with the positioner.

Exclusion Criteria

- Poor compliance with the positioner: compliance was judged based on the notes that were made by the resident in the chart;
- Patients in which treatment was discontinued (prematurely terminated) or was followed by prosthodontic treatment;
- Missing, incomplete or damaged records.

All tooth positioners were made by a commercial orthodontic laboratory. According to the instructor's preference, the tooth positioners were fabricated using a face bow transfer or an average bite opening. In collecting the consecutive sample of 100 cooperative positioner patients, 51 patients were excluded; 22 of them demonstrated poor cooperation with the positioner and it was discontinued. Clinic policy is to discontinue the positioner in favor of retainers after two uncooperative notes are entered in the clinical record.

Record Occlusal Contacts

Occlusal bite records, made with silicone-based impression material (Exabite NDS II, GC, Alsip, Ill), were obtained from finish casts fabricated from impressions taken when the appliances were removed (control) or following tooth positioner treatment (experimental).

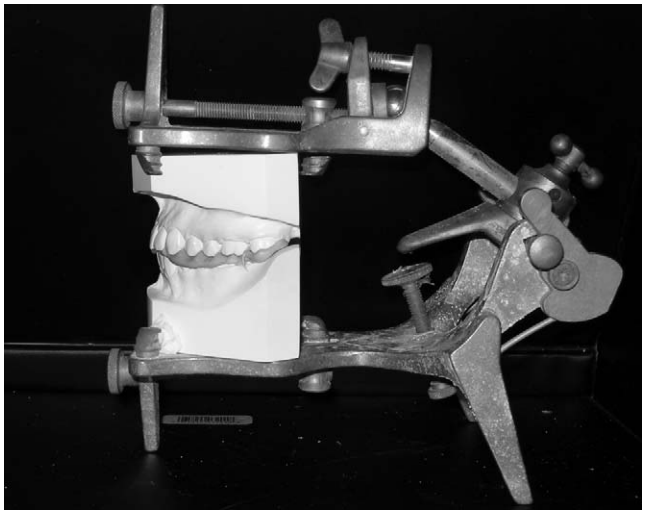

Figure 1. Galleti articulator with bite registration.

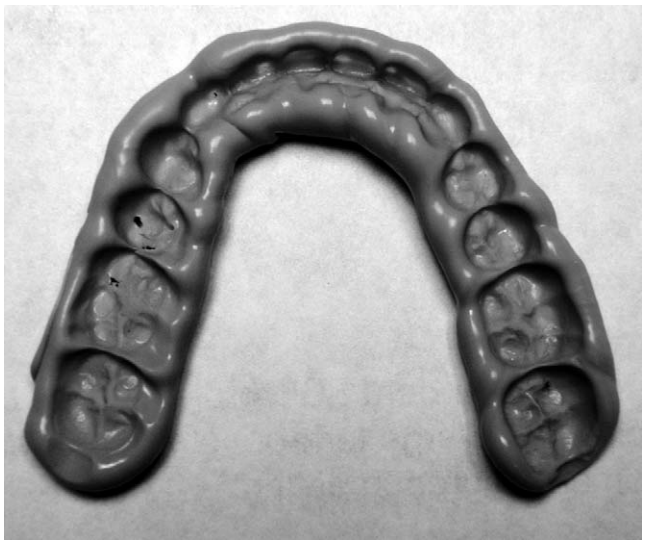

Figure 2. Occlusal bite registration with perforations (true contacts).

Each set of casts was mounted on a Galleti articulator (Figure 1) in maximum interdigitation. Impression material was applied onto the mandibular occlusal surface and the articulator was closed with moderate hand pressure. Each patient's occlusal record was taken twice to control for distortion errors. If there was a discrepancy between the registrations, the process was repeated until two registrations matched.

The occlusal records (Figure 2) were placed on a view box in a dark room and the perforation and transparent areas were measured with a caliper to a tolerance of 50 μm. Perforations and registration thickness of less than 50 μm were considered "true contacts." "Near contacts" were defined as areas of articulation with a thickness greater than 50 μm but less than 350

Table 1. Pretreatment Characteristics of the Sample Groups

	All			Control			Positioner			
	N	Mean	SD	N	Mean	SD	N	Mean	SD	*P* Value
Age at start	200	15.2	5.8	100	15.7	6.3	100	14.7	5.2	.2930
Age at debond	200	18.1	5.7	100	18.4	6.2	100	17.8	5.1	.8091
Treatment time	200	31.5	13.3	100	29.6	12.2	100	33.3	14.1	.0861
Discrepancy index	200	15.1	7.9	100	15.0	7.8	100	15.1	8.0	.8671
Number of teeth	200	27.0	1.7	100	27.1	1.6	100	26.9	1.7	.4519

Table 2. Sample Composition

	All		Control		Positioner		
	N	%	N	%	N	%	*P* Value
Sex							
Female	138	69	68	68	70	70	.7598
Male	62	31	32	32	30	30	
Race							
White	169	85	88	88	81	81	.1714
African-American	19	10	8	8	11	11	
Hispanic	7	4	2	2	5	5	
Asian	5	3	2	2	3	3	
Angle classification							
I	101	51	56	56	45	45	.0239
II	73	37	36	36	37	37	
III	5	3	2	2	3	3	
II division 2	21	11	6	6	15	15	
Extraction							
No	151	76	79	79	72	72	.2498
Yes	49	25	21	21	28	28	
Equilibration							
No	182	91	99	99	83	83	.0001
Yes	18	9	1	1	17	17	

μm.[3] Since the ideal location of occlusal contact is difficult to define, any contacts on the cusps of the occlusal table were considered as occlusal contacts.[8]

Data Analysis

Tooth positioners were used for finishing based on instructor preference. There was no specific indication for use of a tooth positioner. To control for potential bias based on severity of the malocclusion, the ABO discrepancy index (DI) was calculated for all patients.[9]

The following variables were recorded for each experimental and control patient in the sample: total contacts (sum of true and near contacts), anterior contacts, posterior contacts, malocclusion class, DI (pretreatment), ABO OGS score at treatment completion, patient demographics (age, race, gender), treatment rendered (extraction or nonextraction), number of teeth present at the end of active treatment (beginning of the retention phase), and occlusal adjustments (yes or no).

Statistical Methods

The groups were compared for differences in pretreatment patient characteristics. Wilcoxon rank sum tests were used to compare the groups for differences in age at start of treatment, age at debond, treatment time, DI, number of teeth, number of premolar teeth, number of molar teeth, and number of posterior teeth. Chi-square tests were used for comparisons of sex, race, extraction performed, and equilibration. A Mantel-Haenszel test for ordered categories was used for the comparison of Angle classification. This is a variation of the log-rank test commonly used for comparing morphological classifications between groups. Correlation coefficients were calculated to assess the relationships between the outcomes (occlusal contacts and ABO OGS score) and age at the start of treatment, age at debond, treatment time, discrepancy index, number of teeth, number of premolar teeth, number of molar teeth, and number of posterior teeth. Wilcoxon rank sum tests and Kruskal-Wallis tests were used to assess the relationships between the outcomes and sex, race, extraction performed, and equilibration. The outcomes were compared between the two groups using analysis of covariance models, with the pretreatment patient characteristics included as covariates.

RESULTS

Comparisons of the pretreatment patient characteristics between groups showed significant differences for Angle classification ($P = .02$) and equilibration ($P < .0001$) (Tables 1 and 2). In general, the positioner series had more Class II, division 2 patients (15% vs 6%) and equilibration was used more often (17% vs 1%). Treatment time tended to be longer for positioner patients ($P = .086$).

Most of the pretreatment patient characteristics were related to one or more of the outcomes. The correlations were relatively weak except for obvious relationships like total contacts and number of teeth present ($P < .0001$). However, there was a negative correlation between the DI and either total or near occlusal contacts ($P < .0001$).

Table 3. Comparison Between the Control Group and the Positioner Group in Occlusal Contacts

	All (n = 200)		Control (n = 100)		Positioner (n = 100)		
	Mean	SD	Mean	SD	Mean	SD	*P* Value
Total contacts	32.2	8.4	31.7	8.7	32.6	8.1	.2046
Near contacts	26.2	7.8	25.8	7.9	26.6	7.7	.2579
Actual contacts	5.8	2.3	5.6	2.3	5.9	2.4	.0671
Anterior contacts	5.0	2.4	4.5	2.1	5.5	2.6	.0012
Anterior near contacts	1.4	1.1	1.4	1.0	1.4	1.2	.9647
Actual contacts	6.3	2.4	5.8	2.2	6.9	2.4	.0011
Posterior contacts	21.4	6.7	21.6	6.9	21.2	6.6	.7886
Posterior near contacts	4.4	2.1	4.3	2.1	4.5	2.2	.0922
Posterior actual contacts	25.8	7.3	25.8	7.7	25.7	6.9	.6731

Table 4. Using the American Board of Orthodontics Objective Grading System (ABO OGS) score

	All (n = 200)		Control (n = 100)		Positioner (n = 100)		
OGS Component	Mean	SD	Mean	SD	Mean	SD	*P* Value
Alignment rotation	2.5	1.7	2.8	1.6	2.3	1.7	.0301
Marginal ridge	2.4	1.8	2.6	1.8	2.2	1.7	.1112
Buccolingual inclination	3.5	2.2	3.4	2.2	3.7	2.3	.1683
Overjet	1.8	2.0	2.2	2.3	1.4	1.7	.0052
Occlusal contacts	3.4	2.5	3.5	2.7	3.1	2.3	.3184
Occlusal relationship	2.3	2.3	2.6	2.4	2.0	2.2	.015
Interproximal contact	0.4	0.7	0.5	0.9	0.2	0.4	.0022
Root angulation	2.0	1.6	2.3	1.7	1.8	1.5	.0205
ABO OGS total score	18.3	7.1	19.9	6.9	16.7	7.0	.0009

Table 5. Comparison of Tooth Positioner Group with All Excluded Patients and Patients with Poor Compliance Using the ABO OGS Score

	Tooth Positioner (n = 100)		All Excludes (n = 51)			Poor Compliance (n = 22)		
OGS Component	Mean	SD	Mean	SD	*P* Value	Mean	SD	*P* Value
Alignment rotation	2.3	1.7	3.5	2.0	.0001	4.3	2.1	.0001
Marginal ridge	2.2	1.7	3.2	2.2	.0082	3.7	2.4	.0021
Buccolingual inclination	3.7	2.3	4.2	3.0	.1997	4.2	2.8	.4162
Overjet	1.4	1.7	2.5	2.7	.0012	2.4	2.0	.0199
Occlusal contacts	3.1	2.3	4.7	3.4	.0028	4.2	2.8	.0914
Occlusal relationship	2.0	2.2	2.9	3.3	.0282	3.4	3.9	.0147
Interproximal contact	0.2	0.4	0.9	1.4	.0001	0.7	0.9	.0095
Root angulation	1.8	1.5	2.2	1.5	.3036	2.4	1.5	.1295
ABO OGS total score	16.7	7.0	24.1	10.2	.0001	25.3	8.2	.0001

After adjusting for pretreatment patient characteristics, there were group differences for several outcomes. Patients using the positioner had significantly higher anterior near contacts ($P = .001$), but only marginally higher true contacts ($P = .067$, Table 3). Posterior true contacts were marginally higher ($P = .09$) than for control patients. Patients using the positioner had significantly lower scores ($P = .0009$) in alignment and rotation, overjet, occlusal relationship, interproximal contact, root angulation, and ABO total than control patients (Table 4). All OGS parameters except for axial and buccolingual inclinations were less favorable for patients excluded from the study for poor compliance or any other reason (Table 5).

DISCUSSION

The purpose of this study was to determine if tooth positioners contribute to improvement in the final occlusion primarily by increasing the number of occlusal contacts. This is an important issue for a university graduate program striving for the most efficient treatment to achieve optimal results. Tooth positioners are preferred by some clinicians for achieving details difficult and time consuming to accomplish with fixed appliances. However, other clinicians feel positioners are not worth the added expense and treatment time because the appliance is so dependent on patient cooperation. The results of this study demonstrate that

positioners do increase the quality of the final occlusion, but the improvement is not primarily due to an increase in occlusal contacts.

Durbin and Sadowsky[6] found the average of 36.6 total contacts (near and actual) for orthodontic patients at debond, while Sauget et al[10] reported a mean 34.33 ± 10.45 of total contacts at the end of fixed appliance treatment. In the present study, the tooth positioner group showed total occlusal contacts of 32.58 ± 7.99, and the control group had total occlusal contacts of 31.74 ± 8.69. However, there are important technical issues to consider when comparing these data. In the present study, the occlusal bite registrations were obtained from casts mounted on an articulator. In contrast, in the previous studies, the occlusal bite registrations were taken directly from patients biting into the registration material. Biting force and functional shifts are important uncontrolled variables associated with direct bite registrations. Heavy biting force can create an actual contact by a functional shift or distortion of bone and periodontal ligament. On the other hand, casts are susceptible to distortion error, which is a trade-off for the advantage of being able to control the force when bringing the maxillary and mandibular teeth into occlusion. A combination of both methods would probably be the best index of occlusal contacts. No reports to date have compared the occlusal contacts for both articulated and direct bite registrations in the same patient. This is an important area for future research.

The tooth positioner and control groups showed no significant differences except for the Angle classification ($P = .024$). The tooth positioner group contained fewer class I and more Class II division 2 patients than the control sample (Table 2). Some of pretreatment characteristics were related to one or more outcomes. Overall, the bias of case selection was minimal, particularly since the principal difference (more Class II, division 2 patients) would be expected to bias the positioner sample toward a less desirable ABO OGS score. Knierim et al[11] reported that Class II, division 2 patients in the current series were the most difficult to finish ideally. These data strengthen the conclusion that positioners are valuable for improving the ABO OGS score.

The DI was negatively related to the total contacts, near contacts, posterior contacts, and contacts on premolars ($P < .001$). These data demonstrate that the most difficult malocclusions (elevated DI) were the most challenging with respect to achieving an optimal number of occlusal contacts.

The tooth positioner and control groups did not differ in the number of occlusal contact numbers ($P = .2046$). This result suggests that once a tooth contacts its antagonist it is unlikely to improve in position with additional, short-term positioner wear. Improvement in the number of occlusal contacts during the period of positioner wear could probably be achieved with judicious adjustment of contacts on inclined planes. Occlusal adjustment was not an important factor in the current study because only 17% of positioner patients had any occlusal alterations. Occlusal equilibration did not affect treatment outcome ($P = .9830$), probably because it was performed primarily to remove premature contacts. The latter is a common procedure for many patients during the retention phase.

The present results are consistent with the findings of Vorhies[12] who reported that intrusion and extrusion of teeth with a positioner was unpredictable despite the alteration of the wax set-up. In his study, the mean length of tooth positioner treatment time was 31.8 days. On the other hand, Durbin and Sadowsky[6] reported more teeth in contact over time when positioners were compared with conventional retainers over a 3-month period. In the present study, impressions for final casts were taken after the clinical instructor was satisfied with the outcome, which involved <3 months of wear (mean of 36 days ± 35.63). These results demonstrate that the tooth positioner is able to guide the settling of occlusion after orthodontic treatment in a cooperative patient, even though it is not able to extrude or intrude teeth selectively.[13]

Although there was no difference in actual contacts, the tooth positioner group exhibited more total anterior contacts than the control group (Table 3, $P = .0011$), but the effect was due almost entirely to more near contacts (Table 3, $P = .0012$). These data are consistent with previous research demonstrating that tooth positioners effectively change axial inclinations of the anterior teeth,[12,13] and retain both overbite and overjet corrections.[13]

The tooth positioner group had a significantly (Table 4, $P = .0009$) improved mean ABO OGS score of 16.7 ± 7.0 compared with 19.9 ± 6.9 for the control group. Positioner wear improved alignment and rotation, overjet, occlusal relationship, interproximal contact, and root angulation. ABO OGS scores for the present study were better than the mean of 25.19 ± 11.16 reported by Knierim et al[11] for the same series of patients. This discrepancy is probably due to the exclusion of ''early debond'' patients (premature termination) from the present study.

Nett and Huang[14] reported that the ABO OGS score was improved an average of four points over a 10-year period of retention. However, their areas of improvement are different from the present results. In their research, the biggest improvements were achieved in occlusal contacts and overjet, marginal ridge, and buccolingual inclination. The scores for alignment and rotation deteriorated significantly. It is clear that short-

term positioner wear improves the occlusion by a different mechanism than that reported for long-term retention.

Positioners readily correct rotations of incisors because the shape of these teeth results in a biomechanics couple when the positioner is worn. However, more rounded teeth such as premolars or any severely rotated teeth are not readily corrected by wearing a positioner.[15] With good patient cooperation, positioners are particularly effective for correction and maintenance of lower incisor alignment.[13] In addition, the present study showed a statistically significant (Table 4, $P = .0052$) improvement in overjet score compared with controls.

Positioners have been used effectively to correct second molar crossbites,[15] and to control overjet while minimizing undesirable side effects.[13] However, treatment objectives must be realistic. It is rarely possible to achieve more than 1–2 mm of tipping of individual teeth. If more of a correction is attempted, it is difficult for a patient to wear the positioner because of poor fit and excessive pain. Positioners have been used to guide the mandible into a class I position.[16] Even if an intermaxillary correction is accomplished, it is uncertain that the change will be stable.[15]

Tooth positioners have been used to close band space[15–17] and mandibular diastemas.[13] These reports are consistent with the present results that positioners are effective for closing small amounts of space.

Root angulations were also improved by tooth positioner wear. Even though positioners are not very effective for second order movement, the first order tipping of teeth to correct excessive anterior or posterior overjet can result in a substantial change in the axial inclination of the teeth.[13] First order tipping can result in third order correction if a tooth has increased overjet when fixed appliances are removed. These data are consistent with the present findings that the ABO OGS result is superior for cooperative positioner patients, for all parameters except root angulation and buccolingual inclination (Table 5).

For the present study, patient compliance was assessed by notes in the chart. Poor cooperators were eliminated from the present sample because the objective was to determine if positioners were an effective adjunctive therapy for cooperative patients. However, compliance continues to be the biggest drawback for tooth positioners and is an important consideration in determining the efficacy of the method.[15] It is not uncommon for the patients to experience increased salivary flow, sore teeth, and difficulty breathing.[18] It is important for clinicians to monitor positioner wear objectively. If a patient is wearing the tooth positioner, it should be progressively looser as the teeth move into the desired position.[19]

Clearly, positioners improved the result, but it is not known how much the patients with no positioner would have improved during the same period with posttreatment settling. Future studies should concentrate on comparing the improvement associated with positioner wear, compared with natural settling controlled with retainers, in the same series of patients. A randomized clinical trial of positioners vs conventional retention following fixed appliance removal would be an ideal design. Another important variable to assess is the long-term result (2 years or more) after positioner or retainer refinement at the end of fixed appliance treatment.

CONCLUSIONS

- Although the effect was independent of an increased number of occlusal contacts, tooth positioners did improve the overall orthodontic treatment outcome as quantified by the ABO objective scoring method.
- Tooth positioners are effective short-term adjunctive therapy for enhancing the finish of cooperative patients; the effect is achieved primarily by improving first order alignment.
- If the objective of positioner wear is an increased number of occlusal contacts, judicious adjustment of occluding inclined planes is suggested because vertical movement of teeth is inhibited after an initial occlusal contact is achieved.

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