Efficacy of the mini tooth positioner in improving orthodontic finishes

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Introduction: The primary objective of this study was to assess the effectiveness of the mini tooth positioner in improving the quality of orthodontic treatment outcomes, as measured by the American Board of Orthodontics (ABO) cast-radiograph evaluation (CRE). **Methods:** Thirty patients were treated prospectively with a minipositioner for 4-6 weeks immediately after debond. Sixteen patients who had received a maxillary vacuum-formed retainer (VFR) and fixed mandibular canine-to-canine retainer at time of debond were enrolled retrospectively as control subjects. Models from time of debond (T1) were graded with the use of the ABO CRE and compared with models obtained 4-6 weeks after debond (T2) for each group. **Results:** For the minipositioner group, the overall CRE score improved significantly by an average of 6.77 points. Significant improvements were noted in the categories of alignment and rotations (−0.68), marginal ridges (−1.40), buccolingual inclination (−0.45), overjet (−0.97), and occlusal contacts (−3.00). For the control group, overall CRE score improved significantly by an average of 1.16 points. Only the categories of overjet (−0.38) and occlusal contacts (−1.22) showed significant improvements. **Conclusions:** The minipositioner is an effective tool in improving the overall finish of orthodontic treatment. In the 4-6 weeks after debond evaluated in this study, the minipositioner significantly outperformed the maxillary VFR/mandibular fixed canine-to-canine retainer in improving final treatment outcomes. (Am J Orthod Dentofacial Orthop 2019;155:844-50)

One of the major goals in orthodontics is to deliver high-quality results in a timely and efficient manner. In today's world of rapidly changing technology and constant introduction of new products and techniques, orthodontists are exposed to a variety of treatment modalities that promise faster treatment times and superior results.[1-3] In such a climate, it becomes ever more critical for the prudent orthodontist to emphasize evidence-based care on behalf of his or her patients and resist the temptation to offer treatment modalities that may not actually decrease treatment time or improve final results. With this in mind, the primary focus of any new treatment modality should be to improve the quality of the finish, with a secondary benefit resulting from any accompanying decrease in treatment time.

One of the more challenging aspects in orthodontic treatment comes in the finishing phase, at which time an orthodontist must successfully compensate for individual patient variation from the particular bracket prescription used along with imperfect bracket placement by the practitioner.[4] Although the use of prescription brackets along with skilled bends accomplishes most of the final detailing and finishing movements, maximizing occlusal contacts for function and stability, also referred to as "settling" of the occlusion, often requires additional treatment modalities to produce the quality required to pass the American Board of Orthodontics (ABO) clinical examination. These cases must display a high quality in finishing as evaluated by the ABO cast-radiograph evaluation (CRE), which currently serves as the criterion standard of measuring final treatment outcomes.[5]

One such finishing modality available to clinicians is the tooth positioner, an appliance that has been used in orthodontics for decades after initial introduction by Harold Kesling in 1945.[6] Several studies have verified that the positioner is effective in increasing occlusal contacts, but comparisons with the traditional Hawley retainer yield similar improvements in tooth contacts over time.[7-9] It is also well established in literature that

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vacuum-formed retainers (VFRs), one of the most widely used retention appliances, hold teeth in their debonding position, allowing for minimal to no settling movements.[10-12] In the only known study to evaluate positioner effects as measured with the use of the CRE, Stock et al[13] demonstrated that, in addition to improving occlusal contacts, several other categories also demonstrated significant improvements. Thus, when deficiencies in multiple finishing categories exist, the positioner may be more effective than other methods of retention. The ability to achieve these improvements in a more rapid manner than other forms of settling offers another advantage to positioner use. However, more studies are necessary to validate these findings.

The advent of digital dentistry and new workflows along with positioner design modifications present new variables that should also be investigated. One such appliance now available is the smaller "minipositioner" (TP Orthodontics, Fort Wayne, IN), which is intended to improve patient compliance by targeting the common complaint that traditional positioners are too bulky and uncomfortable (Fig 1).[14] In addition, a practitioner can now create a digital impression before braces are removed, immediately send it to his or her laboratory of choice, and view and modify the digital setup before the appliance is fabricated. Ideally, this should improve laboratory turnaround time along with final outcomes, given that the clinician is able to determine final tooth position rather than blindly trusting the laboratory technician.

To date, the authors are unaware of any published studies evaluating the efficacy of this new class of minipositioner or addressing the digital workflow available for positioner setup and fabrication. The present study aimed to address this gap in the literature by examining the efficacy of the minipositioner fabricated through a digital workflow in improving final orthodontic treatment outcomes. In addition, results would either corroborate or contradict previous studies in regard to the efficacy of the tooth positioner as a finishing appliance. Ultimately, the results of this study should give clinicians the necessary evidence to decide whether or not to implement use of such an appliance in their practices.

MATERIAL AND METHODS

This clinical study included a prospectively enrolled group of 30 patients who were treated with a minipositioner finishing appliance (TP Orthodontics) for 4-8 weeks after removal of braces, along with a retrospectively analyzed control group (CG) of 16 patients who received a maxillary VFRs and mandibular fixed canine-to-canine retainer. All patients were treated at the Graduate Orthodontic Clinic at the University of Texas Health Science Center at Houston. The groups were determined to be well matched based on the average age of the patients, time in total treatment, beginning complexity (Discrepancy Index score), and intervention time, as presented in Table I. This study was reviewed and approved by the Institutional Review Board of the University of Texas Health Science Center at Houston (HSC-DB-17-0096). All methods were performed in accordance with approved guidelines and regulations, including informed consents of prospectively enrolled participants.

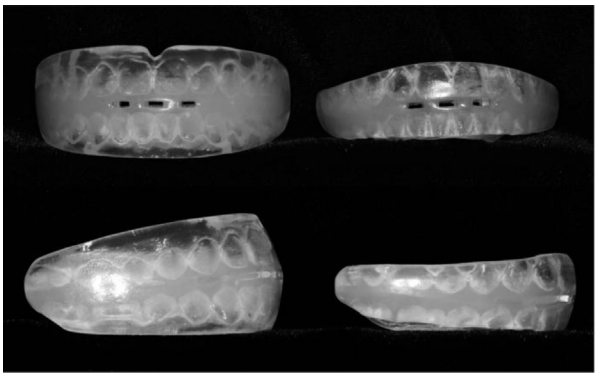

Fig 1. Side-by-side comparison of a traditional positioner (left) and the minipositioner (right).

In deciding on the desired sample size for this study, a preliminary analysis of study power was used. Assuming an effect size of 0.5 and within-subject correlation of 0.5, a sample of 34 patients would be required to achieve a power of 0.8 at the 0.05 significance level. We anticipated that the effect size and correlation are likely actually higher than these values and would therefore require a smaller sample size, but decided to err on the conservative side to ensure validity and strength of the study. In the Stock et al[13] study, on which much of this study design is modeled, a sample size of 34 was used for each group based on a similar analysis of power.

Inclusion criteria for the minipositioner group (MPG) consisted of well treated cases (no early debond) and verbal consent to adhere to the minipositioner wear protocol. Patients with a history of poor compliance or multiple missed appointments were excluded from the study. Owing to time constraints and availability of patients during the enrollment period, only 30 patients were enrolled in the MPG.

Initially, the plan was to use the T1 models of the MPG to serve as their own internal control. The assumption was that there would be minimal change in CRE score for a patient wearing a maxillary VFR and mandibular fixed canine-to-canine retainer during the intervention

Table I. Patient demographics

Group	Age at start of treatment (y)	Treatment time (y)	Intervention time (d)	Initial DI score
Control (n = 16)	15.6 ± 4.7	1.9 ± 0.3	33.6 ± 8.8	17.1 ± 8.4
Minipositioner (n = 30)	15.9 ± 4.7	1.8 ± 0.4	39.5 ± 9.1	19.6 ± 9.8

DI, Discrepancy Index.

time (4-8 weeks). Further review of literature after initiation of this study yielded an article by Hoybjerg et al[15] that reported an average improvement in CRE score of 2.66 points after 1 year of retention for patients who had received a maxillary VFR and mandibular fixed canine-to-canine retainer. This led to a necessary inclusion of a similar retention group as a control to assess the impact of natural settling during the short intervention time used in this study.

Inclusion criteria for the control group consisted of finished cases who received maxillary VFR and mandibular fixed canine-to-canine retention and who also had models made at the time of debond and within 4-8 weeks thereafter. The cases needed to be well treated and well matched with the previously collected MPG sample. Ultimately, a search of existing records from the same group of residents who treated the MPG and satisfying the inclusion criteria yielded 16 patients to include as control.

For patients enrolled in the MPG, a consistent protocol was used. Once patients were determined by presiding faculty to be ready for debond, a fixed mandibular canine-to-canine retainer was placed, a fixed maxillary lateral incisor–lateral incisor retainer was optional, wires were temporarily removed, and a digital impression of both arches and bite registration were made with the use of an iTero scanner (Align Technology, San Jose, Calif). Wires were then replaced with no alterations, so as not to produce any active orthodontic tooth movement. A cephalometric radiograph was also made to determine the patient's individual hinge axis, instead of the facebow mounting traditionally used with stone models. This was included with the digital submission of the STL-format model files and prescription to TP Orthodontics. The same minipositioner design with retention springs mesial to the maxillary first molars, anterior airway for improved comfort and breathing during wear, and medium crystal flex material was used in all cases. The same dedicated laboratory technician was assigned to complete the digital setups and fabrication of all appliances for consistency. Digital setups of final tooth positions were reviewed by the treating clinicians and modified as deemed necessary to produce the desired final occlusion.

After 2-3 weeks, the patient returned to have all appliances removed, full records obtained (T1), and delivery of the minipositioner with wear and care instructions. Patients were instructed verbally and in writing to wear the appliance full-time for the first 2 days, followed by a minimum of 4 hours of active daytime wear and full-time wear at night. This was in accordance with the guidelines recommended by TP Orthodontics.[16] Patients then presented for recall ~4 weeks later. If the patient reported good compliance and the clinician was satisfied with the occlusion, another set of final photographs and models (T2) was obtained. Patients who did not initially report consistent minipositioner wear at this first recall appointment were allowed up to another 4 weeks to wear the appliance. Regardless of compliance, final photographs and models (T2) were obtained at the second recall appointment for these patients. The authors did not take a second panoramic radiograph to assess changes in root angulation, because minimal change would be expected and doing so would expose patients to unnecessary radiation. To calculate total CRE score, the root angulation score from the T1 panoramic radiograph was used for both T1 and T2. Thus, no assessment of changes in root angulation was possible in this study.

At completion of the finishing protocol, a maxillary VFR was fabricated for all patients. The patients were instructed to keep the minipositioner as a backup retainer or to continue using it as the primary retainer if preferred.

Statistical analysis

Each set of models (T1 and T2) was deidentified and assigned a random number for anonymity during grading. Two graders were used in this study: a calibrated ABO examiner of 15 years' experience (J.D.E.) and the primary investigator (P.D.C.), who was calibrated to the ABO grader through repeated grading sessions involved in another research project. The 2 graders assigned a CRE score for each set of models. All analyses were conducted in R (R Development Core Team, Vienna, Austria). An intraclass correlation coefficient (ICC) of 0.954 was calculated from the grading of all 92 sets of models, indicating high intergrader reliability.

Descriptive statistics were reported for the CRE scores from the pre- and posttreatment models of both groups.

Owing to the nonnormal distribution of the data, Wilcoxon (paired) signed rank tests were conducted to assess any statistically significant differences ($P < 0.05$) between time points within each group. Kruskal-Wallis rank sum tests, which do not require balanced designs, were used to evaluate if the differences between the 2 times differed between control and treatment outcomes of the minipositioner. Mean values of graders were used to avoid pseudoreplication.

RESULTS

For the 30 patients included in the MPG, results for each category and overall CRE score are listed in Table II. The mean CRE score at T1 was 27.50. The ranks of individual categories were occlusal contacts 6.72, alignment and rotations 5.33, marginal ridges 4.70, buccolingual inclination 3.53, occlusal relationships 2.93, overjet 2.42, root angulation 1.70, and interproximal contacts 0.17. At T2, after an average of 39.5 days of minipositioner wear, the mean CRE score experienced a significant decrease of 6.77 points. Five individual categories demonstrated a significant reduction in score: occlusal contacts −3.00, marginal ridges −1.40, overjet −0.97, alignment and rotations −0.68, and buccolingual inclination −0.45. Only the categories of occlusal relationships and interproximal contacts did not experience significant change.

For the 16 patients included in the CG, results for each category and overall CRE score are listed in Table III. The mean CRE score at time of debond (T1) was 25.19. In order of greatest to least contribution to the final score, the ranks of individual categories were as follows: alignment and rotations 5.44, occlusal contacts 5.03, marginal ridges 3.88, occlusal relationships 3.66, buccolingual inclination 3.16, overjet 2.09, root angulation 1.88, and interproximal contacts 0.06. After an average of 33.6 days of retainer wear (T2), the mean CRE score for the sample decreased significantly ($P < 0.05$) by 1.16 points. Of the 8 individual categories, only occlusal contacts (−1.22) and overjet (−0.38) demonstrated significant reduction in score. The remaining categories did not change significantly, ranging from slight improvement (−0.06) to slight worsening (+0.25).

A summary of the comparison between the 2 groups in relation to overall change from T1 to T2 and level of significance are listed in Table IV. The most notable result is the difference in the improvement of the overall CRE score between the 2 groups, with the CG improving by an average of 1.16 points compared with an improvement of 6.77 points for the MPG. That is to say, the MPG outperformed the CG by an average of 5.61 points during the intervention times used in this study. When looking at the direct statistical comparison between the CG and MPG for each individual category and overall scores, the MPG significantly outperformed the control group in alignment and rotations, marginal ridges, buccolingual inclination, occlusal contacts, and overall CRE score. There was no significant difference in the other categories, and the CG did not outperform the minipositioner in any category.

Visible changes in occlusion associated with a representative case treated with a minipositioner for 1 month are shown in Figure 2. The case demonstrates an improvement in CRE score of 7 points, which reflects the average change observed of 6.77 points for the minipositioner group. It is also meaningful to look at the overall CRE scores in relation to the threshold of 27 points or less generally resulting in a passing ABO clinical evaluation score.[9] Table V presents the number of patients in each group who earned a passing (≤27) score at each time point. For the CG, 11 of the 16 participants (68.8%) initially

Table II. Minipositioner group results (Wilcoxon paired signed ranks test)

ABO CRE measure	*T1 mean*	*T2 mean*	*Difference*	P
Alignment/rotations	5.33	4.65	−0.68	2.58×10^{-4}‡
Marginal ridges	4.70	3.30	−1.40	1.75×10^{-5}‡
Buccolingual inclination	3.53	3.08	−0.45	0.018*
Overjet	2.42	1.45	−0.97	0.0018†
Occlusal contacts	6.72	3.72	−3.00	5.78×10^{-6}‡
Occlusal relationships	2.93	2.80	−0.13	0.332
Interproximal contacts	0.17	0.03	−0.13	0.072
Root angulation	1.70	N/A	N/A	N/A
Total CRE score	27.5	20.73	−6.77	2.65×10^{-6}‡

*$P < 0.05$; †$P < 0.01$; ‡$P < 0.001$.

Table III. Control group results (Wilcoxon paired signed ranks test)

ABO CRE measure	*T1 mean*	*T2 mean*	*Difference*	P
Alignment/rotations	5.44	5.69	0.25	0.098
Marginal ridges	3.88	3.81	−0.06	0.71
Buccolingual inclination	3.16	3.28	0.13	0.386
Overjet	2.09	1.72	−0.38	0.036*
Occlusal contacts	5.03	3.14	−1.22	0.0012†
Occlusal relationships	3.66	3.78	0.13	0.389
Interproximal contacts	0.06	0.06	0	N/A
Root angulation	1.88	N/A	N/A	N/A
Total CRE score	25.19	24.03	−1.16	0.012*

*$P < 0.05$; †$P < 0.01$.

Table IV. Control group versus minipositioner group (Kruskal-Wallis rank sum test)

ABO CRE measure	*Control difference*	*Positioner difference*	*Chi-square value*	P	*Positioner performs better*
Alignment/rotations	0.25	−0.68	14.89	1.14×10^{-4}	Yes†
Marginal ridges	−0.06	−1.40	16.12	5.94×10^{-5}	Yes†
Buccolingual inclination	0.13	−0.45	5.57	0.018	Yes
Overjet	−0.38	−0.97	2.34	0.126	No
Occlusal contacts	−1.22	−3.00	8.32	0.0039	Yes*
Occlusal relationships	0.13	−0.13	1.72	0.189	No
Interproximal contacts	0	−0.13	2.29	0.121	No
Root angulation	N/A	N/A	N/A	N/A	N/A
Total CRE score	−1.16	−6.77	20.31	6.58×10^{-6}	Yes†

*$P < 0.05$; †$P < 0.01$.

Fig 2. Representative case treated with a minipositioner, demonstrating a 7-point reduction in CRE score from time of debond (top) to 1 month of minipositioner wear (bottom).

Table V. ABO pass rates

Group	*Number passing at T1*	*Number passing at T2*	*Difference*
Control (n = 16)	11 (68.8%)	12 (75.0%)	+1 (6.2%)
Minipositioner (n = 30)	17 (56.7%)	25 (83.3%)	+8 (26.7%)
Total Sample (n = 46)	28 (60.9%)	37 (80.4%)	+9 (19.6%)

demonstrated passing scores. Of the remaining 5, 1 improved such that the T2 score decreased below the passing threshold, leading to an overall pass rate at T2 of 75% for the CG. For the MPG, 17 of the 30 participants (56.7%) had a passing score at T1. At T2, 8 additional participants (26.7%) had achieved passing scores, resulting in an overall pass rate for the MPG of 83.3%. When taken as a combined total sample, 37 of the 46 participants (80.4%) finished this study with a passing CRE score.

DISCUSSION

The performance of the minipositioner used in this study closely mirrors the results from the only other known study evaluating the effectiveness of the tooth positioner as measured by the CRE. After 1 month of positioner wear, Stock et al[13] reported an overall improvement in CRE score of 6.61 points, compared with the 6.77-point improvement found in this study. Not only were the overall score reductions nearly identical, but the individual category improvements also were similar. Improvements in occlusal contacts resulted in nearly half of the overall score reduction in both studies, and significant improvements were also noted in marginal ridges and alignment and rotations. Minor differences were

noted in the categories of buccolingual inclination and occlusal relationships, although neither had profound impacts on the final overall CRE score. The biggest discrepancies were in the categories of overjet, which the present study found to decrease at a significant level compared with no significant change in the Stock et al study, and interproximal contacts, which decreased significantly in the Stock et al study but not in this study. This difference may be explained by the fact that the Stock et al protocol used removal of wires with lacing and up-and-down elastics before positioner wear. They found a significant reduction in overjet before positioner wear due to detorqueing of the upper incisors, limiting opportunity for improvement from positioner wear. Regarding interproximal contacts, very few patients enrolled in this study were treated with the use of molar bands, resulting in an average of only 0.17 points scored in this category, compared with the 2.41 points scored on average in the Stock et al group. Overall, the agreement between the studies strengthens the evidence of the efficacy of the minipositioner as a finishing appliance. With proper compliance, one can expect improvements in several categories, ultimately resulting in a net decrease in overall CRE score of nearly 7 points.

The results of the control group were largely expected and were consistent with the results of the Hoybjerg et al[15] study, which looked at changes in CRE after 1 year of retention in 3 different retention protocols. The maxillary VFR/mandibular fixed canine-to-canine retainer group in that study demonstrated an overall improvement in CRE of 2.66 points, compared with the 1.16-point improvement in this study. The greater improvement in the Hoybjerg study is likely due to the increased settling time of 1 year. It is likely that the CG in the present study would have demonstrated continued improvement in CRE with an increased observation time—up to a certain point. In concert with the Hoybjerg study, only 2 individual categories demonstrated significant improvements: occlusal contacts and overjet. Because there was no mandibular occlusal coverage for these patients, these changes are most likely the result of minor settling of the mandibular dentition. Even so, the results from these studies indicate that the improvements from settling with a maxillary VFR/mandibular fixed canine-to-canine retainer are unlikely to match the results of effective positioner wear.

Although the ABO appears to be phasing out the CRE portion of the clinical examination for certification,[17] the CRE remains the criterion standard in assessing the overall quality of finished orthodontic cases. With this in mind, one of the most striking results from this study was that 8 of the 30 patients (26.7%) in the MPG improved such that they achieved passing CRE scores after initially failing. With an average expected improvement of 6-7 points, the minipositioner offers the ability to significantly improve final orthodontic treatment outcomes in a relatively short period of time.

Of note, the Hoybjerg et al[15] study also found that use of a maxillary Hawley and mandibular fixed canine-to-canine retainer resulted in an improvement in CRE of 6.53 points after 1 year of retention, with significant improvements in 5 of the 8 individual categories. For the ~47% of clinicians regularly using a maxillary Hawley or wraparound retainer,[18] this would therefore indicate that they should expect a similar level of improvement after 1 year of settling compared with 1 month of positioner wear. For the remaining 41% who use maxillary VFRs and 11% who use only maxillary fixed retention,[18] there is an obvious benefit to including the minipositioner as part of the finishing protocol immediately after debond to improve final treatment outcomes. Residents in the university setting may also consider regular use of the minipositioner to achieve these finishing improvements for their patients in a more timely manner, because there is typically insufficient time to allow the months of settling and regular recall possible in a private practice setting.

This study is not without limitations. The authors acknowledge that an increased sample size for the control group to match the treatment group size would have strengthened the quality of the results. The consistency of results with similar previous studies, however, yields confidence that sample sizes were sufficient. Another weakness is that there was no formal recording of compliance with positioner wear. Patients self-reported whether or not they had worn the positioner as directed, and none were excluded, to allow the sample to realistically represent a normal patient population. Pratt et al[19] noted that compliance with orthodontic retention of any kind is generally unacceptable. As such, the authors highly recommend placement of fixed maxillary lateral incisor–lateral incisor and mandibular canine-to-canine retainers before positioner use to limit relapse in those patients noncompliant in positioner wear. Also, patients with a history of noncompliance or long treatment times who may be “burnt out” should not be considered as candidates for any type of positioner appliance.

CONCLUSIONS

Although the minipositioner may not be the appliance of choice for every practice, it is certainly an effective tool when used appropriately. With 4-6 weeks of wear, one can expect an average improvement of nearly 7 points in overall CRE score, with significant improvements in

occlusal contacts, marginal ridges, overjet, alignment and rotations, and buccolingual inclination. The minipositioner statistically outperformed the maxillary VFR/mandibular fixed canine-to-canine retainer, which demonstrated an improvement in CRE of only ~1 point.

In addition to validating the previous evidence of the effectiveness of the tooth positioner in improving final orthodontic treatment outcomes, this study demonstrates that the smaller class of minipositioner appears to be as effective as the traditional tooth positioner. The results also suggest that the digital workflow used in this project, the first noted in association with positioner setup and fabrication, is as effective as the traditional stone model and wax setups used in the past. Although no direct measures of laboratory time savings or faster turnaround time were evaluated, one can appreciate the opportunities for increased efficiency through proper utilization of current digital technology.

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