Original Article

Factors Influencing Child Compliance in Deep Bite Correction with a Removable Anterior Bite Plane

Thanapat Sangwattanarat* Supunsa Pongtiwattanakul** Udom Thongudomporn***

Abstract

Background: An important factor that influences the treatment success of deep bite correction using a removable anterior bite plane (RABP) is patient compliance. To date no studies have reported on the factors that influence patient compliance during treatment with an RABP, especially the wearing protocols. **Objective:** To investigate and compare patient compliance between two RABP wearing protocols: full-time wear with RABP on during meals (F+M), and RABP off during meals (F-M) and to evaluate possible factors that might affect patient compliance. **Materials and methods:** Thirty-three participants with deep bite (mean age 10.88 ± 2.16 years) were randomly assigned to either the F+M (n = 18) or F-M group (n = 15). The ActualWear was individually recorded by a TheraMon microsensor embedded in the RABP for the duration of six months. This study defined compliance as the ratio of actual duration of wearing an RABP (ActualWear) and the recommended duration of wear (RecommendedWear). The RecommendedWear was based on the ideal, but sensible, expected wearing duration of each wearing protocol. The Mann-Whitney *U* test compared between-group differences of compliance, age, gender, wearing protocol, type of motivation, type of school, and parental occupation ($\alpha = 0.05$). **Results:** Patient compliance was significantly influenced by age and type of motivation ($P < 0.001$), but not by the wearing protocol, gender, type of school, or parental occupation ($P \geq 0.05$). **Conclusion:** The RABP wearing protocols did not affect patient compliance. However, age and type of motivation affected patient compliance during RABP use for deep bite correction.

Keywords: Anterior bite plane, Deep bite, Microsensor, Patient compliance, Wear duration

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Corresponding author: Udom Thongudomporn
E-mail: udom.t@psu.ac.th

* Dentist, Faculty of Dentistry, Chiang Mai University, Mueang, Chiang Mai, Thailand
** Dentist, Professional Level, Ranong Hospital, Mueang, Ranong, Thailand
*** Associate Professor, Faculty of Dentistry, Prince of Songkla University, Hat Yai, Songkhla, Thailand

Introduction

Excessive vertical overlapping of the anterior teeth of more than 4 mm is called deep bite.[1] This malocclusion is found in children in the range of 18.40 % to 34.50 %.[2] It can create a range of issues that affect one or more individual teeth, surrounding alveolar bone structures, as well as soft tissues. These problems may occur independently or in conjunction with other malocclusions. The clinical manifestations of a deep bite include shortened lower facial height, flattened mandibular plane angle, decreased gonial angle, large overjet, supraocclusion of incisors, infraocclusion of posterior teeth, and excessive curve of Spee.[3]

Deep bite correction can be achieved by extrusion of posterior teeth, intrusion of anterior teeth, proclination of anterior teeth, and combination treatment. A removable anterior bite plane (RABP) is regularly used for deep bite correction in growing patients by the combination of posterior teeth extrusion and proclination of anterior teeth.[4-6]

The two most recommended RABP wearing instructions found in the literature are full-time wearing, which includes during meals (F+M),[7,8] and full-time wearing except during meals (F-M).[9,10] A previous study found no difference in cephalometric changes between the F+M and F-M wearing protocols, but noted a different rate of deep bite correction.[4] The different rate of deep bite correction may be due to varying levels of compliance between protocols. It is possible that wearing an RABP during a meal might cause patient discomfort that affects cooperation. Conversely, removing the appliance during meals might reduce wearing time if the eating period is prolonged, which potentially leads to inconsistent appliance use.

Assessing patient compliance with removable appliances during wear is challenging. Subjective assessments of patient compliance, such as the patient, parent, or doctor reports, are not reliable. Objective assessment is recommended for a more accurate compliance evaluation to reduce limitations.[11] The TheraMon microsensor offers a solution by detecting temperature when the appliance is worn intraorally. The accuracy of this device in measuring the wearing time of removable orthodontic appliances was demonstrated in previous studies.[12]

The level of compliance in this study was defined as the ratio of the actual duration of wearing an RABP (ActualWear) to the recommended duration specified in each RABP wearing protocol (RecommendedWear). The factors that influence patient compliance with RABP treatment, particularly the wearing protocols, have not been documented in existing studies. This study aimed to compare patient compliance between two RABP wearing protocols: F+M and F-M. Moreover, since several factors, such as age, gender, educational levels, and types of malocclusion, were shown to correlate with patient compliance levels,[13] our secondary objective was to investigate other possible factors that affect patient compliance in wearing an RABP.

Materials and methods

Trial design

This prospective study was approved by the Human Research Ethics Committee of the Faculty of Dentistry, Prince of Songkla University with ethical approval number: EC6601-001. The study was registered at the Thai Clinical Trial Registry under the identifier TCTR20230305001.

Sample size calculation

According to a previous study[14] on the correlation between wearing time and patient compliance, the sample size was calculated using G*Power software version 3.1 (Heinrich Heine University Düsseldorf, Düsseldorf, Germany). The coefficient of standard deviation daily wear time was 0.35, and the effect size was 0.592 with $\alpha = 0.05$ and $\beta = 0.95$. The calculated sample size of this study was 31 participants.

Participants and eligibility criteria

Thirty-three participants were recruited in this study at the Orthodontic Clinic of the Dental Hospital, Faculty of Dentistry, Prince of Songkla University, Thailand. The inclusion criteria were: 1) dental deep bite (overbite > 4 mm); 2) molar Class I or II relationship; 3) Class I or mild Class II skeletal relationship (ANB = 1° – 9°); 4) growing patient (CVM stage ≤ CS5); 5) normo- or hypodivergent pattern (SN-MP < 35°); 6) no signs and symptoms of temporomandibular disorders; and 7) no history of orthodontic treatment. The exclusion criteria were: 1) noncooperative patients; 2) incomplete root formation of the mandibular incisors on panoramic radiography; or 3) long-term use of anti-inflammatory or immunosuppressive medications.

Randomization and blinding

All participants were randomly assigned into either the F+M group or F-M group using computer-generated numbers (random.org). All numbers were randomized before the recruitment, and the generated numbers were printed and enclosed in sealed envelopes. All participants received the sequence from top to bottom. Before entering the trial, all participants with their parents were obligated to furnish written informed consent. The treatment was administered by one orthodontist while data collection and measurements were executed by a single researcher. Due to the known wearing protocol, blinding of both subjects and the orthodontist was not feasible. Nevertheless, blinding was maintained during the statistical analysis for subject identification and allocation.

Demographic data collection

We collected demographic information from all patients before starting the intervention. The demographic data used in this study included age, gender, patient's type of motivation, type of school (private or public), and parental occupation (self-employed or employed). Based on Piaget's theory of cognitive development,[15] children aged 11 and above were found to be significantly more logical than those of earlier age groups. Therefore, the patients were divided into two age groups: < 11 years of age and ≥ 11 years of age. In addition, the type of motivation was defined as either internal or external. Internal motivation refers to the intrinsic factors that drive individuals to seek or adhere to treatment based on personal desires. External motivation, in contrast, is influenced by extrinsic factors such as social influences and parental encouragement.[16] The patient and accompanied guardian were asked at the time of the initial visit for data collection whether the motivation was internal or external. If both internal and external motivation were mentioned, the patient would be classified into an external motivation group because external motivation has an impact on internal motivation.[17]

Appliance design and interventions

All participants were assigned to wear the RABP that consisted of Adam's clasps at the maxillary first molar, a labial bow, and a baseplate with an anterior bite plane made from poly (methyl-methacrylate), which was embedded with a temperature microsensor (TheraMon, Hargelsberg, Austria) near the soft tissue side (Figure 1). The F+M group subjects were informed to wear the RABP full-time with the exception of tooth brushing. On the other hand, the F-M group subjects were informed to wear the RABP full-time except during tooth brushing and meals. All participants were recalled monthly for 6 months. All participants were instructed to avoid cold drinks or foods and not to soak the appliance in warm or hot water.

Wearing duration measurement

The objective wearing duration was recorded using the TheraMon microsensor embedded in the RABP. Data from the microsensor was transferred to a computer via radio frequency identification using the TheraMon pen reader. All data were analyzed using

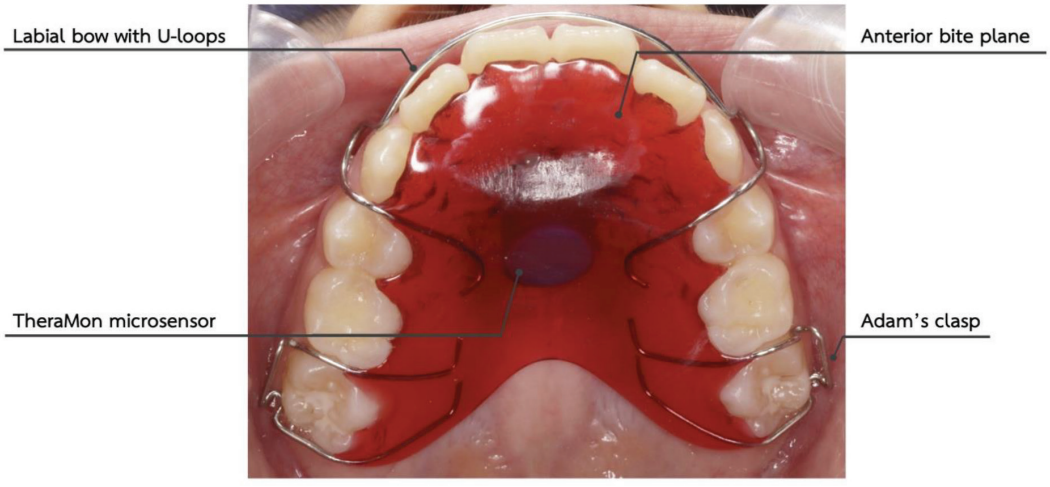

Figure 1 Removable anterior bite plane with TheraMon microsensor.

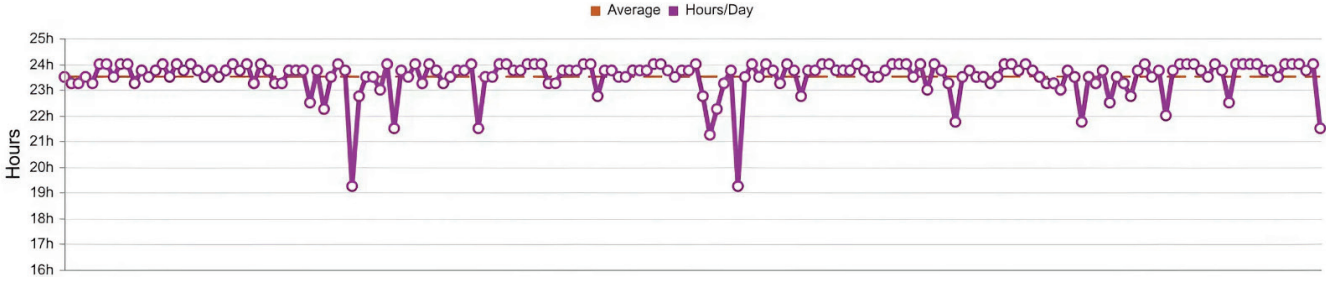

Figure 2 Output data from the TheraMon software demonstrating the average and actual wearing duration per day.

TheraMon software (Figure 2). The total wearing time for the duration of 6 months was recorded.

Eating duration evaluation

All participants were asked to self-report the duration of a typical meal. These individual reports were then used to calculate the mean eating duration for one meal across all participants. The estimated total eating time for the 6-month study period was then calculated based on this mean eating duration.

Patient compliance measurement

After six months of wearing the RABP, the actual wearing time (ActualWear) was the objective wearing time that was recorded from the microsensor. The recommended wearing duration (RecommendedWear) was calculated from six months duration (4,320 hours). The estimated eating duration for six months was calculated from the patient's self-report, and for brushing time, the recommended two minutes per brushing period.[18]

Patient compliance percentage (% Compliance) was calculated using this equation:

$$\% \text{ Compliance} = \frac{\text{ActualWear}}{\text{RecommendedWear}} \times 100\ \%$$

The RecommendedWear for the F+M group was calculated from this formula:

$$\text{RecommendedWear}_{(F+M)} = (\text{6 months duration}) - (\text{brushing time})$$

The RecommendedWear for the F-M group was calculated from this formula:

$$\text{RecommendedWear}_{(\text{F-M})} = (\text{6 months duration}) - (\text{brushing time}) - (\text{eating time})$$

Statistical analysis

The Statistical Package for Social Sciences (SPSS version 29, SPSS Inc., IBM, Armonk, NY, USA) was used for the statistical analysis. The Shapiro-Wilk test showed that all data were non-normally distributed. The Mann-Whitney *U* test was performed to compare the differences between the two groups. The Spearman's rank correlation coefficient was performed to examine the correlation between initial overbite and patient compliance. The significance level was set at 0.05.

Results

A total of 36 participants were recruited; however, three participants declined to participate. The remaining 33 subjects were randomly assigned into the F+M and F-M groups with a 1:1 allocation ratio. No dropouts occurred during this trial. Table 1 shows the baseline characteristics. The average participant age in this study was 10.88 ± 2.16 years (range 8-14 years) with 15 males and 18 females. The average initial overbite was 5.51 ± 1.47 mm.

Between-group comparisons indicated no significant differences in the average meal time per day between the F+M and F-M groups ($P \geq 0.05$) (Table 2). However, the average daily wearing time in the F+M group was significantly higher than in the F-M group ($P < 0.001$) (Table 2).

Table 1 Characteristics of the participants before observation.

Variable	Mean ± SD
Age (y)	10.88 ± 2.16
Initial overbite (mm)	5.51 ± 1.47
Gender, n (%)	
Male	15 (45.45 %)
Female	18 (54.55 %)
Wearing protocol, n (%)	
F+M	18 (54.55 %)
F-M	15 (45.45 %)

F+M, full-time appliance wearing except for tooth brushing; F-M, full-time appliance wearing except for meals and tooth brushing.

Table 2 Average wearing times and average meal times in each wearing protocol.

	F+M (Mean ± SD)	F-M (Mean ± SD)	*P* value
Average daily wearing time (hour)	22.68 ± 1.34	19.60 ± 2.38	< 0.001***
Average meal time per day (min)	103.94 ± 19.32	98.87 ± 12.44	0.388

F+M, full-time appliance wearing except for tooth brushing; F-M, full-time appliance wearing except for meals and tooth brushing. *P* value of Mann-Whitney *U* tests.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Table 3 Comparisons of the percentages of patient compliance[+] in each variable.

Variable	Compliance percentage (%, Mean ± SD)	*P* value
Age		
< 11 years old (n = 14)	89.50 ± 10.15	0.005**
≥ 11 years old (n = 19)	97.67 ± 4.45	
Gender		
Male (n = 15)	94.16 ± 5.63	0.625
Female (n = 18)	93.32 ± 10.75	
Wearing protocol		
F+M (n = 18)	95.61 ± 5.66	0.233
F-M (n = 15)	91.42 ± 11.10	
Motivation type		
Internal (n = 17)	88.37 ± 9.83	< 0.001***
External (n = 16)	98.73 ± 2.26	
School type		
Private school (n = 20)	94.68 ± 6.58	0.941
Public school (n = 13)	92.21 ± 11.34	
Parental occupation		
Self-employed (n = 15)	92.69 ± 10.14	0.426
Employed (n = 18)	94.55 ± 7.46	

[+]Patient compliance percentage was calculated using this equation:

$$\text{Compliance percentage} = \frac{\text{ActualWear}}{\text{RecommendedWear}} \times 100\%$$

F+M, full-time appliance wearing except for tooth brushing; F-M, full-time appliance wearing except for meals and tooth brushing. *P* value of Mann-Whitney *U* tests.

* $P < 0.05$, ** $P < 0.01$, *** $P < 0.001$

Patients under 11 years old had a significantly lower compliance percentage than patients aged 11 years and over ($P < 0.001$). The compliance percentage was significantly higher in participants with external motivation than in participants with internal motivation ($P < 0.001$). However, there were no significant differences in compliance percentages between genders, wearing protocols (F+M or F-M), private and public schools, or parental occupations (self-employed versus employed) ($P \geq 0.05$) (Table 3). The correlation between initial overbite and patient compliance was not significant (r = 0.005; $P = 0.980$).

Discussion

The success of deep bite correction in growing patients using an RABP often relies on patient compliance in following the wearing instructions. A patient's willingness to cooperate and adhere to all treatment recommendations can significantly influence orthodontic treatment outcomes.

Based on the RABP wearing protocols, the F+M group had a longer instructed wearing duration than the F-M group. Moreover, the F+M group tended to have higher patient compliance than the F-M group, but the difference was not statistically significant. The average meal time per day observed in this study was

similar in both groups but higher than that reported for American teenagers aged 15 and older.[19] This study found that the RABP wearing protocols did not impact patient compliance. This might be because the protocols differed only during meals, which may not have affected the patients' habits of wearing the RABP after mealtime. In this study, both male and female observed compliance levels were comparable. This finding contrasts with the results of a previous study,[13] which reported that females generally had a higher cooperation level than males. On the other hand, another previous study[20] reported that males had more significant compliance with clear aligner therapy than females. This might be attributed to variations in individual parental care provided within each family. Different levels of parental involvement and support could influence the compliance behaviors of children regardless of their gender.

This study found that patients under 11 years of age were less compliant than patients aged 11 years and over. This result was consistent with previous studies[21,22] that reported younger patients were generally less mature and motivated than older patients, which led to lower compliance. However, several studies[23-25] have found no relationship between age and compliance. These conflicting results may be due to factors such as the development of an independent identity and variations in parental attention.[26]

A previous study[27] reported that laypeople had low recognition of deep bite and high esthetic tolerance for it. Our study found that the amount of initial overbite had no effect on patient compliance. This may be because the patients did not recognize deep bite as a problem. Moreover, parental recognition of the deep bite may not have been sufficient to encourage appliance wearing in accordance with the orthodontist's instructions.

The type of school (private or public) attended by the patients in this study did not have a direct effect on compliance levels. The nature of the educational institution does not influence patient adherence to the RABP wearing instructions. However, one study[28] reported that knowledge of a patient's performance in the school environment might assist in predicting compliance levels. This discrepancy highlights the need for further research. Future studies should explore potential factors within the school environment that might impact patient compliance beyond the simple classification of schools as either private or public.

Parental occupation had no effect on the level of patient compliance in our study. This might be due to individual differences in education and parenting styles. However, a previous study[29] found that the mother's occupation had a significant effect on changing the compliance level in growing patients. Moreover, our study did not include other parental factors that might influence compliance, such as parental involvement or attitudes towards orthodontic treatment.

Participants with external motivation had a higher compliance percentage than those with internal motivation, which might be explained by factors such as parental attitudes. The external reasons for seeking orthodontic treatment were primarily from the parents. This finding was consistent with previous studies, which showed that parental involvement can significantly impact a child's compliance during orthodontic treatment.[30-32]

The TheraMon microsensor provides precise measurements of wearing duration that surpasses the accuracy of traditional data collection methods such as self-report logbooks.[33] This study collected the duration times of wearing the RABP daily using the objective measurements of the TheraMon microsensor. Participants in the F+M group were expected to wear the appliance for nearly 24 hours daily, while those in the F-M group were expected to maintain an average daily wear time of 22.50 hours (accounting for an average meal time of about 1.50 hours per day). The observed average daily wearing durations were 22.68 hours for the F+M group and 19.60 hours for the F-M group, which was the result of 91 % to 96 % compliance with the wearing instructions. The recorded

wearing duration might have been affected by the Hawthorne effect,[34] as patients were aware of being closely observed. In real-life conditions, the level of compliance might be lower than in these experimental conditions. Additionally, a recent study[4] found that wearing an RABP for a longer duration resulted in a faster rate of deep bite correction. Further investigation of the association between the rate of deep bite correction and patient compliance is required.

The factors affecting patient compliance during deep bite correction with an RABP include age and type of motivation. Younger patients should receive compliance reinforcement to increase compliance. Moreover, motivation from parents is also the key to successful treatment with removable orthodontic appliances.

Conclusion

The removable anterior bite plane wearing instructions did not affect patient compliance. Both the F+M and F-M wearing protocols had similar compliance levels. Patient adherence during deep bite correction with a removable anterior bite plane was affected by age and type of motivation.

Author contributions

TS: Conceptualization, Methodology, Software, Formal analysis, Data curation, Writing-Original draft preparation; SP: Methodology, Formal analysis; UT: Visualization, Investigation, Resources, Supervision, Funding acquisition, Writing-Reviewing and Editing, Project administration.

Ethical statement

This research protocol was approved by the Human Ethics Committee of the Faculty of Dentistry, Prince of Songkla University, with Ethical Approval Number: EC6601-001.

Disclosure statement

The authors have no conflicts of interest.

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