Original Article

Masticatory function after bite-raising with light-cured orthodontic band cement in healthy adults

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ABSTRACT

Objectives: To evaluate the effects of bite-raising with light-cured orthodontic band cement, a method commonly used in contemporary orthodontic treatment, on masticatory function, as assessed by objective and subjective methods.

Materials and Methods: The objective evaluation of masticatory performance and subjective evaluation of masticatory ability were performed on 30 healthy volunteers (19 females and 11 males, 22.3 $\pm$ 1.56 years) with a normal occlusion. Assessment was performed before and immediately after bite-raising. The bite-raising was done by adding light-cured orthodontic band cement ($3 \times 5 \times 2$-mm width $\times$ length $\times$ height) on the palatal cusps of the upper first molars. The masticatory performance index (MPI) was calculated from chewed test food particles using a sieving method. For the subjective evaluation, the participants performed the food intake ability (FIA) test using a questionnaire with six types of food. The correlation between the evaluation methods was determined.

Results: The MPI and FIA scores of the participants were significantly reduced after bite-raising ($P < .001$). The MPI and FIA score reduction was not significantly different between females and males. No significant correlations were found between the changes in MPI and FIA scores.

Conclusions: Masticatory function after bite-raising with light-cured orthodontic band cement was immediately reduced, both objectively and subjectively. However, because there was no significant correlation between the objective and subjective results, an individual may not perceive his/her decreased masticatory ability to the same degree as masticatory performance was reduced. Further study is required to evaluate the long-term adaptation to this bite-raising method. (*Angle Orthod.* 2020;90:263–268.)

KEY WORDS: Bite-raising; Masticatory ability; Masticatory performance; Vertical dimension

INTRODUCTION

Bite-raising is often needed as an initial temporary phase in treating orthodontic patients with an anterior crossbite or deep overbite.[1] This short-term treatment phase is necessary to keep specific groups of teeth out of occlusion and to prevent full jaw closure. Adding light-cured orthodontic band cement on the occlusal surfaces of the posterior teeth is a convenient bite-raising method with which to eliminate occlusal interferences from blocking tooth movement.[2]

Compared with conventional removable orthodontic appliances with posterior bite planes, this method is hygienic, minimizes bulkiness, reduces interference with speech, and is less intrusive on the tongue space. This method is also recommended for uncooperative patients because it requires minimal compliance.[2,3] Posterior bite-opening using this method resulted in spontaneous anterior crossbite correction in the mixed dentition.[4]

There are concerns, however, that this method is not consistent with the concept of an optimized functional occlusion. Functional occlusion is essential for even and simultaneous intercuspal contact on all posterior teeth and to provide axial loading of occlusal forces, leading to functional equilibrium in the masticatory musculoskeletal system.[5] During bite-raising using

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orthodontic band cement, the cement is applied bilaterally on the occlusal surfaces of the maxillary first molars, resulting in only two occlusal contacts—thus, it does not contribute to a functional occlusion. However, the effect on masticatory function and the potential impairment when using this method have not been determined. A previous study[6] revealed that superficial masseter and anterior temporalis electromyography (EMG) activity was reduced immediately during clenching and chewing after the application of this bite-raising method. It was subsequently hypothesized that masticatory function would be affected by this bite-raising method.

The objective evaluation of masticatory performance and the subjective evaluation of masticatory ability are considered effective for quantifying masticatory function.[7] There are various methods for objectively evaluating masticatory performance. Several studies determined masticatory performance as the percentage (by weight) of the chewed particles that passed through a standard sieve after a fixed number of chewing strokes. Although not easily performed in the clinic, this sieving method is considered to be a reliable and valid method for assessing masticatory performance.[8] The subjective methods include a questionnaire to determine the self-assessed ability to chew several types of foods. The food intake ability (FIA) questionnaire has been used as an effective tool with which to evaluate the masticatory ability in clinical settings.[9,10] However, one study[11] found no agreement between objective and subjective measures of mastication in healthy subjects, which indicates the need to use both methods to evaluate masticatory function.

The aim of this study was to evaluate masticatory function, objectively and subjectively, before and after the application of the orthodontic band cement bite-raising method in normal occlusion participants. Thus, both masticatory performance and masticatory ability were quantified based on the subject's chewing efficiency and questionnaire responses, respectively. The correlation between the evaluation methods was also investigated.

MATERIALS AND METHODS

This study was approved by the Human Research Ethics Committee of the Faculty of Dentistry, Chulalongkorn University (HREC-DCU 2015-090).

Study Participants

The sample size was calculated based on a priori information from a pilot study using the formula for testing the mean of two dependent populations ($n = [Z_{\alpha/2} + Z_{\beta}]^2 \times \sigma^2/[\mu_1 - \mu_2]^2$). The calculation indicated that 29.7 samples were required to achieve a power of 80% and a 5% significance level. Thus, the study participants consisted of 30 healthy volunteers, randomly recruited from dental students at the Faculty of Dentistry, Chulalongkorn University. The participants comprised 19 females and 11 males aged 18–25 years who gave informed consent to participate in this study. The inclusion and exclusion criteria were previously described.[6] Briefly, all participants had a Class I occlusion, a positive overjet and an overbite of $<$3 mm, skeletal normal bite, full permanent dentition without third molars, no edentulous areas, no significant facial deformity, no signs or symptoms of temporomandibular disorders, and no orthodontic treatment in the past 3 years.

Experimental Design

The evaluations were conducted during two visits, with 1 week between the visits. During the first visit, the participants' objective and subjective masticatory function were recorded to determine their baseline levels before the bite-raising intervention. At the second visit, bite-raising using light-cured orthodontic band cement was performed on the palatal cusps of the upper first molars, as described in a previous study.[6] Briefly, after polishing, rinsing, drying, and isolating the occlusal surfaces of the respective molars, Ultra Band-Lok BLUE (Reliance Orthodontic Products Inc, Itasca, Ill) was applied in a thermoplastic sheet template (3 $\times$ 5 $\times$ 2-mm width $\times$ length $\times$ height trapezoid slot) and placed on the isolated occlusal surfaces. A light-curing unit, providing a minimum of 600 mW of continuous output, was used to cure the material by positioning the tip adjacent to the occlusal surface of the molars for 30 seconds. The occlusion was evaluated by identifying an occlusal contact on each side, as described by Anderson et al.[12] The interocclusal distance was set at 2 mm, measuring from the mesio-buccal cusp of the upper first molar to the buccal groove of the lower first molar. The bite-raising material was removed using adhesive-removing pliers after evaluating masticatory function. All intervention procedures and measurements were performed by the same examiner and during the same period of the day.

Objective Evaluation of Masticatory Performance

Masticatory performance was determined (at the first and second visits) by having the participants naturally chew artificial test food on their preferred side, as previously descibed.[13,14] Briefly, the artificial test food (20 mm in diameter, 5 mm thick) was made of a polydimethylsiloxane condensation silicone impression material, OptoSil (Heraeus Kulzer GmbH, Hanau, Germany), which was cut into four equal parts to allow

Table 1. Participants' Demographic Characteristics (Mean ± Standard Deviation)

	Female (n = 19)	Male (n = 11)	Total
Age, y	21.95 ± 1.65	22.91 ± 1.22	22.30 ± 1.56
Overbite before bite-raising, mm	2.18 ± 0.69	2.63 ± 0.46	2.35 ± 0.65
Overbite after bite-raising, mm	−0.74 ± 0.73	−0.26 ± 0.56	−0.57 ± 0.70
Overbite change, mm	2.92 ± 0.19	2.88 ± 0.23	2.90 ± 0.20

the experiment to be repeated four times. After each quarter was chewed for 20 strokes, the chewed particles were expectorated onto a filter paper placed over a beaker. The participants were asked to rinse their mouth with water until all the particles were removed. The masticated particles were dried in an oven at 80°C for 1 hour and then weighed (W1) on an 0.01-g analytical balance, separated using a standard sieve with a 4-mm mesh size, stacked on a mechanical shaker, and vibrated (Vibratory Sieve Shaker AS 200 digit) for 2 minutes.[8,13] The masticated food that passed through the standard sieve was weighed on an 0.01-g analytical balance (W2). The degree of fragmentation of the chewed food of each subject was quantified by the mastication performance index (MPI), which is the percentage of masticated food (by weight) that passed through the standard sieve (MPI = W2/W1 × 100).[8]

Subjective Evaluation of Masticatory Ability

The Food Intake Ability (FIA) test was performed (at the first and second visits) using a validated and reliable self-assessment questionnaire concerning the participants' masticatory ability while chewing six different test foods. These foods were the artificial test food, tofu, cookies, ham, apples, and watermelon.[10,15] The participants scored the FIA questionnaires after chewing each food. This questionnaire used a five-point Likert scale evaluating masticatory ability as follows: cannot chew at all (1 point), difficult to chew (2 points), cannot say either way (3 points), can chew some (4 points), and can chew well (5 points).[10,15] The total FIA score was calculated as the average score for the six foods. The average scores of the three hard foods (test food, cookies, and apples) and the three soft foods (tofu, ham, and watermelon) were also calculated separately.

To assess the intrarater reliability for subjective evaluation of masticatory ability, the subjects performed two FIA tests (conducted 1 week apart) without intervention. The intrarater reliability was determined using the intraclass correlation. The intraclass correlation coefficients (ICCs) for the total FIA, the FIA score for hard food, and the FIA score for soft food were 0.924, 0.911, and 0.750, respectively, indicating excellent reliability of the total FIA and hard food FIA scores and good reliability of the soft food FIA scores.[16] In addition, the interrater correlation was calculated for the subjective method at baseline using the ICC, and the results were 0.977, 0.978, and 0.761 for the total, hard food, and soft food FIA scores, respectively. These interrater correlations indicated that the participants had an excellent degree of agreement for the total and hard food rating score, while the soft food agreement was good between raters.[16]

Statistical Analysis

Data normality was verified using the Kolmogorov-Smirnov test for each variable. The MPI and FIA scores were compared before and after bite-raising using the paired *t*-test or the Wilcoxon signed-rank test as a parametric or nonparametric test, respectively. In addition, to determine whether this bite-raising method had a different effect on female and male masticatory function, the mean difference in scores before and after bite-raising between females and males was compared using the independent *t*-test or Mann-Whitney *U*-test based on the normality of the data.

Pearson's rank correlation was performed to evaluate the correlation between the change in MPI and FIA scores after bite-raising. The significance level was set at .05. All statistical analyses were performed using SPSS software version 17.0 (IBM, Chicago, Ill).

RESULTS

The demographics of the study participants are shown in Table 1. The participants had a mean age of 22.30 ± 1.56 years, with a male:female ratio of 1:1.7. The mean overbite decreased by 2.90 ± 0.20 mm after performing bite-raising.

The MPI and FIA scores significantly decreased after applying the bite-raising method (Table 2). The mean MPI score was reduced by 43.3%, and the total FIA score was reduced by 14.6%. The FIA subscores for hard food and soft food decreased by 21.3% and 14.0%, respectively. These results indicated that both masticatory performance (objective masticatory function) and ability (subjective masticatory function) parameters were significantly decreased after applying the bite-raising method.

The results were also analyzed based on sex (Table 3). The mean MPI, total FIA, and FIA subscores for hard food and soft food for females were reduced by 40.8%, 11.7%, 13.6%, and 9.3%, respectively. For

Table 2. Mean ± Standard Deviation MPI and FIA Scores Before and After Bite-Raising in All Participants[a]

	Before Bite-Raising	After Bite-Raising	Mean Difference (95% CI)	*P*-Value
MPI	88.06 ± 15.43	49.91 ± 12.40	38.15 (32.58–43.72)	<.001*
FIA				
Total FIA score	4.69 ± 0.25	4.02 ± 0.57	0.68 (0.4–0.89)	<.001**
Hard food FIA score	4.43 ± 0.41	3.71 ± 0.67	0.72 (0.46–0.98)	<.001**
Soft food FIA score	4.94 ± 0.15	4.33 ± 0.58	0.61 (0.40–0.82)	<.001**

[a] MPI indicates masticatory performance index; FIA, food intake ability; and CI, confidence interval.
* Significant difference ($P < .05$, paired *t*-test).
** Significant difference ($P < .05$, Wilcoxon signed-rank test).

males, the means of these variables were reduced by 44.2%, 18.7%, 19.9%, and 17.7%, respectively. No significant differences were found in the mean difference in scores before and after bite-raising between females and males.

The correlation analysis between the objective and subjective assessments on masticatory function found no significant correlations between the change in MPI and FIA scores before and after bite-raising (Table 4).

DISCUSSION

This study investigated the immediate effect of short-term bite-raising using light-cured orthodontic band cement on masticatory performance and masticatory ability. Based on the results, the participants' masticatory function, assessed both objectively and subjectively, was reduced immediately after bite-raising. However, no significant correlation was found between the two evaluation methods after the intervention.

The significant MPI reduction found after bite-raising was consistent with that noted in previous studies.[17,18] Hatch et al.[17] demonstrated a reduction in MPI with a decreased number of posterior occlusal units. In addition, an uneven distribution of these occlusal units was shown to influence masticatory performance.[17] Julien et al.[18] also reported an association between masticatory performance and occlusal contact area. Conversely, after bite-raising with a full-arch maxillary splint (ranging from 2 to 6 mm), researchers found no significant changes in masticatory performance[19] or in the EMG activity of the superficial masseter and anterior temporalis muscles during rest or maximal biting.[20] These studies suggested that raising the occlusal bite evenly in all teeth did not impair objective masticatory function. Thus, the reduction in MPI in the current study could have resulted from the decreased occlusal contact area for shearing and grinding food. The results were in agreement with those of Dahlstrom and Haraldson,[20] who suggested that the reduced EMG activity of the superficial masseter and anterior temporalis muscles when using bite plates was due to the smaller occlusal contacts on the bite plates. However, the current experimental model included only two occlusal surfaces on the upper first molars to raise the bite, as per usual clinical orthodontic practice.[4,21] It would be interesting to test whether an improvement in masticatory performance could be achieved when using this method by applying the orthodontic band cement on more than two occlusal surfaces, and this should be investigated in a future study. This information would be useful in developing a standard protocol for bite-raising with this method regarding its impact on patients' quality of mastication.

Individual factors known to affect masticatory function, such as age, number of functional tooth units, and malocclusion,[22,23] were controlled for in this study. The artificial test food was prepared as previously described to standardize the test food.[14] A single sieve method was used to compare the masticatory performance before and after bite-raising. The single sieve method is a convenient and reliable test with which to determine the masticatory performance of the participants if the sieve aperture does not deviate too much

Table 3. Mean ± Standard Deviation MPI and FIA Scores Before and After Bite-Raising by Sex[a]

	Female (n = 19)			Male (n = 11)			
	Before Bite-Raising	After Bite-Baising	Mean Difference (95% CI)	Before Bite-Raising	After Bite-Raising	Mean Difference (95% CI)	*P*-Value
MPI	83.51 ± 17.24	48.08 ± 11.71	35.44 (28.65–42.22)	95.92 ± 6.96	53.08 ± 13.49	42.84 (32.19–53.48)	.196
FIA							
Total FIA score	4.66 ± 0.26	4.11 ± 0.56	0.55 (0.28–0.83)	4.98 ± 0.24	3.86 ± 0.59	0.89 (0.51–1.26)	.133
Hard food FIA score	4.40 ± 0.41	3.79 ± 0.67	0.61 (0.28–0.95)	4.48 ± 0.43	3.58 ± 0.67	0.91 (0.43–1.39)	.250
Soft food FIA score	4.93 ± 0.18	4.47 ± 0.57	0.46 (0.20–0.71)	4.97 ± 0.10	4.10 ± 0.56	0.88 (0.51–1.24)	.057

[a] MPI indicate masticatory performance index; FIA, food intake ability; and CI, confidence interval. *P*-value from comparison between mean difference in females and males (independent *t*-test for MPI, Mann-Whitney *U*-test for total, hard food, and soft food FIA score).

Table 4. Correlations Between the Change in MPI and FIA Scores Before and After Bite-Raising[a]

	MPI	
	ρ	*P*-Value
Total FIA score	0.046	.810
Hard food FIA score	−0.127	.503
Soft food FIA score	0.058	.761

[a] MPI indicates masticatory performance index; FIA, food intake ability.

from the median particle size of the chewed food.[8] Thus, the sieve aperture was chosen based on the median particle size found in the pilot study.

The FIA test was used to assess masticatory ability subjectively based on previous studies.[9,10,24] A Likert scale was used to determine the ability to consume five types of foods and included the artificial test food in the hard food category. The modified number of foods was due to the recommendation to adjust the food list to be suitable for each country[10] and due to the study design, which assessed the immediate effect after temporary bite-raising. The total FIA and the FIA scores for hard food and soft food were significantly reduced by bite-raising. These results were in agreement with those of a study[24] that found lower FIA values in the participants with insufficient occlusal contact. Because the participants in the current study had a severely reduced occlusal contact area during bite-raising, they needed more effort to bring the food to this limited area to break it down. The soft food score was higher compared with that of the hard food. This was because soft food rarely needs to be thoroughly broken down before swallowing.

The current study found no significant difference in the reduction in MPI and all FIA scores between females and males. However, further research using a larger sample size of both sexes is needed to confirm these results.

It was also found that upon bite-raising, there were no significant correlations between the change in MPI and FIA scores. These findings were consistent with those of previous studies[11] that showed no correlation between masticatory performance and self-assessed chewing ability. This may indicate that although the objective masticatory function was reduced, the participants rarely perceived the same degree of weakened masticatory function.

The limitations of this study included the fact that we recruited only healthy adults with a normal occlusion. The effects on these participants may not be completely generalized to patients with malocclusion who need bite-raising during orthodontic treatment. Another limitation was the short evaluation period. It cannot be ruled out that a biological adaptation process might occur if this bite-raising method was used long term. A recent study[25] demonstrated a decrease in chewing efficiency and worse Oral Health Impact Profile (OHIP) questionnaire scores immediately after inserting oral appliances with an occlusal flat table in healthy subjects; however, the OHIP scores of all subdomains, except that of psychological discomfort, improved within 5 days after insertion. The FIA scores after bite-raising in the current study might have improved similarly if longer observation periods were used. However, a long-term investigation with healthy subjects was not possible as a result of ethical concerns. Thus, further studies with a longer follow-up evaluation are required to determine the adaptation period in patients undergoing this bite-raising method.

CONCLUSIONS

- A significant reduction in masticatory function was found immediately after the application of bite-raising with light-cured orthodontic band cement, as assessed both objectively and subjectively. However, there was no significant correlation between the change in objective and subjective scores.
- Future studies with this bite-raising method should evaluate subjects over a longer time frame and should compare this method with conventional removable orthodontic appliances that use flat posterior bite planes.

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