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Comparison of Maximal Bite Force in Children Undergoing Adenotonsillectomy: A Prospective Case-control Study with 6-month Follow-up

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Abstract

Objective: This study investigated the early and late postoperative maximal bite force (MBF) values in pre-pubertal children undergoing adenotonsillectomy (AT) and compared them with healthy control.

Methods: A total of children aged 6-12 years, diagnosed with chronic obstructive adenotonsillar hypertrophy (COATH), undergoing AT (n=30), and healthy controls (n=30) were included. The MBF and body mass index (BMI) were recorded for up to sixth months. The duration of active surgery was recorded. The visual analog scale (VAS) was applied to the patients for the pain on postoperative first and seventh days.

Results: There was no significant difference in MBF values between the groups from the baseline to sixth month ($p>0.05$). A statistically strong positive correlation was observed between MBF and age ($p<0.05$). A significant difference was observed in MBF changes in patients with duratşon of active surgery more than 20 min compared with those with less from the baseline to the first month ($p<0.05$). In the study group, it was observed that there was a low and moderate correlation in the mean changes between the MBF and BMI in the first, 7th day, and 1st-month matches ($p<0.05$). The VAS scores did not show a significant correlation with the MBF values ($p>0.05$).

Conclusion: The COATH and sex did not have a significant effect on MBF in pre-pubertal children, but age did. The postoperative MBF values were reached in the 1st month almost baseline values and there was a rapid increase between three and six months after AT. The prolonged operative time may affect MBF during one month postoperatively.

Keywords: Bite force, adenotonsillectomy, temporomandibular joint, pain, biting

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INTRODUCTION

Adenotonsillectomy (AT) is one of the most common surgeries performed during childhood. The most important complications that surgeons deal with include postoperative pain and bleeding (1). Besides these, temporomandibular joint (TMJ) dislocation, tooth loss, mandible condyle fracture, masseter muscle (MM) tenderness, and tooth enamel fracture have been reported due to the use of a mouth retractor (2).

Chronic diseases of the adenoid and tonsils, hypersomnia with sleep apnea, and adenoid vegetation (AV) are among the indications, although chronic obstructive adenotonsillar hypertrophy (COATH) has come to the fore recently (3). Growth and development decrease in children who suffer from COATH compared with their healthy peers (4).

Maximal bite force (MBF) is defined as the maximum force applied by a person while deliberately biting through an object. In childhood, the relationship between MBF with masticatory dysfunctions, occlusal condition, maxillofacial morphology, and demographic factors has been shown in previous studies (5,6-9).

A mouth gag was used during the AT to provide a better view of the tonsillar fossa and to fix the mouth opening. However, the view may change according to the condition of the masticatory and oro-dental structures such as TMJ, MM, mandibular body, teeth, and accordingly, more or less force can be applied through the mouth gag. The mouth gag used during AT may affect these structures, which allow the biting and chewing function.

The MBF measurements are used in studies conducted on orthodontic interventions and structural factors that cause pain in TMJ and MM (5,7,8,10,11). Studies have shown that MBF values are positively correlated with many parameters such as nutrition, chewing, breaking down solid foods, sleep, and oral health (5,7,8,12,13). As far as it is known, although many studies have investigated the effects of both AT and COATH on the quality of life and growth development, there is no study in which MBF is an objective evaluation parameter and compared with body mass index (BMI) changes after the AT.

For a purpose that it may be a reference study to predict the effects of other transoral surgeries as long-term the mouth opening, we conducted a study consisting of the pre, early and late postoperative MBF measurements, which were measured using a bite force recorder (BFR), in pre-pubertal pediatric patients COATH undergoing AT and compared them their demographics, operative times and healthy controls.

METHODS

The study was approved by the University of Health Sciences Turkey, Istanbul Bakirkoy Dr. Sadi Konuk Training and Research Hospital, Ethical Committee (decision no: 2015/03/05, protocol code: 2015/25) and performed according to the Declaration of Helsinki. At the start of the study, it was determined that a minimum of 30 participants would be needed for each group (1:1), with a 5% difference and 85% power. It was performed on 30 children (group 1) diagnosed with COATH who planned to have AT and 30 age and gender-matched healthy children (group 2). All the participants and their parents were informed about the study, and they provided written informed consent. The participants were detailed examined by an ear nose throat surgeon and a dentist. Prepubertal children aged 6-12 years with angle class I molar relationship without extracted or restored teeth, open bite, or crossbite were included in the study. Those who have had AT surgery with diagnoses other than COATH, maxillofacial trauma, known TMJ dysfunctions, intellectual disability, syndromic disease, malignancy, neuromuscular disease, craniofacial abnormality, tooth loss or mobility, gingival infection, asthma, having class II-III malocclusion, morbid obesity, dental coating, fillings or suspenders, having dental caries on first permanent molars, coagulation disorders, revision surgery were excluded from the study.

All participants underwent fiberoptic nasal endoscopic examination to estimate AV size. The size of the adenoid was determined and the distance of the adenoid tissue from the vomer was assessed and graded as grade I: Distance >1 cm, grade 2: Distance 0.5-1.0 cm, grade 3: Distance <0.5 cm (14). In the examination, the size of the tonsillar hypertrophy (TH) was evaluated Friedman's classification. The children with FC sizes 3 or 4 TH and grade 2-3 AV were included in group 1 and the children who had other low grades were included in group 2. Subsequently, a dentist examined the occlusion, mouth opening, TMJ function, and MM sensitivity of all patients. During the study, the weight and height were measured in the morning times before breakfast, and BMI (kg/m^2) was calculated.

In group 1, the patients were operated on by the same surgeon, and a classic cold knife AT was performed. During the surgery, Boyle-Davis mouth gag (in sizes suitable for the age of the child) and tongue blade equipment were used by hanging on the operating table-fixed visor. The time from the moment the mouth retractor was opened in the mouth to when it was removed from the mouth was recorded in minutes [duration of active surgery-(DAS)]. The same anesthetic drugs and acetaminophen were administered to all the patients.

MBF values were measured using a BFR, which was placed in the mid incisor with left and right molar area. The subjects were asked to bite as strongly as they could. A total of three measurements were made for each patient from the left and right molar sensors in each session, a 10-minute rest was taken between measurements, and the highest value was recorded. The reliability of this device for MBF measurements has been demonstrated both *in vitro* and *in vivo* (9,13). The device recording the bite force using three strain gauge (Model 13; Honeywell Sensotec, Columbus, OH, USA) was placed between 0.85 mm thick stainless-steel plates; its output was amplified by an amplifier (AD627; Analog Devices, Norwood, MA, USA); and the values were analyzed by computer, using a software (HOBOware; Onset Computer, Bourne, MA, USA) (Figure 1).

Six times measurements for the study group and four times measurements for the control group were made, which are as follows: Before the operation, on the 1st, 7th days, and 1st, 3rd, and 6th months after the AT in the study group; in the control group, baseline, and on the 1st, 3rd, and 6 months were made.

The visual analog scale (VAS) was used to rate the pain. Using the faces pain rating scale, the patients were instructed to point to the position on the line between the faces to indicate how much pain they felt. On postoperative days 1 and 7, they were asked to rate their pain on a VAS diagram.

Figure 1. The dental apparatus of the bite force recorder device, designed to be suitable for the incisor and molar tooth sections, and the unit that amplifies the bite force data are shown

Statistical Analysis

All statistical analyses were performed using SPSS version 17 (IBM, SPSS, Turkey). Chi-square or Fisher's exact tests were used to compare categorical variables. Correlation coefficients and statistical significance were calculated with the Pearson test for relationships between parametric variables, of which at least one is not normally distributed or ordinal. In addition to descriptive statistical methods, a repeated ANOVA test was used to compare repetitive parameters with normal distribution for the comparison of quantitative data. Post-hoc Bonferroni test was used to evaluate the differences between the groups. Student's t-test was used to compare independent parameters. A p value of <0.05 was considered statistically significant.

RESULTS

The mean ages of group 1 and group 2 were 8.43±2.25, 8.50±1.83, respectively (p=0.900). The gender ratio (F/M) in groups 1 and group 2 was 0.66 and 0.58, respectively (p=0.791). The mean BMI of group 1 and group 2 were 19.05±3.54, 19.82±3.14, respectively (p=0.386).

In group 1, there were 27 grade 3 AVs and three grade 2 while in group 2, all of the AV sizes were grade 1. In group 1, there were 26 size 4 THs and four size 3 while in group 2, 23 size 1 THs and seven size 0. In group 1, 28 children had complaints of sleep with open mouth and snoring, while the other group did not have these complaints except for one child. The mean DAS was 20.7±3.03 min.

There was no statistical difference in mean BMI values between the groups from the baseline to 6th month except the 1st month (Table 1).

No significant difference was observed in baseline MBF values between genders (p=0.975). The correlation between baseline MBF values according to age was evaluated. There was a statistically strong positive correlation between MBF and age (R=0.929, p=0.001). There was no statistical difference in mean MBF values between the groups at the baseline (p=0.170)

MBF measurements differed significantly within group 1 according to the postoperative follow-up, and group 2 (p<0.001). The post hoc test revealed that the decrease in measurements on both days 1 and 7 was statistically lower than the preoperative measurement in group 1 (p<0.001). No difference was observed between the preoperative measurement and the postoperative measurement in 1st month (p=0.962). In 3rd and 6th months, the

Table 1. Comparison of MBF and BMI values in the study (group 1) and control (group 2) groups					
Timeline	**Mean MBF (n) ± SD**				
	Group 1	**p***	**Group 2**	**p***	**p****
Baseline	317.49±71.54	NA	341.25±60.54	na	0.170
1st day	265.87±69.19	**<0.001**	NA	NA	NA
7th day	279.39±68.10	**<0.001**	NA	NA	NA
1th month	317.58±71.30	0.962	342.45±61.22	0.136	0.152
3rd month	336.80±73.55	**<0.001**	349.52±62.81	**<0.001**	0.474
6th month	365.42±77.10	**<0.001**	366.20±64.90	**<0.001**	0.967
p***	**<0.001**	-	**<0.001**	-	-
Mean MBF change (n) ± SD					
1st day†	-52.19±17.18	NA	NA	NA	NA
7th day†	-38.09±15.19	NA	NA	NA	NA
1th month†	0.92±10.39	NA	1.21±4.33	NA	0.588
3rd month†	19.31±6.85	NA	8.28±5.75	NA	**<0.001**
6th month†	47.93±10.37	NA	24.95±6.87	NA	**<0.001**
Mean BMI (kg/m²) ± SD					
Baseline	19.05±3.54	NA	19.81±3.14	NA	0.386
1st day	19.03±3.51	0.426	NA	NA	NA
7th day	19.02±3.52	0.107	NA	NA	NA
1th month	18.46±3.43	**<0.001**	19.89±3.10	0.109	**0.033**
3rd month	18.92±3.34	0.067	19.98±3.17	0.064	0.214
6th month	19.49±3.48	**<0.001**	20.38±3.58	**0.034**	0.327
p***	**0.001**	-	-	-	0.151
Mean BMI changes (kg/m²) ± SD					
1st day†	-0.26±0.18	NA	NA	NA	NA
7th day†	-0.36±0.12	NA	NA	NA	NA
1th month†	-0.59±0.33	NA	0.06±0.21	NA	**<0.001**
3rd month†	-0.13±0.38	NA	0.16±0.40	NA	**0.005**
6th month†	0.43±0.47	NA	0.66±01.80	NA	0.416

p*: Paired t-test, p**: Independent t-test, p***: ANOVA test p<0.05, †: Difference between last value - baseline value, MBF: Maximal bite force, BMI: Body mass index, NA: Not applicable, SD: Standard deviation

MBF measurements were found to be significantly higher than the baseline measurement in both groups (p<0.001). There was no significant difference in the mean MBF values from groups 1 and 2 (Table 1). There were also shown mean MBF and BMI values and their changes in Table 1.

MBF measurements were also evaluated in terms of the length of surgery. DAS shorter than 20 min (n=14) and those longer than 20 min (n=16) were compared. The pre-and postoperative MBF measurements are shown according to the DAS in Table 2.

At the baseline, the MBF values did not show a significant correlation with the BMI values in the groups 1 and 2 (R=0.137, p=0.472; R=0.168, p=0.375, respectively). A correlation chart was shown between MBF and BMI values for group 1 in Table 3. On postoperative day 1, the VAS scores did not show a significant correlation with the MBF values (R=-0.262, p=0.163). On a postoperative day 7 as well, the VAS scores did not indicate a significant correlation with MBF values (R=-0.329, p=0.078).

DISCUSSION

A proper masticatory system stimulates the normal development of the maxilla and mandible. The three years before the initiation of mixed dentition are crucial, as normal growth changes and functional adaptability occur during this period (15). In children, the peripheral sensorimotor pathways underlying the jaw-stretch reflex mature as the child continues to obtain oral motor skills (16). AT is the most frequently performed surgery at this age.

Table 2. Comparison of MBF measurements in terms of duration of active surgery in the study group (group 1)

Timeline	Mean MBF (n) ± SD		
	≤20 minutes (n=14)	>20 minutes (n=16)	p
Baseline	318.88±66.36	316.26±77.94	0.922
1th day	276.48±62.80	255.49±74.96	0.416
7th day	289.48±63.45	270.57±72.79	0.458
1th month	323.58±63.08	312.32±79.49	0.674
3rd month	339.14±68.44	334.75±79.93	0.874
6th month	368.49±75.68	362.73±80.69	0.842
Mean MBF change (n) ± SD			
1th day†	-42.39±9.49	-60.77±18.02	**0.002**
7th day†	-29.41±15.19	-45.69±14.51	**0.002**
1th month†	4.69±4.55	-3.93±12.40	**0.020**
3rd month†	20.26±8.03	18.49±5.77	0.490
6th month†	49.60±13.11	46.47±7.34	0.419

†: Difference between last value - baseline value, t-test p<0.05, MBF: Maximal bite force, SD: Standard deviation

During the operation, a Boyle-Davis mouth gag is used, which ensures that the patient's mouth remains in the maximum open position; however, this apparatus is a challenge for the TMJ and masticatory muscles.

MBF is an objective and quantitative measurement used to evaluate masticatory performance (13,17). It has been shown in previous studies that MBF was negatively affected by several TMJ diseases, masseteric silent period, masticatory dysfunctions (7,18,19). For this reason, in this study, we compared MBF values by preoperative, early, and late postoperative periods and observed that these values decreased significantly in the early period after the operation but approached the preoperative values in 1st month.

Bite force follows an increasing trend since childhood, remains stable between the ages of 20 and 40 years, and then begins to decline (20,21). Facial structure, the gender difference in post-puberty, general muscular force, dental condition, malocclusion, and TMJ disease also affect MBF (22,23). In this study, it was found significant that MBF increased as age increased. Previous studies showed that MBF in the pre-pubertal period was similar in both genders due to yet undifferentiated maxillofacial muscles and jaw structures. Similarly, in this study, there was no significant difference noted between the two genders. In another study, it was reported that the history of mouth breathing in children did not have a significant effect on MBF (24). In this study, there was no difference between the baseline MBF values of both groups of children with a diagnosis of COATH and the healthy control group. Hatch et al. (25) reported that MBF was directly related to masticatory performance, but it was not as effective as the number of functional teeth. Julien et al. (26) found that MBF, along with occlusal contact area and body size, explained 72% of the variation in masticatory performance among children and adults. Lepley et al. (18) investigated the effects of occlusion, MBF, and chewing cycle kinematics on masticatory performance and found that occlusal contact area and occlusal discrepancies are related to bite force and chewing cycle kinematics. They also found that MBF was positively associated with masticatory performance. Despite all these reports on nutrition and solid food chewing, no significant correlation was reported between BMI and MBF (3,5,18,25,26). In this study, there was no correlation between MBF and BMI. Unlike the evaluations of these studies, it was observed that there was a weak or moderate correlation between MBF and BMI changes in the 1st three months postoperatively.

Additionally, although all patients had full dentulous and normal occlusion, those with TMJ who remained fully open for more than 20 min showed a significant difference in mean MBF changes over one month compared to those with shorter periods. However, the average MBF values rose rapidly after 3 months, approximating the control group values with a slight difference (Figure 2). There was no significant correlation between VAS scores and MBF values on postoperative days 1 and 7. It showed that during the early postoperative recovery period of AT, regardless of other factors such as inflammation and pain that might affect the bite force, the force applied by the mouth gag to the TMJ alone decreases MBF. However, a significant difference in month mean BMI values between the two groups on 1st month made us think that the reduction in MBF was a

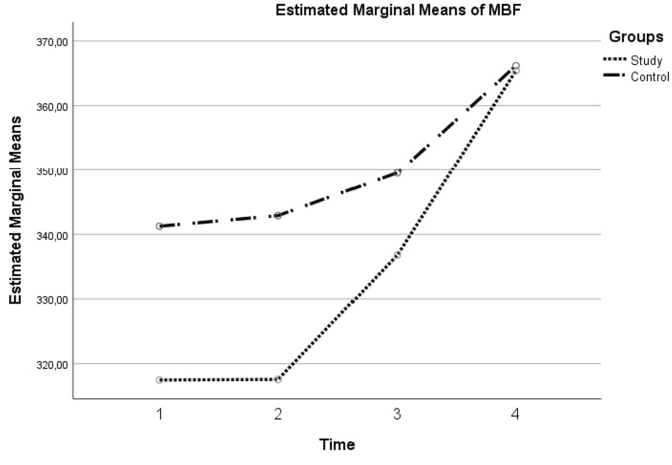

Figure 2. The course of mean MBF values in the study (group 1) and control (group 2) groups
MBF: Maximal bite force

Table 3. The relationship between MBF and BMI values on postoperative days one, seven, and months one, three and six in the study group

Mean BMI change										
Mean MBF change	1st day		7th day		1st month		3rd month		6th month	
	R	p	R	p	R	p	R	p	R	p
Postoperative 1st day	0.494	**0.005**	0.513	**0.004**	0.583	**0.001**	0.518	**0.003**	0.137	0.470
Postoperative 7th day	0.499	**0.005**	0.456	**0.011**	0.478	**0.008**	0.425	**0.019**	0.164	0.386
Postoperative 1st month	0.592	**0.001**	0.652	**<0.001**	0.540	**0.002**	0.296	0.112	0.161	0.394
Postoperative 3rd month	0.113	0.551	0.277	0.139	0.019	0.920	0.097	0.612	0.031	0.873
Postoperative 6th month	0.170	0.368	0.227	0.229	0.034	0.860	0.132	0.488	0.032	0.865

R: Pearson correlation coefficient p<0.05, MBF: Maximal bite force, BMI: Body mass index

criterion that should not be ignored in the regulation of early post-AT nutrition.

Maini et al. (27) measured the interincisal distance in adult patients who underwent tonsillectomy surgery using a Boyle-Davis mouth gag at preoperative and postoperative week 6 and compared them with the group that had nasal surgery. In patients who underwent tonsillectomy, the interincisal distance decreased at postoperative week 6, whereas there was no significant difference in the nasal surgery group. They reported that tetanus might occur because of nerve irritation, inflammation of the pharyngeal, and spasm of the hyoid and masticatory muscles after tonsillectomy and the symptom regress took 2-3 weeks after the surgery when the relaxation of the muscles, and operation cavity was completely covered with mucosa. In this study, we had the opportunity to observe the course of the change in the post-operative MBF, which was a result of the functions of the MM and TMJ, by comparing it with the control group, beyond the effects of acute inflammation and spasm, by keeping the follow-up period long.

In several studies, it has been shown that there are functional changes in the facial muscles in the postoperative period from the first month to the sixth month in children after AT or tonsillectomy, and maxillary expansion in cephalometric measurements up to the 14th month. The reason for the increase in MBF seen in the study group from the 1st to the 6th month could be related to the results of this study, but in our methodology, a cephalometric evaluation that could compare this was not performed (28,29).

Yosetake et al. (30) compared 44 mouth breathers with upper airway obstruction between the ages of three to 12 years healthy children in terms of MBF and did not find a significant difference between the two groups. They also did not find a correlation between the degree of obstruction and MBF in mouth breathers. They reported that MBF increased with age in the healthy control group, but that MBF did not correlate with age in patients with mouth breathing. Similarly, there was no significant difference in MBF values between the groups in our study, either before the operation or in the first month or after. However, differently, it was observed that MBF increased with age in COATH patients. The fact that participants with class I occlusion and without craniofacial anomalies were included in our study may have been beneficial to our results.

Study Limitations

There were limitations to this study related to calibrating the BFR every week so that we could measure the measurements as accurately as possible. Although the participants with normal morphology, the fact that cephalometric measurements were excluded from our study is a limiting factor. The evaluation of puberty, the initial examination findings and the information obtained from the parents of the children were taken as reference and no additional hormone was examined.

CONCLUSION

Children undergoing AT might experience a decrease in MBF in the acute period and this decrease could be related to the average operation time. Postoperative MBF values almost reached preoperative values in the first month and increased rapidly between three and six months after AT and reached a level significantly comparable to healthy children of the age match evaluated.

It may be useful to conduct prospective studies that include the active operation time and MBF changes during transoral surgeries in childhood.

Ethics

Ethics Committee Approval: The study was approved by the University of Health Sciences Turkey, Istanbul Bakirkoy Dr. Sadi Konuk Training and Research Hospital, Ethical Committee

(decision no: 2015/03/05, protocol code: 2015/25) and performed according to the Declaration of Helsinki.

Informed Consent: Written informed consent.

Peer-review: Externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: Y.A., İ.A., B.T., H.S., E.A.A., M.B., M.İ., Concept: Y.A., S.A., D.D., Y.U., Design: Y.A., S.A., D.D., O.Ü., M.B., Data Collection or Processing: S.A., İ.A., H.S., E.A.A., Analysis or Interpretation: Y.A., T.L.K., Literature Search: Y.A., O.Ü., İ.A., B.T., H.S., E.A.A., Writing: Y.A., S.A., O.Ü., T.L.K.

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