A 1-year Intraindividual Evaluation of Maximum Bite Force in Children Wearing a Removable Partial Dental Prosthesis

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ABSTRACT

Purpose: The aim of this study was to evaluate the effect of a removable partial dental prosthesis on the bite force in 22 children from 6 to 9 years of age with early loss of primary molars.
Methods: The dental prosthesis was fabricated with autopolymerized acrylic resin and artificial teeth, retained by clasps made of orthodontic wires. Bite force was determined with a pressurized tube transducer connected to a sensor element. The facial proportions were evaluated on photographs and body variables determined. All evaluations were performed before, 6 months after, and 1 year after the rehabilitation.
Results: No statistical significant difference between genders was found. There was a significant increase in bite force from the first to the second evaluation (302±61N) and (345±43 N), but not in the third evaluation (360±47 N). Body weight and height increased during the follow-up period. Facial proportions did not correlate with bite force, whereas body height correlated with bite force at the six-month evaluation (r=0.521; *P*=.007), with a low adjust determination coefficient (24.01%).
Conclusion: The findings showed that the removable partial dental prosthesis increased the bite force in the first 6 months. This suggested that the prosthesis was adequate to replace the missing posterior primary teeth, with the possibility of improving the masticatory system function. (J Dent Child 2007;74:171-6)

KEYWORDS: FACIAL MORPHOLOGY , MIXED DENTITION, OCCLUSAL FORCE, PREMATURE TEETH LOSS

The prevalence of dental decay appears to be declining, but a considerable number of children still suffer from it.[1] Sometimes tooth extraction is necessary, which can diminish the probability of injuries to the permanent teeth—especially when there is a periapical lesion involving the subjacent tooth's crypt.[2,3] Nevertheless, the premature tooth loss often leads to space closure and alteration in the proper contact of the inclined planes of the teeth. Moreover, the masticatory function can be affected, decreasing the masticatory muscle strength[4,5]–which determines the amount of available force to cut or chewing of food.

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Various techniques have been used to clinically evaluate the physiological characteristics of the masticatory muscles. One of them is the individual bite force levels that have been widely used in dentistry. These levels are used primarily to understand the mechanics of mastication[7,8], evaluate the evaluation of the therapeutic effects of prosthetic devices[9], and provide reference values for studies on the biomechanics of oral prostheses.[10]

During childhood, the bite force increases with age, staying fairly constant from 20 to 40 years of age then declining.[11] The bite force increases, however, with the chewing necessity,[12] but decreases with dentition deterioration—like decayed and missing teeth, which tend to lead to weaker bite forces.[4,5] Consequently a decline in masticatory function can occur, which, in turn, affects food selection and nutritional well-being.[13] In this manner, premature loss of primary teeth is an indication for prosthetic provision in the form of space retainers or partial dentures. Without prompt treatment, different acquired facial-occlusal defects may develop.[14]

To the best of the authors' knowledge, there are no reports in the dental literature that study removable dental prosthesis in children or its effects on the functional aspects of the stomatognathic system. Thus, the aim of this study was to evaluate the effect of a removable partial dental prosthesis on the bite force in children before, 6 months following, and 12 months after the oral rehabilitation. Furthermore, the correlations of facial proportions and body variables were verified.

METHODS

SUBJECTS

Two hundred forty nine children from 6 to 9 years old who were slated to start dental treatment in the Department of Pediatric Dentistry, Dental School of Piracicaba, São Paulo, Brazil, were evaluated. Twenty-five children, 13 boys and 12 girls, were selected. Written and verbal consent was obtained from each child's parents, and the Ethics Committee of the Dental School of Piracicaba approved the research. After 1 year, 3 subjects had the treatment discontinued because they did not wear the prosthesis properly during the first 6 months or missed the appointments. Thus, a total of 22 subjects remained (12 boys, 10 girls).

The inclusion criteria were absence of systemic disturbance and parafunctional habits, normality of the oral tissues, presence of maxillary and mandibular first permanent molars in Angle's Class I relationship, presence of primary or permanent incisors and primary canines, premature loss of one or more maxillary or mandibular primary molars, or extraction indication assessed by clinical and radiographic examinations.

The eruption process and degree of root formation of the successor teeth were evaluated on the radiographies, indicating the space maintenance needed. An individual treatment plan was established, including preventive and curative measures. Impressions of the children's maxillary and mandibular arches were taken with alginate (Jeltrate Dentisply, Petrópolis, RJ, BR), and the dental casts were mounted in a joint articulator. The removable partial dental prosthesis was fabricated with autopolymerized acrylic resin (Vipi Flash, Vipi, Pirassununga, SP, BR) and artificial teeth (Biotone, Dentisply, Petropolis, RJ, BR), retained by clasps (orthodontic stainless steel wires, 0.7 mm). The artificial teeth were set up in maximum intercuspation.

The follow-up period was 1 year, and 3 evaluations of maximum bite force, facial proportions, body weight, and height were performed before the prosthesis placement, 6 months after its placement, and 12 months after placement of the appliance.

BITE FORCE MEASUREMENT

Bite force was determined with a pressurized rubber tube (diameter=10 mm) joined to a sensor element (MPX 5700, Motorola SPS, Austin, Tex). These were connected to a converse analogue/digital electronic circuit and fed by an analogical signal coming from the pressure-sensitive element. The system was connected to the computer, and software for reading the pressure sign was developed in Basic language. Being elastically deformed during biting, as it was flexible, the tube was placed bilaterally between the maxillary and mandibular first molars—thereby providing a more uniform force distribution. The children bit the tube with maximum force 3 times successively for 5 seconds, with a 10-second interval between each bite, keeping the Frankfort plan approximately parallel to the floor. Values were converted into Newtons (N), taking into account the tube area, since force is equal pressure multiplied by area. The means were considered.

The reliability of the bite force measurements was determined on 10 randomly selected children using Dahlberg's formula: $ME=\sqrt{\Sigma(m1-m2)^2/2n}$ on 2 repeated measurements (x_1, x_2). The measurement error (MSE) was also calculated, considering that $MSE=[(\sqrt{\Sigma d2})/2n)]/[(M1+M2)/2n]x100$, with:

1. d being the difference between the second and the first recordings;
2. n=the number of double measurements; and
3. M1/M2=mean of measurements assessed at the 2 occasions.

The method error was 16.28 N, and the measurement error was 6.55%. In addition, this method was already tested in the authors' laboratory with good results as stated by Rentes et al[7] and Bonjardim et al.[15]

FACIAL PROPORTIONS

Children's frontal facial photographs were taken in a standard way for facial morphology determination.[16] They were standing in a relaxed position at 1.05 m distance from the camera, which was adjusted to the eye level, under natural light against a light background. The head was positioned so that the saggital and the Frankfort plane would remain, respectively, perpendicular and parallel to the ground. The mandibular position was clenching with a maximum pressure with the lips in the resting position. Three images were obtained from each child and transferred to the computer. The best one was chosen for the measurements, which were taken using ImageLab software (Softium Informática Ltda, Fortaleza, CE, Brazil).

The anterior facial height (FH), bizygomatic facial width (FWz), and intergonial width (FWa) were measured on the photographs, and the FH/FWz and FH/FWa proportions were calculated.[16] The reliability of the facial proportions measurements was assessed by remeasuring 2 randomly selected photographs. The ME was 0.027 mm for FH/FWz and 0.034 mm for FH/FWa. The MSE was null for both proportions.

BODY VARIABLES

Weight and height were determined through an anthropological commercial balance, and the body mass index ($BMI=weight/height^2$) was calculated.

*Table 1. Mean Values and Standard Deviation (±SD) for Bite Force (N), Weight (Kg), Height (m), Body Mass Index (kg/cm2), and Facial Proportions (mm)**

	First evaluation			*Second evaluation*			*Third evaluation*		
	Girls	Boys	Mean	Girls	Boys	Mean	Girls	Boys	Mean
BF	309^{a}±66	295^{a}±58	302^{A}±61	359^{b}±37	331^{b}±55	345^{B}±43	327^{b}±50	350^{b}±42	360^{B}±47
Weight	22.81^{a}±3.68	26.24^{a}±6.93	24.59^{A}±5.77	24.44^{b}±4.27	27.89^{b}±8.071	26.24^{B}±6.63	27.09^{c}±6.09	30.6^{c}±9.0	28.99^{C}±7.85
Height	1.22^{a}±0.06	1.25^{a}±0.06	1.23^{A}±0.06	1.26^{b}±0.07	1.27^{b}±0.06	1.27^{B}±0.06	1.30^{c}±0.08	1.30^{c}±0.1	1.31^{C}±0.07
BMI	15.17^{a}±1.46	16.71^{a}±2.98	15.97^{A}±2.45	15.41^{a}±1.52	16.95^{a}±3.51	16.21^{AB}±2.80	15.96^{b}±1.97	17.4^{b}±3.8	16.65^{B}±3.13
FH/FWa	0.659^{a}±0.02	0.659^{a}±0.03	0.659^{A}±0.03	0.656^{a}±0.02	0.653^{a}±0.03	0.654^{A}±0.03	0.669^{a}±0.018	0.651^{a}±0.022	0.658^{A}0.023
FH/FWz	0.777^{a}±0.04	0.794^{a}±0.38	0.786^{A}±0.04	0.775^{a}±0.04	0.802^{a}±0.04	0.789^{A}±0.04	0.816^{a}±0.025	0.778^{a}±0.049	0.794^{A}±0.045

** Similar small letters in the same line mean no statistical difference (P>.05) between genders. Different capital letters in the same line mean statistical difference (P<.05) between evaluations.*

STATISTICAL ANALYSIS

The normality of the distributions was assessed using the Shapiro-Wilk's W test. The comparisons between genders were performed via unpaired t test or Mann-Whitney tests. The comparisons between evaluations of the bite force, body variables, and facial proportions were done using the paired t test or Wilcoxon. The correlations among the variables were assessed by Spearman's or Pearson's coefficients, and different regression models adjusted to the data were applied in each correlation significant at the P<.05 level. All analyses were carried out using SPSS 9.0 (SPSS, Chicago, Ill).

RESULTS

There was no statistically significant differences (P>.05) among the variables for boys and girls (Table 1). Therefore, the data were pooled. The descriptive statistics for bite force, facial proportions, and body variables at the 3 examinations are demonstrated in Table 1.

There was a statistically significant difference in the maximum bite force between the first and the second examinations (*P*<.0001). Nevertheless, there was statistically significant difference in the bite force between the second and third examinations (Figure 1).

Body weight and height showed significant increases from the first to the third evaluation (*P*<.01). The facial proportions did not show any significant differences among evaluations (*P*>.05).

Bite force was significantly correlated with body height at the second evaluation (Table 3), whereas no correlation was observed with weight and body mass index (Tables 2, 3, and 4; *P*>.05). Linear regression showed that the adjusted determination coefficient was 24.01% (*P*=.0075).

Bite force was not correlated with FH/FWz and FH/FWa proportions at the 3 evaluations (Tables 2, 3, and 4).

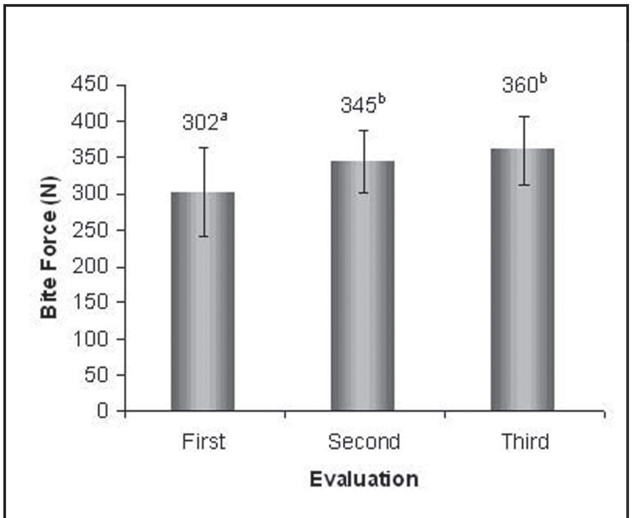

Figure 1. Mean value of bite force in Newtons (N) in the 3 evaluations. Different letters means statistical difference.

*Table 2. Matrix of Correlation for Bite Force, Facial Proportions, and Body Weight, Height, and Body Mass Index (BMI): First Evaluation**

	1. Bite Force	2. FH/FWz	3. FH/FWa	4. Weight	5. Height	6. BMI
1. Bite force	-	*.34*	*.56*	*.89*	*.37*	*.19*
2. FH/FWz	-0.201	-	*.000*	*.20*	*.59*	*.51*
3. FH/FWa	-0.124	0.730†	-	*1.00*	*.70*	*.59*
4. Weight	-0.028	-0.266	0.000	-	*.000*	*.000*
5. Height	0.187	-0.114	0.083	0.894†	-	*.001*
6. BMI	-0.268	-0.139	-0.113	0.870†	0.602†	-

** P<.05. † P<.01; P values in italics.*

*Table 3. Matrix of Correlation for Bite Force, Facial Proportions, and Body Weight, Height, and Body Mass Index (BMI): Second Evaluation**

	1. Bite Force	2. FH/FWz.	3. FH/FWa	4. Weight	5. Height	6. BMI
1. Bite force	-	*.32*	*.12*	*.08*	*.007*	*.6655*
2. FH/FWz	-0.208	-	*.000*	*.20*	*.81*	*.003*
3. FH/FWa	-0.323	0.727	-	*.80*	*.55*	*.39*
4. Weight	0.354	-0.266	0.053	-	*.000*	*.000*
5. Height	0.521†	-0.052	0.127	0.872†	-	*.008*
6. BMI	0.091	-0.569†	-0.179	0.835†	0.519†	-

** P<.05. † P<.01; P values in italics.*

Table 4. Matrix of Correlation for Bite Force, Facial Proportions, and Body Weight, Height, and Body Mass Index (BMI): Third Evaluation*

	1. Bite force	2. FH/ FW	3. FH/ FWa	4. Weight	5. Height	6. BMI
1. Bite force	-	*.98*	*.23*	*.15*	*.26*	*.13*
2. FH/FWz	0.007	-	*.000*	*.28*	*.48*	*.06*
3. FH/FWa	-0.266	0.647†	-	*.05*	*.52*	*.001*
4. Weight	0.317	-0.238	-0.425†	-	*.000*	*.000*
5. Height	0.245	-0.160	-0.143	0.862†	-	*.000*
6. BMI	0.335	-0.414	-0.669†	0.858†	0.546†	-

** P<.05. † P<.01; P values in italics.*

DISCUSSION

Primary teeth play a critical role in the growth and development of a child. The main functions of a primary tooth are to hold space for the permanent successor until it is ready to erupt, improve esthetics, improve eating, improve speech, and encourage normal function and resultant expected growth.[17]

When a child presents with premature tooth loss, it is important to determine the level of cooperation expected from the child and the parents, to indicate the proper dental prosthetic treatment. For this study, the selected children were able and willing to wear the removable prosthesis, which was chosen due to the following advantages[18]: the ease with which it can be cleaned, adjusted, and maintained; the minimal damage that is caused to adjacent teeth; and its low cost. There are some disadvantages, however: the tendency for the prosthesis to accumulate plaque; and the need for constant attention and periodic revisions, which require excellent child and parent cooperation.

Thus, in this study the children were in constant follow-up. Therefore, the biofilm control was stimulated periodically, allowing for the continuous use of the prosthesis to be checked.

There was no statistically significant difference between male and female subjects ($P>.05$), agreeing with previous investigations.[5,7,11,19-21] due to children's age. The increase in muscle mass during puberty, influenced by androgenic steroids, creating the differences between male and female muscle strength.[21,22] The difference between boys and girls on bite force values has been reported to be evident after the age of: 9 years[23]; 13 years[5]; 17 years[20]; and 18 years.[22] Garner and Kotwal[20] found that the average bite force values for 11- to 16-year-old females were equal to or even higher than those for males. These findings are in accordance with the present study, which found an equal bite force for younger girls and boys (Table 1).

The bite force magnitude ranged from 160 to 450 N (mean values in Table 1), which agrees with previous investigations[5,7] but differs from others.[24,25] Bite force values vary greatly among studies due to several factors like, location of bite force transducer, material, size, lack of "give" or flexibility, dynamic responsiveness and accuracy of transducer, and sensitivity of the teeth, muscles, and temporomandibular joints.[26]

These factors add to the normal biological intraindividual variation and to technical imperfections. It must be considered that the correlations and conclusions found in each study are more important than the values achieved.

In our study the results showed a significant increase in bite force from the first evaluation (before the placement of the prosthesis) to the second evaluation (6 months after the placement of the prosthesis; $P<.01$). This was probably due to the occlusion stability and increase in the number of tooth contacts. The number of antagonistic tooth contacts has been found to be a great factor of influence on bite force,[4,27] which increases when more chewing is required.[12] Tooth contacts allow for greater force distributions among teeth, thus reducing localized pain perception and permitting harder biting. Good occlusal stability results in strong muscles leading to higher bite force values.[27]

The subjects in this study had absence of teeth prior to the treatment, which were replaced by the artificial teeth adapted on the removable partial dental prosthesis. Therefore, they could chew better, had an improved muscle function and, consequently, an increased bite force during the first months, and adapted to a new oral condition, giving time for the muscle to add new sarcomeres for restoring optimal working length and, thus, bite force.

This fact can be evidenced by the lack of gain in bite force from 6 months to 1 year after the oral rehabilitation. Thus, the children could develop a better chewing function and thereby exercise the muscles—especially during the first months of wearing the dental prosthesis. Many follow-up studies are concluded at 3 months on the assumption that adaptation will then be complete.[28] Nevertheless, this study's sample was composed by children who need more time for oral function improvement that depends on the daily performance and on the neuronal and psychosocial maturation.[29] In children, peripheral sensorimotor pathways that underline the jaw stretch reflex are mature as the child continues to acquire oral motor skills.[30]

The correlation coefficient between bite force and weight or body mass index was not significant, agreeing with others.[15,21,22] A correlation between body height and maximum bite force was verified only at the second evaluation, which suggests that the subjects grew as they gained bite strength. The adjusted coefficient determination showed that the height in the second evaluation could explain only 24% of the bite force variability. Therefore, bite force evidently depends on more complex factors than body size, such as the cross-sectional area of masticatory muscles and jaw biomechanics.[31] This fact becomes evident when one considers the presence of no correlation between bite force and body variables at the third evaluation, after a large period in which the subjects had worn properly the appliances.

Nevertheless, children are constantly growing and developing, which could be a factor of influence. The weight and height increased significantly during the first months, as children keep growing from the second to the third evaluation, and the bite force did not increase during this follow-up period. This can suggest that the gain on bite strength in the first months may have been due to the use of the prosthesis. If the development were to solely influence the increase in muscle strength, it would have done so the entire time through. Acs et al[32] observed that, after therapeutic intervention, children with early childhood caries exhibited significantly increased growth velocities during the course of the follow-up period, reflecting the phenomenon of catch-up growth. The association between the prosthesis' placement in children and the masticatory performance's enhancement related to the increase in bite force—as well as the dietary changes after the insertion of the prosthesis—must be studied further.

Several authors have found a correlation between bite force and facial morphology, stating that individuals with longer faces have lower bite forces.[19,33] Sonnesen and Bakke[24] found a clear correlation between bite force and craniofacial morphology in boys only. Ingervall and Minder[27] reported significant relationships between the maximum bite force and the mandibular plane angle in girls only. Kiliaridis *et al*,[21] meanwhile, showed only weak relationships between craniofacial morphology and the maximum incisal bite force and no correlation with the maximum molar bite force in 7- to 13-year-old children. This study did not find a significant correlation between facial morphology and bite force, due to the fact that the subjects had similar facial morphological proportions. The children's ages could also be an explanation, as it has been hypothesized that the correlation between masticatory muscle force and facial form develops during adolescence.[34] Kiliaridis et al[21] showed only weak relationships between craniofacial morphology and the maximum incisal bite force and no correlation with the maximum molar bite force in 7- to 13-year-old children. Sonnesen and Bakke,[24] however, found a clear correlation between bite force and craniofacial morphology in boys only.

This study's findings corroborate those by Kotsiomiti et al[35] and Dominguez and Aznar,[28] considering that by replacing missing teeth, several oral functions could be maintained or re-established. Nevertheless, in this study, one type of appliance was used. This makes it necessary to evaluate the bite force in children who have been treated with fixed appliances—such as a lower lingual holding arch, Nance arch, or transpalatal appliance—to obtain comparative results.

CONCLUSION

This study's findings showed that the removable partial dental prosthesis increased the bite force in the first 6 months. This suggested that the prosthesis was adequate to replace the missing posterior primary teeth, with the possibility of improving the masticatory system function.

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