Original article

Occlusal bite force change after orthodontic treatment with Andresen functional appliance

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Summary

Objectives: The aim of this study was to determine the occlusal bite force (OBF) changes, at the incisal and molar regions, after orthodontic treatment with functional appliance therapy in preadolescent subjects.

Materials and methods: OBF was measured for patients (17 females and 16 males) before and after the treatment with Andresen functional appliance for an average period of 9 months (mean age was 11.8 ± 1.1 years). Three variables were registered; maximum OBF at molar region and the average of three readings at the molar (AOBF) and incisal regions (IOBF). The same variables were measured in two occasions for a matching non-treated control group with a period of 9 months between the two measurements.

Results: No significant changes were seen in the OBF measured parameters in the control group. There was a reduction in all measured parameters. The mean reduction in maximum OBF was 76.1 ± 12.4 N (P < 0.001), 58.5 ± 13.0 N in AOBF (P < 0.001), and 69.3 ± 11.6 N IOBF (P < 0.001).

Conclusions: Treatment with functional appliance caused a significant reduction in OBF immediately after treatment.

Introduction

While many indicators have been used to assess the functional state of an occlusion, occlusal bite force (OBF) has been a key predictor of masticatory performance (1). Bite force, in turn, is influenced by several factors such as number of occlusal contacts (2), age (3), gender (4), temporomandibular joint problems (5), periodontal support of teeth (6), and craniofacial morphology (7).

Malocclusion has also been associated with reduced occlusal bite force (8–11). Children with a unilateral posterior crossbite have been reported to have reduced maximum bite force and a reduced number of occlusal contacts compared with children with normal occlusions (8). Henrikson et al. (12) showed that females with normal occlusion had better masticatory performance than their Class II counterparts.

It has been reported that OBF decreases during orthodontic treatment (13–14). Yawaka et al. (15) reported that OBF in patients with anterior crossbite was the lowest, during orthodontic treatment, just after the improvement of crossbite and then increased gradually to stabilize after 6 months. Winocur et al. (14) found that OBF increased after orthodontic treatment compared with that measured prior to appliance removal.

Almari and Abu Alhaija (16) reported that OBF was reduced during the first month of orthodontic treatment and then recovered to the pre-treatment levels following the second month after commencement. Sonnesen and Bakke (13) examined bite force in children with a unilateral posterior crossbite before and immediately after orthodontic treatment. OBF reduced immediately after treatment but increased after retention and approached bite force levels in children with normal occlusion.

Antonarakis et al. (17) recorded the maximum OBF (MOBF) at the first molar before and after treatment with functional appliances. They reported a significant reduction in MOBF. Some earlier studies, on the other hand, reported a similar (18–19) or increased electromyographic tonic activity of the masseter muscle after the use of functional appliances (20–21).

The measurement of bite force can provide useful data for the evaluation of jaw muscle function and activity. It is also an adjunctive
value in assessing the performance of the dentition \((22)\). Generally, the literature is deficient in studies on the OBF change after orthodontic treatment with contradictory results. Therefore, the aim of this study was to determine the OBF changes, at the incisal and molar regions, after orthodontic treatment with functional appliance therapy in preadolescent subjects. The Null hypothesis is that OBF measurements are not affected by orthodontic treatment with Andresen functional appliance.

**Materials and methods**

Ethical approval for the conduction of this study was obtained from the Institution of Research Board (IRB)/Jordan University of Science and Technology (JUST). All patients attending the orthodontic clinic at the Dental Teaching Center, JUST, during the period between October 2008 and June 2009 were screened. Sample size calculation revealed that for a 95 per cent power and 5 per cent precision \((\alpha = 0.05)\), the study should include at least 14 subjects.

Of the 253 orthodontic patients, 40 (20 females and 20 males) patients who fulfilled the following criteria were included in this study: Caucasian, Class II skeletal pattern, average maxillomandibular plane angle \((23)\), no crowding, no congenitally absent or missing permanent teeth, no posterior crossbite, no signs or symptoms of temporomandibular joint dysfunction, no craniomandibular anomalies or systemic muscle or joint disorder, no large carious lesions or restorations on upper or lower first permanent molars, and small carious lesions were restored prior to orthodontic treatment. All patients were scheduled for treatment with functional appliance only.

The age of the participants ranged between 10 and 13 years with a mean age of 11.8 ± 1.1 years. Their dental development ranged from late mixed dentition stage to early permanent stage. The average ANB angle for the sample was 6.0 ± 0.2 degrees (ranging from 5.5° to 6.5°), while the average maxillomandibular plane angle was 28.3 ± 2.9 degrees (ranging from 25° to 30.5°). Overjet was increased and averaged 6.6 ± 0.3 mm, molar and canine relationships were Class II.

A control group was examined in order to determine whether there was any fluctuation of the OBF in a period of 9 months. Thirty-two school children (17 females and 15 males) with a mean age of 11.0 ± 1.2 years were selected to act as a control sample. OBF was recorded in these subjects on two separate occasions with an interval of nine months between the two measurements.

The OBF registration procedure was explained to the participants. A written consent of participation and compliance was signed by all subjects’ guardians prior to the commencement of the study.

All patients were treated by the same consultant (EA) with Andresen functional appliance as described by Andresen and Häupl \((24)\). The average period of treatment was 9.1 ± 0.4 months. Of the 40 subjects who started their treatment, 7 (3 females and 4 males) were uncooperative and declined or were dropped from the study leaving 33 subjects (17 females and 16 males) who were included in the study.

OBF was recorded using a battery-operated portable type of OBF gauge (GM10, Nagano Keiki, Tokyo, Japan). The bite force gauge consisted of a hydraulic pressure gauge and a biting element made of a vinyl material encased in a polyethylene tube (disposable cap). The measured OBF force was calculated in Newton (N) and displayed digitally.

OBF was measured in the incisal and the first permanent molar regions. Before recording, each subject was instructed to sit upright, looking forward without head support and with Frankfort plane parallel to the floor. Each subject was instructed to bite as hard as possible without moving their head. Three OBF measurements were recorded on each side and incisally with a 15 second rest between each bite, the average of the three readings was used. Three OBF measurements were considered in the analysis: the maximum OBF (MOBF) achieved by the subject, the averaged OBF on molars (AOBF), and the OBF at the incisal region (IOBF). All OBF measurements were carried out by the same investigator (SM).

OBF was recorded just before the insertion of the functional orthodontic appliance (T1) and at the end of active treatment (T2).

Number of teeth in contact was measured using double-sided articulation paper strips that was smeared with a thin layer of petroleum jelly prior to its’ use so as to improve the visualization of the markings of the contact points that existed in a subject’s intercuspal position. Subjects were instructed to tap their teeth together firmly through the articulation paper five times in succession. Each subject was instructed to attempt to generate their perceived maximum occlusal force while tapping through the articulation strips. Standardized photographs were taken of the markings for the calculation of the number of teeth in contact.

**Method error**

OBF measurements and number of teeth in contact were taken twice for 10 subjects with a 1-week interval between measurements. The Dahlberg formula \((25)\) was used to calculate the standard error of the method \(S = \sqrt{2d/2n}\). Houston’s coefficient of reliability \((26)\) was also calculated. Dahlberg error was 15.74 N and the coefficient of reliability was 85 per cent.

**Statistical analysis**

Statistical analysis was performed using Statistical Package for Social Science (SPSS) computer software (SPSS 20.0, SPSS Inc., Chicago, USA). Descriptive statistics of OBF measurements were calculated.

Normality distribution test for sample was conducted; it was normally distributed under the Gaussian curve. Paired sample \(t\)-test was used to detect differences between the OBF measurements at T1 and T2 in the total sample, in females and in males. Independent 2-sample \(t\)-test was used to detect differences in the OBF measurements between the control and study groups at T1. Change in bite force was compared between females and males using also independent 2-sample \(t\)-test.

Significance was predetermined at the \(P < 0.05\) level.

**Results**

The sample was normally distributed under the Gaussian curve. The means and standard deviation (SD) for OBF measurements, number of teeth in contact, differences between means and standard error (SE) of the difference in the total sample, females and males at T1 and T2 are shown in Table 1 for the study group and in Table 2 for the control groups.

Differences in OBF measurements between studied and control groups were not detected at T1 \((P > 0.05)\).

All measured parameters were significantly reduced after functional appliance therapy in the total sample and in males. The differences were significant at \(P < 0.001\). In females, changes in MOBF and number of teeth in contact were significantly reduced \((P < 0.001)\). Changes in AOBF and OBF, although the readings were reduced, did not reach a significant level.

There were significant differences in the changes in all measured parameters between males and females in the study group.
### Table 1. Means and standard deviations (SD) for occlusal bite force measurements (measured in Newton), difference between means and standard error (SE) of the difference in the studied group at T1 and T2 in females, males and total group

<table>
<thead>
<tr>
<th></th>
<th>Females (N = 17)</th>
<th>Males (N = 16)</th>
<th>Total (N = 33)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1 Mean (SD)</td>
<td>T2 Mean (SD)</td>
<td>Mean difference (SE)</td>
</tr>
<tr>
<td>Maximum occlusal bite force</td>
<td>315.7 (51.8)</td>
<td>263.6 (56.3)</td>
<td>−52.1 (9.7)***</td>
</tr>
<tr>
<td>Average occlusal bite force</td>
<td>258.7 (42.5)</td>
<td>221.3 (65.6)</td>
<td>−37.4 (18.8)</td>
</tr>
<tr>
<td>OBF</td>
<td>259.4 (72.6)</td>
<td>219.0 (79.8)</td>
<td>−40.4 (19.2)</td>
</tr>
<tr>
<td>No. of teeth in contact</td>
<td>18.1 (3.7)</td>
<td>14.6 (3.0)</td>
<td>−3.5 (0.4)***</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>T1 Mean (SD)</th>
<th>T2 Mean (SD)</th>
<th>Mean difference (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum occlusal bite force</td>
<td>347.3 (118.5)</td>
<td>348.6 (89.2)</td>
<td>−0.7 (17.7)***</td>
</tr>
<tr>
<td>Average occlusal bite force</td>
<td>354.4 (117.4)</td>
<td>284.9 (91.9)</td>
<td>−69.5 (17.1)***</td>
</tr>
<tr>
<td>OBF</td>
<td>317.1 (81.8)</td>
<td>232.6 (70.2)</td>
<td>−84.5 (13.7)***</td>
</tr>
<tr>
<td>No. of teeth in contact</td>
<td>21.2 (3.6)</td>
<td>16.1 (2.3)</td>
<td>−5.1 (0.5)***</td>
</tr>
</tbody>
</table>

***P < 0.001.

### Table 2. Means and standard deviations (SD) for occlusal bite force measurements (measured in Newton), difference between means and standard error of the difference (SE) in the control group at T1 and T2 in females, males and total group

<table>
<thead>
<tr>
<th></th>
<th>Females (N = 17)</th>
<th>Males (N = 16)</th>
<th>Total (N = 32)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>T1 Mean (SD)</td>
<td>T2 Mean (SD)</td>
<td>Mean difference (SE)</td>
</tr>
<tr>
<td>Maximum occlusal bite force</td>
<td>331.8 (92.1)</td>
<td>337.1 (87.5)</td>
<td>5.3 (5.7)</td>
</tr>
<tr>
<td>Average occlusal bite force</td>
<td>274.7 (64.0)</td>
<td>287.2 (54.2)</td>
<td>12.5 (4.2)*</td>
</tr>
<tr>
<td>OBF</td>
<td>245.4 (56.6)</td>
<td>243.1 (63.6)</td>
<td>−0.3 (4.3)</td>
</tr>
<tr>
<td>No. of teeth in contact</td>
<td>18.9 (3.5)</td>
<td>18.1 (3.7)</td>
<td>−0.8 (0.4)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>T1 Mean (SD)</th>
<th>T2 Mean (SD)</th>
<th>Mean difference (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum occlusal bite force</td>
<td>397.8 (107.1)</td>
<td>405.3 (97.8)</td>
<td>7.5 (4.3)</td>
</tr>
<tr>
<td>Average occlusal bite force</td>
<td>352.1 (99.1)</td>
<td>349.4 (96.2)</td>
<td>−2.7 (10.2)</td>
</tr>
<tr>
<td>OBF</td>
<td>252.8 (53.1)</td>
<td>253.5 (56.1)</td>
<td>0.7 (2.8)</td>
</tr>
<tr>
<td>No. of teeth in contact</td>
<td>21.8 (2.7)</td>
<td>20.8 (3.8)</td>
<td>−1.0 (0.4)*</td>
</tr>
</tbody>
</table>

*P < 0.05, **P < 0.01.
Males exhibited more reduction in bite force and number of teeth in contact than females did. In the control group, apart AOBF in females that was increased, the other OBF measurements did not differ significantly between T1 and T2 (P > 0.05).

**Discussion**

Functional appliance therapy may directly affect the functional pattern of masticatory muscles (27). Only a few studies have addressed this issue with contradicting results (17,19,21). Moreover, most of these studies investigated the muscular activity of the masticatory system rather than the bite force per se.

In this study, a control group with an age range similar to that of the study group was used to record changes in OBF over a period of 9 months; similar to that of the study period. No significant changes in OBF values were noticed during that period. Accordingly, changes in OBF measured in the study group were considered as a result of the orthodontic treatment with functional appliances.

All treated patients and control subjects exhibited an average vertical skeletal relationship since occlusal bite force has been reported to vary in patients with different vertical relationships (7).

The results of this study showed a significant reduction in all the measured parameters after orthodontic treatment for an average period of 9 months. Reduction in bite force could be attributed to the changes in muscular activity when wearing the functional appliance; although jaw muscles have a good range of adaptation to local and systemic alterations, changes in the functional pattern of the orofacial musculature would cause changes in the muscular activity leading to variations in OBF (28). Mandibular advancement using functional appliances to correct the Class II skeletal discrepancy would cause a reduction in the electromyography activity of the jaw-closing muscles as an immediate neuromuscular response to mandibular advancement (27,29,30). Another reason for OBF reduction could be the reduction in number of occlusal contacts (31). The reduction in number of occlusal contacts, in its turn, could be attributed to the dental developmental stage of the participants and to the development of posterior open bite after functional appliance therapy when the acrylic bite blocks were not trimmed during the treatment (32).

Antonarakis et al. (17) similarly reported a reduction in OBF in the molar region after functional appliance therapy. It was suggested that functional appliance treatment may lead to mild muscular atrophy, possibly due to decreased functional activity of the masticatory muscles (33). The other reason suggested for the OBF reduction was the occlusal instability (17). Sonnesen and Bakke (13) also reported a reduction in OBF after maxillary expansion for a period of 7 months to treat unilateral crossbite. In that study, they attributed the reduction in bite force to the degeneration of the axons in the periodontal ligament after application of orthodontic forces and to the transient changes in occlusal support.

OBF at the incisal region, in this study, was significantly reduced after the treatment. Up to our best knowledge, no studies have evaluated bite force in the anterior region after orthodontic therapy. We could speculate that this reduction is attributed to the degeneration of the axons in the periodontal ligament after application of orthodontic forces (13) and to the pain sensation experienced as a result of dental movement during orthodontic treatment (34).

Additionally, a significant reduction was found in OBF parameters in both genders but more pronounced in males. Such muscular response might be attributed to the anatomic differences between the two genders (4). More reduction in the number of tooth occlusal contacts by the end of the treatment in males than in females could be another contributing factor.

**Conclusions**

1. Functional appliance therapy significantly reduced OBF.
2. More pronounced reduction was noticed in males than in females.

**References**


