Association between orthodontic treatment need and masticatory performance

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**Aim:** This retrospective cohort study assessed the differences between the masticatory performance of individuals with and without orthodontic treatment need. **Methods:** Masticatory performances of 120 participants with equal numbers of males and females (n = 60 each) with and without treatment need (n = 60 each, determined using the index of the complexity, outcome, and need [ICON]) matched by age and sex were assessed. Participants chewed on test foods at sequences of 20, 30, 40, 40, 30, and 20 masticatory cycles. After sieving the chewed particles, the masticatory parameters (median particle size [MPS], masticatory frequency [MF], and broadness of particle distribution [BPD]) were calculated. The associations between treatment need and the MPS with age, weight, and stature, as well as the relationship between sex and MPS and MF, were assessed. **Results:** According to the independent samples t test, MPS of subjects with and without treatment need differed significantly (P < .05) while MF did not. The differences between BPD values reached the level of significance only after 40 cycles of mastication (P < .05). Females showed significantly greater MPS values. Only at the 40-cycle sequence did females in need of treatment chew significantly slower. According to the repeated-measures ANOVA, no significant differences existed (P > .05) between each of the MPS, MF, and BPD values measured at different sequences. No significant correlations were found between MPS and age, sex, or stature (P > .05 [Spearman correlation coefficient]). **Conclusion:** The masticatory performance of individuals with and without treatment need differed for MPS and BPD (at the 40-cycle sequence). Age, weight, and stature did not affect the treatment need and MPS. Females showed poorer results regarding MPS—only at the 40-cycle sequence did females with malocclusion chew significantly slower. ORTHODONTICS (CHIC) 2012;13:e20–e28.

**Key words:** index of the complexity, outcome, and need (ICON); masticatory frequency; masticatory performance; median particle size; orthodontic treatment need
The process of grinding food increases its surface-to-volume ratio as well as the efficiency of the initial digestion with the effect of digestive enzymes and secondary gastric digestion through the facilitation of gastric movements.\textsuperscript{1–3} Therefore, an appropriate masticatory performance (MP) might be necessary for maintaining good quality of life.\textsuperscript{1,4} The stomatognathic system, primarily composed of the neuromuscular system, temporomandibular joint, tongue musculature, and the occlusal surfaces of the teeth, is responsible for degrading the food.\textsuperscript{1,2} It is suggested that a broader interocclusal area with closer occlusal distances might provide more efficient grinding.\textsuperscript{1,2,5–7} Individuals with ideal occlusions might have optimal cusp-to-fossa occlusal contact areas and therefore have superior masticatory performance compared with individuals with malocclusion. On the other hand, individuals with severe malocclusions might have poor masticatory performances,\textsuperscript{1–3,8} although this is controversial.\textsuperscript{9}

Most authors assessed the relationship between occlusal condition and masticatory performance in orthognathic patients based on Angle malocclusion classes.\textsuperscript{1,3,8,10} Only a few studies have used standardized indices to evaluate the occlusion as a combination of multiple traits,\textsuperscript{2,3,11,12} of which only two had a sufficient sample size. Moreover, controversy exists over the reported results, as well as the effect of age, body size, and sex on the masticatory performance.\textsuperscript{1–3,11–13} Therefore, our aim was to evaluate the potential differences between the parameters of masticatory performances of individuals with and without orthodontic treatment need (as determined using the index of complexity, outcome, and need [ICON]\textsuperscript{14}), and to assess the probable link between sex and body size with orthodontic treatment need and masticatory performance in the dental students of a dental facility in Tehran, Iran, between 2008 and 2010.

**METHODS**

This retrospective cohort study was performed on 120 dental students—30 control males and 30 control females with ICON scores < 40 and an equal number of cohort subjects (2 × 30) with ICON scores > 46. The control subjects were matched according to their age and sex. Inclusion criteria were the subjects’ willingness to participate, a full dentition, an absence of any pain in orofacial areas, an absence of any signs or symptoms of temporomandibular disorders or dysfunctions (TMD), no history of orthodontic treatment, no acute/urgent dental problems, and no more than two dental restorations.\textsuperscript{2} The study protocol was approved by the university’s institutional review board, and participants gave written consent.

**Determination of orthodontic need**
The need for orthodontic treatment was assessed using the ICON (Table 1)\textsuperscript{2,14} determined by two blinded observers (a dentist and an orthodontist) based on both clinical examinations and dental records. Inconsistent scores were re-evaluated approximately 1 month later.

**Masticatory performance**
Condensation silicone putty (Speedex, Coltene/Whaledent) was used to fabricate artificial food pieces (a total of 150 pieces of 7.6 g for each subject).\textsuperscript{1,2} Participants chewed the silicone particles at six sequences of 20, 30, 40, 40, 30, and 20 mastication cycles. The examiner counted the cycles and timed the sequences to calculate the masticatory frequency (MF) in cycles per minute. After each sequence, all chewed particles were expectorated, rinsed, and collected. After drying them for 1 hour at 80°C, the content of each sequence was sieved using seven different sieves with mesh sizes of 5.6, 4, 2.8, 2, 0.850,
The median particle size (MPS in mm²) and the broadness of particle distribution (BPD) were computed using the Rosin-Rammler function as previously described. The MPS indicates the central tendency of sieved particles: A lower MPS means a higher masticatory function, whereas a higher BPD value indicates a narrower range of particle size.

Each subject’s age (years), stature (mm), and weight (Kg) were recorded.

Table 1: The ICON

<table>
<thead>
<tr>
<th>Component</th>
<th>Score</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esthetic</td>
<td>1 to 10 based on IOTN-EC</td>
<td>7</td>
</tr>
<tr>
<td>Crowding (mm)</td>
<td>&lt; 2</td>
<td>2.1–5</td>
</tr>
<tr>
<td></td>
<td>2.1–5</td>
<td>5.1–9</td>
</tr>
<tr>
<td></td>
<td>9.1–13</td>
<td>13.1–17</td>
</tr>
<tr>
<td></td>
<td>&gt; 17</td>
<td>17</td>
</tr>
<tr>
<td>Spacing (mm)</td>
<td>&lt; 2</td>
<td>2.1–5</td>
</tr>
<tr>
<td></td>
<td>2.1–5</td>
<td>5.1–9</td>
</tr>
<tr>
<td>Crossbite</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Open bite (mm)</td>
<td>0</td>
<td>0.1–1</td>
</tr>
<tr>
<td></td>
<td>1.1–2</td>
<td>2.1–4</td>
</tr>
<tr>
<td></td>
<td>&gt; 4</td>
<td>4</td>
</tr>
<tr>
<td>Overbite (MIC)</td>
<td>&lt; 1/3</td>
<td>1/3–2/3</td>
</tr>
<tr>
<td></td>
<td>2/3–full</td>
<td>Full</td>
</tr>
<tr>
<td>Buccal segment</td>
<td>Cusp to embrasure</td>
<td>CE and CC</td>
</tr>
<tr>
<td>anteroposterior</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

MIC, mandibular incisor coverage; CE, cusp to embrasure; CC, cusp to cusp; IOTN-EC, the esthetic component of the index of orthodontic treatment need.

Table 2: The mean and SD of age, weight, and stature of male and female participants with and without orthodontic treatment need

<table>
<thead>
<tr>
<th></th>
<th>ICON &lt; 43</th>
<th>ICON &gt; 43</th>
<th>P*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>25 ± 1.71</td>
<td>25 ± 2.03</td>
<td>&gt; .999</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>58 ± 4.26</td>
<td>56 ± 4.41</td>
<td>.079</td>
</tr>
<tr>
<td>Stature (mm)</td>
<td>165 ± 10</td>
<td>163 ± 8</td>
<td>.396</td>
</tr>
<tr>
<td>Male</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
<td>27 ± 2.12</td>
<td>28 ± 3.23</td>
<td>.162</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>78 ± 4.33</td>
<td>80 ± 5.26</td>
<td>.113</td>
</tr>
<tr>
<td>Stature (mm)</td>
<td>179 ± 8</td>
<td>179 ± 8</td>
<td>&gt; .999</td>
</tr>
</tbody>
</table>

*Independent samples t test. SD, standard deviation.

Reliability of the method

After 1 month, dental casts and photographs of 20 participants were randomly selected and scored by both examiners. The reliability of the method was determined as 94% (P < .001) using the Spearman correlation coefficient.

Statistical analysis

The mean MPS and MF of the repeated sequences (eg, both 20-cycle sequences) were calculated as the main MPS and MF of each sequence. A repeated-measures analysis of variance (ANOVA), an independent samples t test, and the Spearman correlation coefficient with powers > 0.8 were used to analyze the data. The level of significance was set at .05.
RESULTS

Until reaching the desired sample size, 307 students were evaluated. Among the excluded individuals were nine subjects with borderline ICON scores (between 40 and 46). The participants’ age, weight, and stature were not significantly different \((P > .05)\) between those needing and not needing treatment, according to the independent samples \(t\) test (Table 2).

According to the independent samples \(t\) test, there was not a significant difference between the MF of individuals in need of orthodontic treatment and those without treatment needs at all 20-, 30-, and 40-cycle sequences \((P > .05)\). The MPS was significantly different between the two groups \((P < .05)\) (Table 3). The BPD was significantly different between the two groups at only the 40-cycle sequence.

The \(t\) test showed a significant difference between the MPS of males and females regardless of their ICON scores (Table 4 and Fig 1). The MF of the control males and females was similar. However, the difference between the males and females in the definite treatment group was more clear. The male-female difference at 40-cycle sequence was significant (Table 4 and Fig 2).
According to the repeated-measures ANOVA, the MPS of individuals without treatment need were not significant through different sequences (males, $P = .552$; females, $P = .278$). Such a similarity was observed between the MPS of individuals in need of treatment at different chewing sequences (males, $P = .752$; females, $P = .495$). Also, there were no significant differences between the MF values and between the BPD values at different chewing sequences, neither for the males nor for the females with or without treatment needs (all $P$ values for the MF > 0.9, all $P$ values for the BPD > 0.5). Using the Spearman correlation coefficient, no statistically significant correlations were observed between the MPS with age, weight, and stature (all rho statistics < 0.25, all $P$ values > .08).
DISCUSSION

In this study, the MPS was significantly greater in the definite treatment need group. However, the MF did not differ significantly between the two groups. The MPS, the MF, and the BPD slightly (and nonsignificantly) reduced by increasing the number of strokes. The age, stature, and weight of the participants did not significantly affect the MPS or MF. Sex did not significantly affect the masticatory frequency either, although males could better degrade particle sizes (MPS).

Masticatory performance

Similar results using the ICON were obtained by previous studies with regard to both the significant effect of malocclusion on MPS and its nonsignificant effect on MF.\textsuperscript{1,2,8,16} In addition, some other studies using other types of malocclusion indices such as the dental esthetic index revealed a greater MPS reduction by patients needing orthodontic treatment.\textsuperscript{17} Toro et al\textsuperscript{3} stated that there was a significant difference between the masticatory performance of individuals with Class I occlusion and those with Class I malocclusion, while the difference between Class I occlusion and Class II malocclusion was not significant. The relationship between the MP and malocclusion might be due to extrinsic factors such as the adverse effects of malocclusion on the efficacy of masticatory muscles, occlusal interferences (reduced maximum intercuspation), and deviations in proper paths of mandibular movements in individuals with malocclusion.\textsuperscript{2,5–7,18–21} The controversies could arise from a long list of diverse factors including differences in the methodologies employed, such as definitions of masticatory performance, environmental influences, sampling methods, sample sizes, statistical analyses (categorical vs continuous), range of individuals’ ages, differences in the number of the sieves used, food types (the standard test food vs different kinds of natural foods), sizes and toughness of test foods, food attributes (appearance, flavor, texture, and swallowability), malocclusion types (Angle classes vs standardized indices), and measurement methods (objective/subjective).\textsuperscript{1–3,10,12,21,22}

The BPD indicates the uniformity of particle sizes. English et al\textsuperscript{1} reported a significant difference between the BPD of individuals with and without treatment need; however, Ngom et al\textsuperscript{2} did not support their findings. The particles chewed by the normal participants were more uniform in size in the present study. Likewise, in the results of Ngom et al,\textsuperscript{2} BPD tended to show greater differences between the two groups by increasing the number of mastication cycles per sequence. This might be attributed to the higher efficacy of grinding in a longer duration of chewing, which might magnify the effects of competent occlusion and incompetent malocclusion on the uniformity of the particle sizes. In this study, the differences between the BPD of the two groups were slightly greater than the findings of Ngom et al\textsuperscript{2} and were slightly lower than the results of van den Braber et al.\textsuperscript{23} Methodologic and probable ethnic differences could contribute to such differences.

There was no observation of a significant difference between the masticatory frequencies of subjects with and without treatment need. This finding was in line with that of some authors.\textsuperscript{1,2,10} However, some other studies reported a significant change in the masticatory frequency of patients with malocclusion, both before and after the orthognathic surgery.\textsuperscript{6} In both groups of this study, increasing the number of mastication strokes reduced the values of masticatory parameters (indicating an improvement in the performance). This was similar to the previous studies\textsuperscript{2,23–25} and might indicate that individuals with malocclusion could chew more to compensate for their poor masticatory performance.\textsuperscript{2,25} However, this possibility might be limited by multiple factors such as individual's tendency to swallow earlier or their personality traits.\textsuperscript{21,26–28}
It should be noted that according to our findings, such enhancements in MP might be subtle.

**Age and body size**

Aging might affect body size and therefore masticatory performance. Nevertheless, no significant associations were observed between the masticatory performance and these factors in this study. Toro et al. reported a significant improvement in masticatory performance of children and adolescents with aging. They also stated that this correlation was rooted in the differences within the larger body sizes of older children. de Morais Tureli et al. stated that the MPS was negatively correlated with age but only in normal-weight children. They also concluded that the overweight children had greater MPS values and that the underweight children were at a risk for poor masticatory performance. However, English et al. and Ngom et al. stated that age, weight, and stature did not significantly relate to the masticatory performance, which was in accordance with our findings. We (as well as Ngom et al.) evaluated the age range of young adults in which the effect of age on growth in muscular mass is smaller, while English et al. studied children and adolescents. It is suggested that the maximum bite force is not associated with masticatory performance and that the occlusion might be related to the masticatory performance more than might be the body size. It should be taken into consideration that the mentioned studies evaluated the effect of age and body size on malocclusion, not on the MPS.

**Sex**

The possible effect of sex might be attributed to the muscular mass or other factors such as higher levels of stress in females, which might be related to problems such as TMD or lower thresholds of pain and emotional sensitivity (although the TMD cases were excluded from this study). Ngom et al. stated that sex did not affect malocclusion, implying that it did not affect the masticatory performance either. Nevertheless, they did not directly evaluate its effect on the MPS or MF. Toro et al. showed that sex did not significantly correlate to the MPS, though the female participants showed significantly slower durations of mastication. In this study, the MPS of females was higher than that of males. In the no treatment need group, the MF of females was similar to that of males. However, females in need of treatment showed slower mastication compared with their male counterparts, which became statistically significant after chewing for 40 cycles. Methodologic differences (differences in the test food and malocclusion classifications), ethnical backgrounds, and age differences might account for the above.

**Limitations and advantages**

There were factors limiting this study. Since standardizing natural food was not possible, a fabricated alternative was used in this and several other studies. However, mastication is a complex procedure based on sensory stimuli, and might therefore differ in efficacy when the level of stimulation varies. A nonswallowable test food without a stimulating flavor and appearance might negatively affect masticatory performance.

The ICON indicates a standardized combination of various traits. Although it might increase the generalizability of the findings, it lacked the assessment of specific traits. For example, a correlation might exist between the vertical facial dimension and the masticatory performance in a way that individuals with open bites may have a poorer MP. However, index scores do not include such detailed data (ie, the extent of open bite). Rather than using only index scores, further studies should assess the correlation between each component...
of such compiled indices with the masticatory performance, as well. Moreover, dichotomizing the ICON scores in this and another study\(^2\) might limit the accuracy of the results. On the other hand, the participants with borderline scores were excluded from the present study to increase the reliability of the findings. In addition, the esthetic component of the index of orthodontic treatment need (IOTN) focused on the esthetics of the anterior teeth. Therefore, the ICON scores, which are standardized to determine the treatment need, may not perfectly reflect the extent of malocclusion, especially when considering the weight of the esthetic component in the ICON (as it is the highest one). This shows that there might still be a need for defining a new standardized method focused on malocclusion to assess its relation with mastication. Toro et al\(^3\) also concluded that the occlusion indices were not reliable predictors of masticatory performance.

**CONCLUSION**

Within the limitations of this study, the masticatory performance of individuals with and without treatment need differed significantly from certain aspects (the MPS and the BPD, the latter only at the 40-mastication sequence). The MF did not differ significantly between the two groups.

The age, weight, and stature did not affect the treatment need and the masticatory performance. Females showed greater particle sizes (poorer results); however, only at the 40-cycle sequence did the females in the definite treatment need group tend to chew significantly slower than their male counterparts.

**REFERENCES**