Pain, masticatory performance and swallowing threshold in orthodontic patients

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Objective: The aim of this study was to assess pain, masticatory performance and swallowing threshold of patients undergoing orthodontic treatment.

Methods: Ten patients of both genders (mean age of 17.25 ± 5.21 years), with complete permanent dentition, who underwent orthodontic treatment with fixed appliances were evaluated. The masticatory performance and the swallowing threshold were assessed by patient's individual capacity of fragmenting an artificial test food (Optocal) which was chewed and had the resulting particles processed by a standardized sieving method, presenting the median particle size (MPS) of crushed units. The intensity of pain / discomfort during chewing was evaluated by means of a visual analog scale. All tests were performed at the following times: T_0 – before activating the orthodontic appliance; T_1 – 24 hours after activation, and T_2 – 30 days after activation.

Results: The results showed a significant increase in pain at T_1 (T_0 – 0.60 ± 0.70 mm; T_1 – 66.2 ± 34.5 mm), returning to baseline values at T_2 (3.20 ± 3.82 mm). Masticatory performance was also reduced in T_1 (MPS 10.15 ± 1.1 mm^2) in comparison to T_0 (MPS 7.01 ± 2.9 mm^2) and T_2 (MPS 6.76 ± 1.3 mm^2). However, particle size was not affected in the swallowing threshold test (T_0 – 5.47 ± 2.37 mm^2; T_1 – 6.19 ± 2.05 mm^2; T_2 – 5.94 ± 2.36 mm^2).

Conclusion: The orthodontic appliances did not interfere in the size of the particles that would be swallowed, even in the presence of pain.

Keywords: Mastication. Malocclusion. Orthodontics.

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How to cite this article: Trein MP, Mundstock KS, Maciel L, Rachor J, Gameiro GH. Pain, masticatory performance and swallowing threshold in orthodontic patients. Dental Press J Orthod. 2013 Nov-Dec;18(6):117-23.

Submitted: December 26, 2011 - **Revised and accepted:** February 19, 2012

» The authors report no commercial, proprietary or financial interest in the products or companies described in this article.

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INTRODUCTION

Orthodontic movement pain is caused by the release of different mediators after the application of forces on the periodontal ligament (PDL). These mediators, including substance P, histamine, serotonin, glutamate, prostaglandins, leukotrienes, and cytokines may activate nociceptors within the PDL resulting in orthodontic pain,[1] which usually lasts for 2 or 3 days and gradually reduces by the 5th or 6th day.[2] Studies report that 95% of orthodontic patients experience some pain during treatment and several methods have been used to reduce these symptoms, including low level laser, transcutaneous electric stimulation, vibratory PDL stimulation and use of anti-inflammatory drugs.[1,3,4] Several factors associated with orthodontic pain are still ignored by many clinicians, such as the duration, intensity and functional limitations possibly induced by this symptom.

It has been shown that almost all orthodontic patients report moderate to extreme difficulties in biting and chewing harder foods, and thus tend to choose a less consistent diet.[1] The orthodontic pain is probably the main responsible for the masticatory limitations associated with fixed appliances. The orthodontic pain occurring within 48 hours is so disturbing that approximately 20 per cent of patients report being awakened at night, some of them take medication, and almost all patients report eating difficulties as a result of pain.[5,6] However, an objective analysis of mastication and deglutition in patients during orthodontic therapy was not performed by previous studies. These analyses are necessary considering that patients normally overestimate their masticatory ability when they are evaluated only by subjective methods. For example, many individuals with a compromised dentition and dentures judge their masticatory function as 'good' while an objective test resulted in values much lower than healthy subjects.[7] Therefore, the aims of this study were to evaluate masticatory performance, swallowing threshold and pain after orthodontic fixed appliance activation.

MATERIAL AND METHODS

Sample

Ten patients of both genders, five males and five females (mean age of 17.25 ± 5.21 years) participated in this study. The following inclusion criteria were considered: Approximately equal number of occlusal units with malocclusions requiring orthodontic treatment, the presence of complete permanent dentition (except third molars), uneventful medical history and good oral health. Bonding of at least 10 teeth in the maxillary arch and 0.014 (NiTi), 0.014 or 0.016-in (stainless steel) archwires ligated with elastomeric rings were used during the experimental period. No extractions were performed during this period. Four individuals had Class I malocclusions, four had Class III and two had Class II. The exclusion criteria were: previous orthodontic treatment and symptoms of temporomandibular joint dysfunction. An informed written consent was obtained from all participants or parents prior to their enrolment in the study. The local Institutional Review Board approved the protocol. The study was carried out at the Department of Orthodontics of the Federal University of Rio Grande do Sul (UFRGS), in Brazil. Sample size was determined on the basis of clinically relevant masticatory performance data obtained from the literature,[8,9,10] with a power of 80%, $\alpha = 0.05$, and 10 individuals were deemed adequate for this longitudinal study in which each patient served as their own control.

Timing of evaluations

The subjects were analyzed at three time points: T_0, at their first consultation, before fixed appliances were installed; T_1, 24 hours after installation and engagement of the first archwire; T_2, 30 days after the first activation and before reactivation of the appliance. The data collected included masticatory performance, swallowing threshold and self-reported pain.

Masticatory performance evaluation

Masticatory performance was evaluated by means of the individual capacity of fragmentation of an artificial test-food (Optocal).[11] Subjects were given 17 cubes (3.0 g) and instructed to chew them for 15 cycles, during which they were visually monitored by a trained examiner who also timed them using a digital stopwatch. After 15 chewing cycles, the particles were spat onto a plastic cup and the mouth was rinsed thoroughly until all particles were eliminated into the cup. The collected fragments were then passed through paper filters to eliminate excess water and then placed in an oven at 60 °C for 20 hours. The dried particles were weighed and placed on a series of 10 stacked sieves with progressively smaller mesh sizes, ranging from 5.6 to 0.71 mm. The sieves were submitted to constant vibration for 5 minutes.

The contents of each sieve were then weighed on an analytic scale with a 0.001 g precision. Since the specific mass of the test-food is known, weight was converted into volume using the Rosim-Rammler equation on Statistical Package for the Social Sciences version 18.0 software. The distribution of the particles by weight was described by the cumulative function of median particle size (X50), which represents a virtual sieve mesh where 50% of the particles would pass through. The higher the X50, the worse the masticatory performance.

Swallowing threshold

The individuals were handed another set of 17 Optocal cubes and instructed to chew them until they felt the urge to swallow. A trained examiner counted the number of chewing cycles and registered the total time of the cycles, which was measured with a digital stopwatch. The swallowing threshold particles were submitted to the same fragment size analysis as it was done for the masticatory performance test, described above.

Pain quantification

After the individuals chewed the Optocal cubes they were handed a visual analogic scale (VAS) for registration of the pain experienced on every experimental period. The subjects were instructed to make a mark on the 10 cm line corresponding to the pain experienced during chewing. The left limit of the scale was described as “without discomfort” and the right limit as “worst discomfort possible”.

Error of method

The X50 data of 10 subjects with the same age were analyzed with the Dahlberg formula and paired t test after 2 analyses within a 7 day interval. There was no statistical difference between the evaluations ($p > 0.05$) and the reproducibility error was less than 10% for the X50 (0.5 mm).

Statistical analyses

Shapiro-Wilks test was used to verify data normality. The variables were analyzed by ANOVA for repeated measures, and by Tukey’s test when they were normally distributed. The Kruskal-Wallis and Dunn’s test were applied when data were not normally distributed. The SPSS software was used and the significance level was set at $p < 0.05$.

RESULTS

The results are presented in Figure 1.

Pain and Masticatory Performance

Figure 1 presents the values of pain level, median particle size chewed for 15 cycles, total chewing time and duration of each cycle.

Pain was significantly higher at T_1 when compared to T_0 and T_2 (Kruskal-Wallis + Dunn, $p < 0.05$). A significant reduction in masticatory performance also occurred in T_1 in comparison to T_0 and T_2 (Kruskal-Wallis and Dunn, $p < 0.05$). However, masticatory performance levels did not show statistical significant difference between T_0 and T_2. Total chewing time and time of each cycle were higher in T_1 than in the other experimental periods (Anova + Tukey, $p < 0.05$).

Swallowing threshold

Figure 2 demonstrates the X50 of the swallowing threshold evaluation, total chewing time, time for each cycle, and number of cycles until deglutition. The median particle size did not show statistical difference between the timepoints. Total chewing time and time for each cycle were increased in T_1 when compared to T_0 but without statistical significance. There was a statistically significant reduction when T_2 was compared to T_1 (Anova + Tukey, $p < 0.05$). Time taken for each cycle was similar in all 3 timepoints and although there was an apparent raise in T_1 it did not reach statistical significance (Kruskal-Wallis, $p = 0.092$).

DISCUSSION

This study evaluated pain, masticatory performance and swallowing threshold in patients undergoing orthodontic treatment with fixed appliances. Although the literature presents some studies on the possible functional impacts of braces,[12,13] no quantitative tool was used for objective evaluation of mastication in these studies.

Objective evaluation of masticatory function is essential in clinical trials, since patients tend to overestimate their chewing ability when evaluated only by subjective methods (e.g. questionnaires). Many patients with compromised dentition or dentures think they have a good chewing ability, even when objective tests show values much lower than in subjects with natural dentition.[7,14]

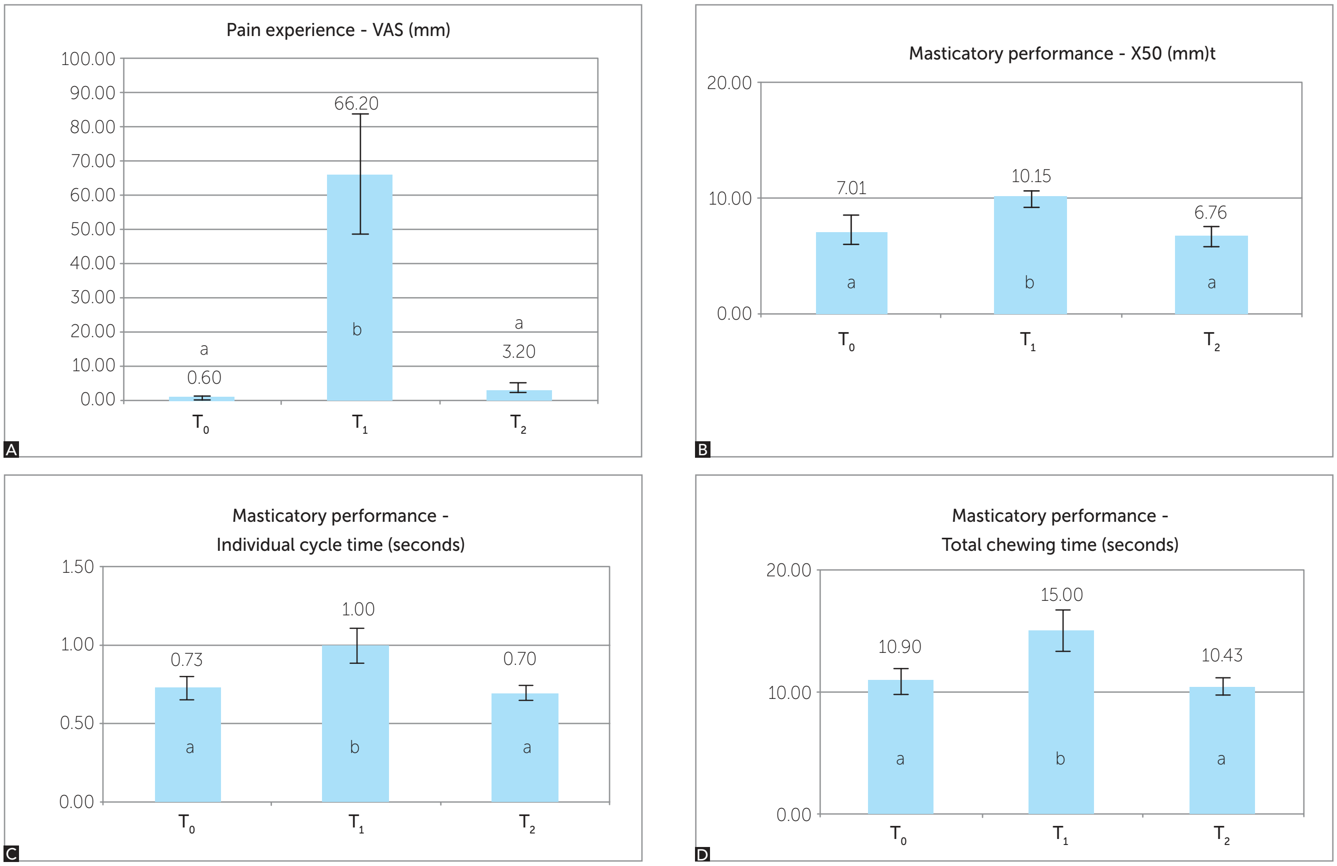

Figure 1 - Masticatory Performance Results. **A**) Pain experience expressed by VAS; **B**) X50 of the particles; **C**) Total chewing time for the 15 cycles; **D**) Individual cycle time. T_0- Before orthodontic appliance activation; T_1- 24 hours after activation; T_2- 30 days after activation. Different letters = statistical significance (Kruskal-Wallis / Dunn or ANOVA / Tukey, $p < 0.05$).

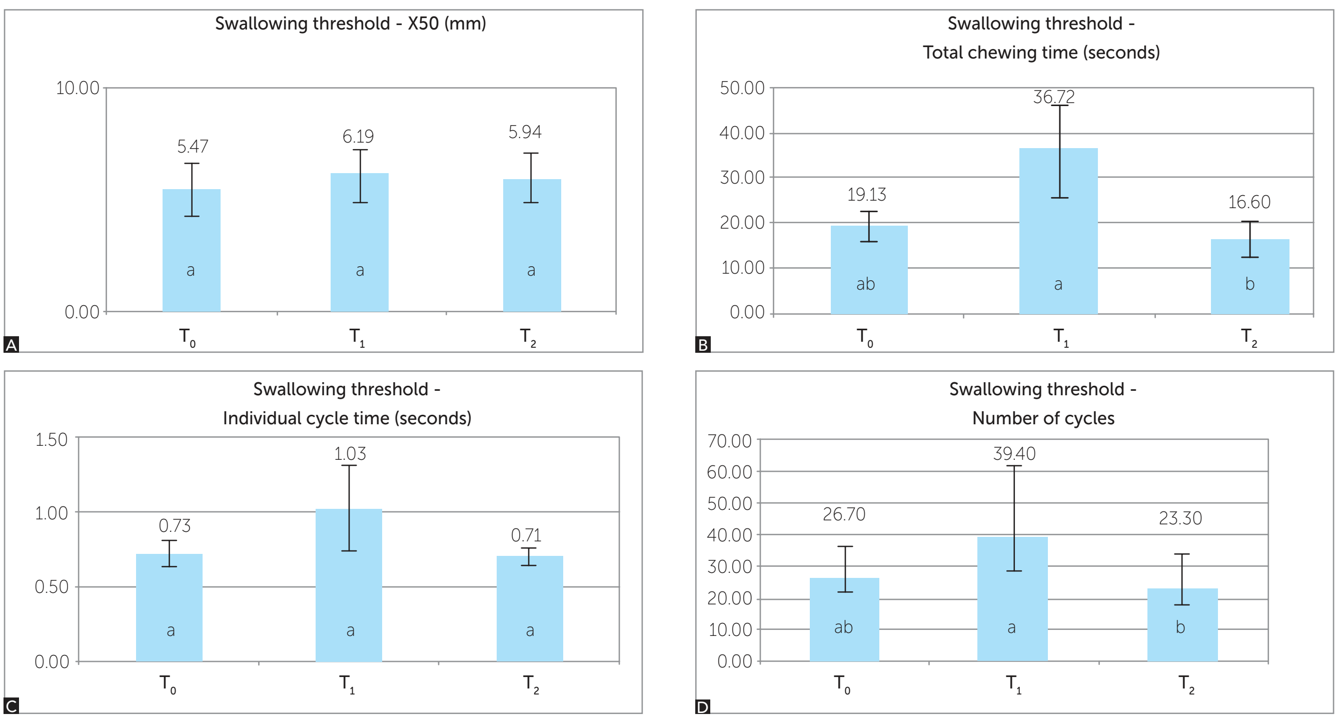

Figure 2 - Swallowing Threshold Results. **A**) X50 of the particles; **B**) Total chewing time until urge of swallowing; **C**) Individual cycle time; **D**) Number of cycles until swallowing. T_0- Before orthodontic appliance activation; T_1- 24 hours after activation; T_2- 30 days after activation. Different letters = statistical significance (Kruskal-Wallis / Dunn or ANOVA / Tukey, $p < 0.05$).

The present study demonstrated that orthodontic patients have low masticatory performance when measured one day after installation and activation of orthodontic appliances. This period represents the peak time of orthodontic pain, which tends to decrease significantly 3 days after insertion of archwires.[2,3,15,16] Erdinç and Dinçer[17] reported the onset of pain as occurring two hours after activation of the device, with a peak within the first 24 hours, in which the recorded average VAS was 48 mm for the group that received a nickel-titanium alloy archwire of 0.016-in section and 49 mm for the group that received a 014-in NiTi alloy archwire. Tortamano et al[18] demonstrated an average registration of 7.25 and 8.25 on a visual scale on the first day after the installation of 0.014-in individualized stainless steel archwires. However, the authors did not use a VAS, but a graduated scale of 1 to 10, in which the subjects had to choose a specific score, which may have resulted in higher average scores. Firestone, Scheurer and Bürgin[19] found an average of 27.5 mm VAS scores for pain caused after the first archwire was installed. It lasted for 7 days with a maximum record of 49.1 mm. In Ong, Ho and Miles study,[16] the peak of reported pain was reached within 24 hours. The work of Fernandes, Ogaard and Skoglund,[20] carried out with subjects from 9 to 16 years old, registered pain experience hourly for the first 11 hours and then on a daily basis for 7 days. The authors found an average of 36 and 37.2 mm VAS scores 24 hours after installation of the first archwire (0.014-in NiTi or 0.014-in Sentalloy). These studies were the basis of our choice of evaluating pain and masticatory performance after 24 hours.

Most studies indicate that there are no gender, age or initial crowding-related differences for pain after orthodontic appliance activation.[2,15,17,21] Firestone, Scheurer and Bürgin[19] did not find gender-related differences for perceived pain. Additionally, Ong, Ho and Miles[16] did not find any relationship between pain and age, gender or initial crowding. The findings of Scott et al[22] demonstrated no correlation between pain and gender or age, either. Therefore, our data was group regardless of gender, age, malocclusion or initial crowding differences. Our results are in agreement with studies that assessed pain associated with braces, and the pain levels reported in the present study (66.2 ± 34.5 mm in T_1) are very similar to those found by Polat, Karaman and Durmus[3] (59.4 ± 31.2 mm), which also recorded the experience of pain by VAS in patients during mastication.

Pain is often underestimated by orthodontists[23] and few studies have assessed the functional impacts of fixed orthodontic appliances.[12,17,24] Pain is often considered the worst aspect of orthodontic treatment, and is also one of the main reasons why patients drop out of treatment.[1,25,26] Some patients report, for example, that the incidence and severity of orthodontic pain is greater than pain caused by tooth extraction.[2] Researchers attribute pain to the hyperalgesia of the periodontal ligament (PDL) caused by induced tooth movement, which is defined as a painful sensation greater than what is expected to a noxious stimulus and felt over a larger area.[27] Orthodontic tooth pressure induces the release of chemical mediators such as histamine, bradykinin, serotonin and prostaglandins, which are capable of activating or sensitizing nociceptors in the PDL.[1,4] In addition to hyperalgesia, orthodontic pain can also be spontaneous or related to non-painful stimuli such as mechanical stimulation of the periodontium during mastication. The pain reported by stimuli that are usually non-painful is called allodynia,[27] and this was clearly observed in our study, since the pain levels were registered right after the masticatory performance and swallowing threshold tests and, after 24 hours, there was significant pain, which is not expected in normal masticatory function. These results are in accordance with those reported by Erdinç and Dinçer,[17] in which approximately 50% of their patients had problems with their daily activities on days 1 and 2 after orthodontic appliance activation and that the discomfort decreased significantly by the third day. In this same study, however, only subjective evaluations were used. In our study, the results of objective evaluation of masticatory function after 24 hours demonstrated that patients presented difficulties in grinding the test food during the masticatory performance test. This can be seen not only by the significant increase in median size of the crushed particles (X50), but also by the increase in the total chewing time and in the time of each cycle during the test.

With regard to the swallowing threshold, there was an increasing trend in time of each cycle and the number of cycles, although not statistically significant. The X50 of the particles right before swallowing was also not increased significantly within 24 hours, indicating that orthodontic patients ingest particles of similar size to that observed prior to the installation of the appliances (T_0). These results suggest that the chewing difficulty presented within 24 hours may have been partially balanced by an upward trend in the number of chewing cycles and time. Other ways to compensate the chewing difficulty during the peak of orthodontic pain may also have been employed, such as changes in the dynamics of jaw movements and bite force, but these variables were not evaluated in this study. Another limitation of our study is that only one test food was evaluated. This test food was chosen because it is less consistent in relation to Optosil® or Cuttersil®,[11] and patients in pain usually avoid harder foods. If we had chosen a harder test-food maybe the results would have pointed towards a more significant difference.

The consequences of inefficient chewing for general health have not been fully elucidated. The particle size ingested, which is determined by the performance of the chewing process, may influence gastric emptying. Some studies suggest that higher masticatory efficiency accelerates gastric emptying,[28,29] although this issue remains controversial. Sierpinska et al[10] found more severe chronic inflammatory changes and infection by Helicobacter pylori in the gastric mucosa in patients with dyspepsia and impaired mastication. If indeed there is a relation of cause and effect between masticatory efficiency and gastric pathologies, orthodontic therapy should not be considered as a potential cause of damage to the patient, since the present results demonstrate that although there is a reduction in masticatory performance within 24 hours, there was no difference in the size of 50X on the verge of swallowing. These findings indicate that orthodontic patients may compensate the functional limitation induced by pain with a more careful mastication until deglutition. To Fontijn-Tekamp et al,[30] individuals with poor masticatory performance tend to swallow larger particles, this observation being similar to that found by English, Buschang and Throckmorton.[13] In the first article cited,[30] adults with good oral health and varied occlusal conditions were evaluated, while the second[13] evaluated individuals with Class I, II and III malocclusions and normal occlusion, but with no braces installed. Both studies reported that individuals with poor masticatory performance do not compensate this deficiency by increasing the number of cycles until swallowing. However, these results cannot be directly compared to ours, due to the fact that these studies did not evaluate individuals with limitations caused by pain, as in our case, in which the subjects reported significant pain during the evaluation period of 24 hours after orthodontic activation. In the papers mentioned above, the performance was determined only by the dental status of individuals, whereas in our study the experience of pain significantly affected the masticatory performance of patients.

CONCLUSIONS

Patients reported a significant increase in pain during chewing 24 hours after activation of orthodontic appliances, but after 30 days there was no difference compared to baseline values.

By setting a limit of 15 chewing cycles (masticatory performance test), the median size of crushed particles was higher within 24 hours in comparison to initial and final values, which indicates a temporary deterioration in masticatory performance, since this decrease was observed only at the peak of orthodontic pain.

However, when individuals were allowed to perform the number of cycles needed until they felt comfortable to swallow (swallowing threshold test), no statistical difference between the sizes of crushed particles in any of the experimental times was found. These results demonstrate that fixed orthodontic appliances do not interfere in the size of the particles swallowed, even in the presence of orthodontic pain.

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