Original Article

Orthodontic debonding and tooth sensitivity of anterior and posterior teeth: *A prospective clinical trial*

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ABSTRACT

Objectives: To assess whether orthodontic debonding and onset of tooth sensitivity were related and if anterior and posterior teeth showed different sensitivity.

Materials and Methods: 40 patients were divided into a trial group (group 1, at the end of the multibracket treatment) and a control group (group 2, not under treatment). After the application of compressed air and cold water to mandibular incisors and first molars, participants were asked to report the pain felt for each tooth using a 100-mm visual analogue scale. In group 1, assessment was performed just before debonding (T_0), immediately after completion of debonding (T_1) and 7 days after (T_2). In group 2, values were assessed at the beginning of a follow-up visit (T_0), at the end of the same visit (T_1) and 7 days after (T_2).

Results: Considering overall teeth, statistical analyses showed significantly higher values in the trial group at T_1 after both stimuli, especially after cold water, besides a significant difference between T_0 and T_2 values in the same group. Anterior teeth showed significantly higher VAS scores than posterior after the two thermal stimuli, except after air stimulation in group 1 at T_2 and in group 2.

Conclusions: Orthodontic debonding leads to sensitivity to thermal stimuli especially in the anterior teeth, however pain level is restored within 7 days. (*Angle Orthod.* 2020;90:766–773.)

KEY WORDS: Debonding; Thermal stimulation; Tooth sensitivity; Orthodontics; Pain; Compressed air; Cold water

INTRODUCTION

Pain is one of the most common negative factors cited among orthodontic patients. Each activation of fixed appliances exacerbates pain spontaneously and during chewing[1,2] due to acute periodontal inflammation. A positive correlation was found in rats between hyalinization and chemical mediators associated with periodontal nociception.[3]

Up to 95% of patients experience unpleasant sensations during orthodontic treatment,[4] including simple discomfort, dull pain, or tooth hypersensitivity.[2] Cold stimuli are reported to be the most common triggers[5] of tooth hypersensitivity but dentin exposure resulting from dental wear is necessary for it to occur. Different stages of the fixed orthodontic therapy cause alterations to the enamel surface[6–9] but the degree of tooth sensitivity after orthodontic debonding has not been investigated specifically.

Therefore, the purpose of this study was to evaluate whether (1) increased tooth sensitivity following two thermal stimuli occurred immediately and 7 days after the debonding procedure, and whether (2) anterior and posterior teeth differed in pain scores. The first null

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hypothesis was that there would be no significant difference between pain immediately and 7 days after debonding compared to baseline, as well as between the intervention and comparison groups at any time. The second null hypothesis was that there would be no significant difference in sensitivity between anterior and posterior teeth.

MATERIALS AND METHODS

Trial Design

This was a prospective, non-randomized, parallel-group, active-controlled, and single-center clinical trial with a 1:1 allocation ratio, approved by the Unit Internal Review Board (2019 0211). This paper is presented in accordance with the Transparent Reporting of Evaluations with Nonrandomized Designs statement.[10]

Participants

Consecutive patients referred for orthodontic treatment at the Unit of Orthodontics and Paediatric Dentistry, University of Pavia, were recruited. All experimental phases took place in this center. Information was collected by administering specific surveys to each patient[11] (Table 1), who subsequently underwent a dental examination performed by the same operator to determine eligibility.

Inclusion criteria for the experimental group (Group 1, n = 20) were: absence of answers "0" in the questionnaire, presence of first molars and mandibular incisors, being toward the end of multibracket treatment lasting no more than 36 months, no rebonding performed on the first molars and mandibular incisors during treatment, no signs of buccal erosion, hypomineralization, hypoplasia, white spots and gingival recession on those teeth, and informed consent for the study.

For the controls (Group 2, n = 20), the same inclusion criteria of group 1 were considered but patients were not currently in multibracket treatment.

Interventions

Victory MBT brackets (3M Unitek, Monrovia, CA, USA) were bonded in group 1 at the beginning of orthodontic treatment with Transbond XT primer and resin (3M Unitek). After finishing treatment, debonding was accomplished with a bracket removing plier (3M Unitek Debonding Instrument, 3M Unitek). Arkansas stones and abrasive discs were used under constant irrigation to accomplish debonding finishing, according to studies assessing lower damage than use of carbide burs.[12]

Just before debonding (T_0, baseline), immediately after debonding completion (T_1), and 7 days after debonding (T_2), the following two thermal stimuli were applied with a syringe on the buccal cervical surface of each mandibular incisor and first molar with an interval of 1 minute: compressed air at first (19°C –24°C, 1 second), and freshly melted ice water afterward (0°C, 1–3 seconds).[11,13] Teeth were chosen considering previous studies assessing the lowest threshold at debond for lower incisors[14] and a major sensitivity for molars.[15]

Since patients of group 2 were not under treatment, no debonding was required for them and the two stimuli were applied at the beginning (T_0), at the end (T_1), and 7 days after (T_2) a periodic follow-up with no psychological impact.

In group 1, the same operator, previously administering the questionnaire and performing the dental inspection, carried out debonding and thermal stimulation at T0. All the other stimulations, including those in group 2, were performed by a second operator.

Outcomes

For each tooth selected, participants reported the degree of pain after the application of each thermal stimulus using a 100-mm visual analogue scale (VAS).[16] Respective mean values were calculated for each patient, considering anterior and posterior teeth separately and overall. Values were averaged among other participants to determine a mean sensitivity VAS score for the experimental and control groups after each of the two thermal stimuli applications at the three time points considered.

Sample Size

Sample size calculation was performed with a computer application (Sample Size Calculator, Clin Calc LLC) for two independent study groups with a continuous primary endpoint. The calculation was performed considering the sensitivity results of a previous study,[11] reporting a mean VAS of 8.61 (SD = 4.32) for the test group and 3.72 (SD = 1.68) for a control group, one day after debonding. The probability of a type-I error was set at 5% (Alpha = 0.05). The probability of a type-II error was set at 5% (Beta = 0.05). The results of the calculation required a sample size of 40 participants (20 cases and 20 controls).

Blinding

Considering that patients undergoing orthodontic treatment were necessarily recruited in the experimental group, random allocation and blinding of participants to the groups was not possible. Blinding was not possible for the operator at T_0 in the experimental group due to the presence of fixed appliances.

Table 1. Example of the Questionnaire Administered to Subjects

Patient's name:
Date:
Birth date:
Gender:
Date of bonding procedure:
Date of debonding procedure:
Duration of treatment:
Type of brackets:
1. Do you complain about tooth sensitivity? 0-Yes, 1-No
2. Do you currently receive or have you previously received professional or home desensitizing treatment (the latter within the last 6 weeks)? 0-Yes, 1-No
3. Have you used anti-inflammatory, analgesic, and psychotropic drugs for a long term?
4. Are you pregnant or breastfeeding? 0-Yes, 1-No
5. Do you have eating disorders (eg, bulimia nervosa)? 0-Yes, 1-No
6. Do you suffer from digestive system or endocrine system diseases (eg, chronic acid regurgitation, diabetes)? 0-Yes, 1-No
7. Do you often (several times a week) drink natural fruit juice or carbonated refreshments, and eat fruits (especially citrus fruits)? 0-Yes, 1-No
8. Have you ever received a dental treatment (restorative or endodontic) on first molars or mandibular incisors? 0-Yes, 1-No
9. Have you had periodontal surgery within the previous 3 months? 0-Yes, 1-No
10. Have you previously whitened your teeth? 0-Yes, 1-No
11. Have you ever undergone a multibracket orthodontic treatment before? 0-Yes, 1-No

Therefore, the operator who determined eligibility of the patients and performed the debonding procedures in the trial group was also instructed to perform thermal stimulation and assessment of the outcome at T_0. Conversely, a blinded assessment in the trial group at T_1 and at T_2, as well as at every time point in the control group, was feasible due to the absence of any fixed appliances. Therefore, in these cases, stimulation and outcome assessment were conducted by another operator who neither knew the participants' allocation nor took part in any of the previous experimental phases; additionally, participants were instructed not to reveal their allocation. The data analyst was blinded throughout the study.

Statistical Analysis

Data were analyzed statistically using computer software (R version 3.1.3, R Development Core Team, R Foundation for Statistical Computing, Wien, Austria). All participants were included for the statistical analysis and no dropouts were recorded. Descriptive statistics (VAS) including the mean, standard error of mean, median, and minimum and maximum values were calculated for each group.

A repeated-measures analysis of variance (ANOVA) was performed to evaluate differences among tooth sensitivity values at the different time points of the same group. Tukey test was applied post hoc. A *t*-test was applied to compare mean sensitivity intensity values between the two different groups at the same time intervals. Significance for all statistical tests was predetermined at $P < .05$.

RESULTS

Participant Flow

The flow of participants is shown in Figure 1.

Recruitment

Patients were recruited from March to November of 2019. The experimentation neither ended nor was stopped in advance. After recruitment, participants were instructed to avoid desensitizing toothpastes, analgesics, and extremely hot or cold foods during the whole study period.

Baseline Data

A total of 57.5% of participants were females (mean age: 20 $\pm$ 2 years) and 42.5% were males (mean age: 23 $\pm$ 4 years). Group 1 was composed of 11 females and nine males with a mean age of 21 years; all trial patients (n = 20) had metal brackets. Group 2 was composed of 12 females and eight males with a mean age of 22 years.

Outcomes and Estimation

Descriptive statistics are shown in Tables 2, 3, and 4. Repeated measures ANOVA showed the presence of significant differences among the various groups ($P < .0001$). When considering the air stimulation on the overall teeth (Figure 2), group 1 reported no significant differences in VAS values if compared to group 2, both at T_0 and at T_2 ($P > .05$) (Table 2). However, values at T_1 were significantly higher than those of controls at the same time point but also higher than those assessed at the other time points in the same group ($P > .05$). This was also true when considering the posterior teeth separately; whereas, for the anterior teeth, a significant difference in group 1 was detected with controls at T_0, also. The anterior teeth were significantly more sensitive than posterior teeth in group 1 at T_0 and T_1 ($P < .05$) but not at T_2, nor in group 2 at any time (Tables 3 and 4).

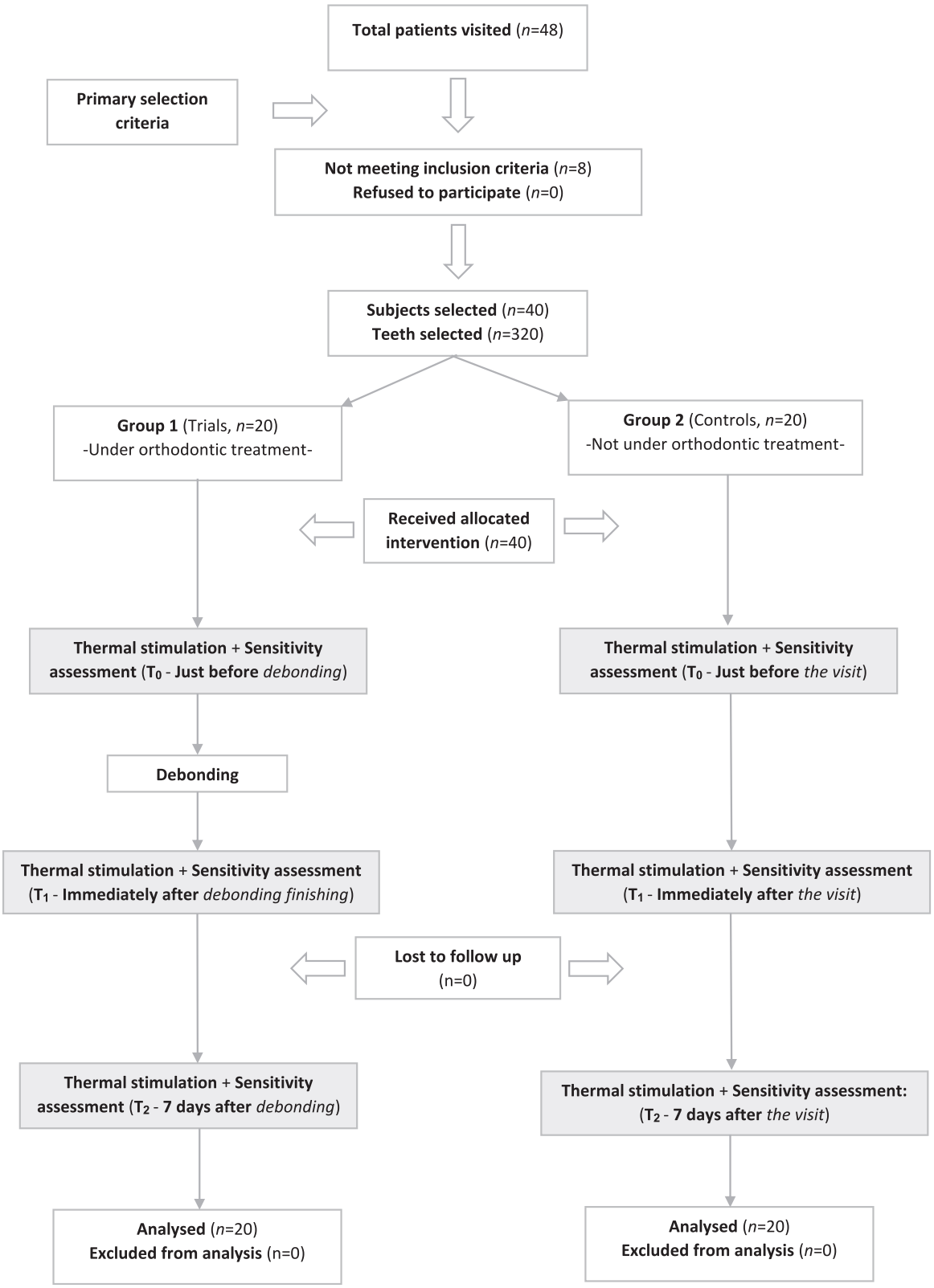

Figure 1. Flow chart of the study.

Table 2. Descriptive Statistics (VAS) at Each Time Point After Application of Compressed Air and Cold Water on the Teeth Overall*

Anterior and Posterior Teeth						
Stimulus	Group	Time	Mean (SD)	Minimum	Median	Maximum
Compressed air	Control	T_0	2.45 (2.05)[a]	0.00	2.00	10.00
		T_1	2.48 (2.04)[a]	0.00	2.00	10.00
		T_2	2.38 (2.17)[a]	0.00	2.00	10.00
	Trial	T_0	4.60 (3.55)[a]	0.00	5.00	15.00
		T_1	6.95 (3.46)[b]	0.00	8.00	20.00
		T_2	2.83 (2.45)[a]	0.00	3.00	10.00
Cold water	Control	T_0	6.13 (4.36)[b]	0.00	5.00	20.00
		T_1	6.35 (4.17)[b]	0.00	5.00	20.00
		T_2	5.85 (3.88)[b]	0.00	5.00	20.00
	Trial	T_0	6.58 (5.56)[b]	0.00	8.50	25.00
		T_1	12.00 (6.01)[c]	0.00	12.50	30.00
		T_2	6.55 (4.81)[b]	0.00	7.00	25.00

* SD indicates standard deviation; superscript letters (a, b, and c) have been used to indicate statistical results. Different letters among the groups indicate significant difference in VAS values among the groups (significant difference at $P < .05$).

For the application of cold water on the teeth considered overall (Figure 3), group 1 showed no significant differences in VAS values compared to group 2, neither at T_0 nor at T_2 ($P > .05$); however, values at T_1 were significantly higher ($P > .05$) (Table 4). This was confirmed also for anterior and posterior teeth considered separately. For cold-water stimulation, the anterior teeth evaluated were significantly more sensitive than posterior teeth in both groups at all time points considered ($P < .05$) (Tables 3 and 4).

Comparing the two thermal stimuli applied and considering the teeth overall, as well as only the anterior teeth, VAS scores of both groups after cold-water application were always significantly higher than those after air stimulation ($P < .05$), whereas no significant difference was detected when considering the posterior teeth only.

Adverse Events

For one experimental patient, tooth sensitivity continued even for some hours after each thermal stimulation.

DISCUSSION

The first null hypothesis was partially rejected. Considering the teeth overall, a significant difference was shown in the intervention group immediately after debonding (T_1), when compressed air and freshly melted ice were applied on first molars and mandibular incisors. Pain values at T_1 in the trial group were also significantly higher than those assessed immediately before (T_0) and 7 days after debonding (T_2) in the same group. Conversely, no significant difference was shown either in the trial group at T_0 and T_2, nor in the control group at any time. These results indicated that teeth were more sensitive to thermal stimuli when debonding

Table 3. Descriptive Statistics (VAS) at Each Time Point After Application of Compressed Air and Cold Water on the Anterior Teeth*

Anterior Teeth						
Stimulus	Group	Time	Mean (SD)	Minimum	Median	Maximum
Compressed air	Control	T_0	2.65 (2.32)[a]	0.00	2.00	10.00
		T_1	2.65 (2.32)[a]	0.00	2.00	10.00
		T_2	2.60 (2.54)[a]	0.00	1.50	10.00
	Trial	T_0	6.65 (3.56)[b]	0.00	7.00	15.00
		T_1	8.50 (3.35)[c]	0.00	8.00	20.00
		T_2	3.45 (2.86)[a]	0.00	3.00	10.00
Cold water	Control	T_0	8.45 (4.25)[c]	5.00	7.00	20.00
		T_1	8.50 (4.17)[c]	5.00	7.00	20.00
		T_2	8.10 (3.26)[c]	5.00	8.00	20.00
	Trial	T_0	10.65 (3.76)[c]	5.00	10.00	25.00
		T_1	15.75 (4.67)[d]	10.00	15.00	30.00
		T_2	9.40 (4.16)[c]	5.00	9.00	25.00

* SD indicates standard deviation; superscript letters (a, b, c, and d) have been used to indicate statistical results. Different letters among the groups indicate significant difference in VAS values among the groups (significant difference at $P < .05$).

Table 4. Descriptive Statistics (VAS) at Each Time Point After Application of Compressed Air And Cold Water on the Posterior Teeth*

		Posterior Teeth				
Stimulus	Group	Time	Mean (SD)	Minimum	Median	Maximum
Compressed air	Control	T_0	2.25 (1.77)[a]	0.00	2.00	6.00
		T_1	2.30 (1.75)[a]	0.00	2.00	6.00
		T_2	2.15 (1.76)[a]	0.00	2.00	5.00
	Trial	T_0	2.55 (2.09)[a]	0.00	2.00	8.00
		T_1	5.40 (2.87)[b]	0.00	5.00	10.00
		T_2	2.20 (1.82)[a]	0.00	2.00	8.00
Cold water	Control	T_0	3.80 (3.09)[a]	0.00	3.00	15.00
		T_1	4.20 (2.91)[a]	0.00	4.00	15.00
		T_2	3.60 (3.10)[a]	0.00	3.00	15.00
	Trial	T_0	2.50 (3.80)[a]	0.00	0.00	10.00
		T_1	8.25 (4.78)[b]	0.00	7.00	20.00
		T_2	3.70 (3.61)[a]	0.00	2.50	10.00

* SD indicates standard deviation; superscript letters (a and b) have been used to indicate statistical results. Different letters among the groups indicate significant difference in VAS values among the groups (significant difference at $P < .05$).

had just been completed, rather than at other time points or in subjects not undergoing debonding procedures. Debonding and residual adhesive removal, along with the enamel etching performed during the application brackets, have been associated with certain enamel alterations which may be the cause of tooth sensitivity.[6] Cold stimulations are the most triggering factors of this process and are linked with higher pain scores.[17]

However, all increases assessed in the trial group at T_1 were not clinically significant because they represented mild pain. Additionally, VAS values were significantly decreased after a 7-day interval (T_1-T_2) and generally appeared even lower than those at T_0, although without statistical significance. Similarly, placement of fixed appliances amplified pain levels for 1 to 3 days after.[18] In the experimental group, the mean percentage reduction in pain values between T_1 and T_2 were greater than 33%, which is considered as the minimum to be positively perceived by the patient.[19]

To date, there is only one study dealing with the subject of the present report[11] and the results were in agreement with the current study. The second aim of the current study was to compare sensitivity between anterior and posterior teeth. In contrast, the previous study just evaluated sensitivity of premolars, which other studies reported to be the most frequently sensitive.[5,20] This could explain why pain values assessed by Dumbryte et al.[11] were higher than those assessed in the current study. Additionally, enamel alterations provoked by the different method used in that study to accomplish debonding (slow-speed handpiece and carbide finishing bur) might have contributed to the difference.

The second null hypothesis of this study was partially rejected. In fact, mandibular incisors appeared significantly more sensitive than first molars to compressed air application at T_0 and T_1 in group 1, but not at T_2 nor in group 2 at any time. However, this finding disagreed with other studies in which air and/or probe stimuli were applied in untreated subjects (therefore, comparable to controls of this report) and a major sensitivity was assessed for incisors[5,21] or for molars.[22] However, for cold-water stimulation, the anterior teeth were significantly more sensitive than posterior teeth in both groups at all time points considered. In fact, first molars showed sensitivity values quite low in comparison to the anterior teeth.

It might be considered that the 1-minute recovery between the applications of the two stimuli was not enough. However, the mild pain values assessed lead to the belief that the values reported for the second stimulus were reliable.

A limitation of this study was that outcomes assessment after debonding was performed only immediately and 7 days later. This makes it difficult to determine how long it actually takes for the pain to decrease and then disappear. Additionally, the results apply only to the specific techniques employed in this study. The removal of brackets can be performed using ultrasound, laser, and electrothermal debonding.[23] Additionally, residual adhesive removal can be performed with tungsten carbide burs, adhesive removing pliers, abrasive discs, fiberglass burs, laser, or ultrasound.[24] These techniques can cause different degrees of enamel damage with, perhaps, a different influence on post-debonding tooth sensitivity.

Results of this study cannot be generalized to patients with buccal enamel altered by erosion, hypomineralization, hypoplasia, white spots, or dental treatments, since these factors were exclusion criteria considered to possibly influence the outcomes recorded. Additionally, the results might have been overestimated due to the presence of dental lesions not visible to the naked eye but which may have lowered

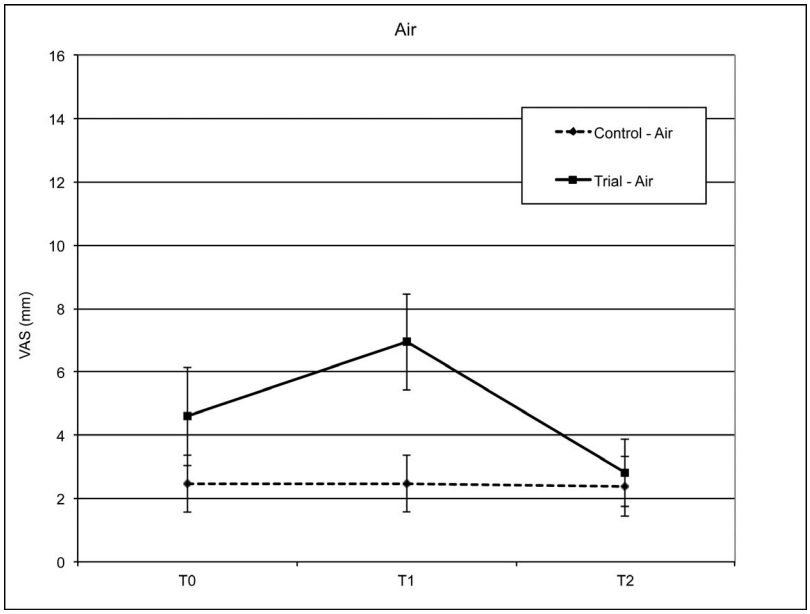

Figure 2. Comparison between VAS values after air (controls and trials). VAS indicates visual analogue scale.

the tooth pain threshold. Finally, no correlation was considered with patients' periodontal indices.

Further clinical trials should be performed to evaluate how tooth sensitivity varies after bracket removal and how different operative techniques, along with the patient's oral conditions, might influence this parameter. It would also be interesting to test treatments such as acetaminophen, verbal behavior modification, or both.[24]

Considering the results obtained and under the limitations discussed, this study points out the importance of warning patients about possible tooth sensitivity in the immediate period following orthodontic debonding, especially for the anterior teeth. Desensitizing pastes could be suggested by clinicians but patients should first be assured that pain is expected to disappear within a few days.

CONCLUSIONS

- After orthodontic debonding, tooth sensitivity to thermal stimuli occurs; however, pain after 7 days is similar to baseline values.

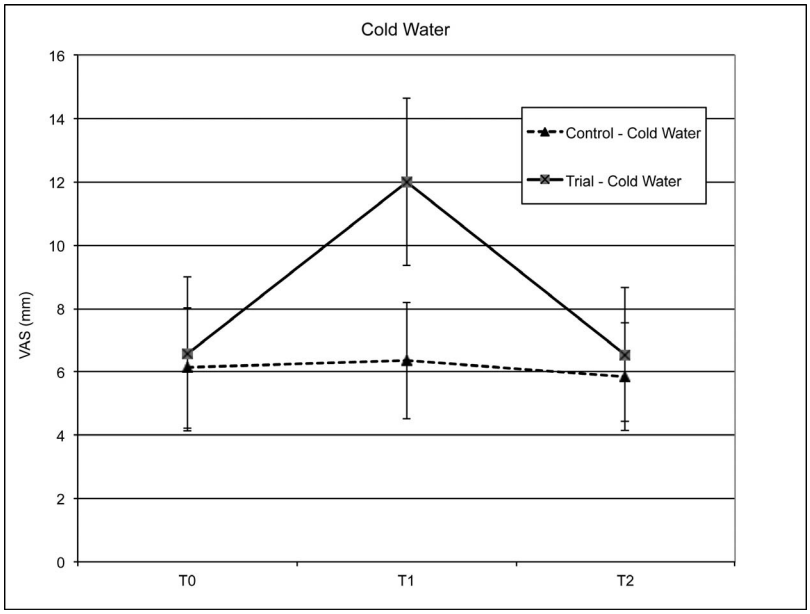

Figure 3. Comparison between VAS values after cold water (controls and trials).

- Mandibular incisors generally appear more sensitive than first molars, independent of the time point considered.

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