TURKISH JOURNAL of ORTHODONTICS

DOI: 10.5152/TurkJOrthod.2022.21091

Original Article

Mechanical Vibration and Chewing Gum Methods in Orthodontic Pain Relief

Fatih Çelebi

Department of Orthodontics, Faculty of Dentistry, Tokat Gaziosmanpaşa University, Tokat, Turkey

Cite this article as: Çelebi F. Mechanical vibration and chewing gum methods in orthodontic pain relief. *Turk J Orthod.* 2022;35(2):133-138.

Main Points

- The effects of mechanical vibration and chewing gum on orthodontic pain caused by initial archwire were evaluated.
- Individual variations such as gender, amount of crowding, and pressure pain threshold of the participants were taken into account while forming the groups.
- The results suggest that both chewing gum and mechanical vibration have no pain-relief effect on orthodontic pain.

ABSTRACT

Objective: The aim of this study was to investigate the pain relief effects of chewing gum and mechanical vibration methods on orthodontic pain caused by the initial archwire.

Methods: In this study, 57 patients, having a 3-6 mm maxillary dental crowding and non-extraction treatment modality were included. The pressure pain thresholds of the subjects were measured. Patients were distributed equally by sex and randomly allocated into 3 groups: mechanical vibration, chewing gum, and control. The fixed orthodontic treatment was started in the upper jaw only. In the first and second groups, mechanical vibration was applied and sugar-free gum was chewed, respectively. The third group was used as the control. The pain perceptions were measured using the Visual Analog Scale. Kruskal–Wallis and Friedman tests were used for statistical analysis.

Results: The groups were similar at the beginning of the study in terms of age and algometer scores ($P = .138$ and $P = .155$, respectively). Statistical significant differences in the Visual Analog Scale scores among the groups could not be detected at any time point. The highest pain scores were detected at the 24th hour of treatment in all 3 groups. There was no statistically significant difference in the highest pain level among the groups ($P = .279$).

Conclusion: Although the average pain values were perceived as lower, particularly in the mechanical vibration group, the temporary displacement of the teeth has no clinically significant pain relief effect on orthodontic pain.

Keywords: Algometer, chewing gum, orthodontics, pain, vibration

INTRODUCTION

Pain is a side effect that occurs at an extremely high rate during fixed orthodontic treatments, resulting in complaints from patients. Although the rate varies according to the studies, many researchers have reported that 80-95% of orthodontic patients experience pain during the treatment.[1,2] A previous study highlighted that pain was the most disliked aspect of orthodontic treatment, and it was ranked fourth in a list of apprehensions and fears prior to treatment.[3] This situation affects both private and social lives as well as the treatment approach and cooperation. Many patients prefer soft foods because they believe that they will cause less pain; however, soft and sticky foods increase the risk of plaque formation and contribute to the deterioration of oral hygiene. In addition, pain is one of the major factors for the discontinuation of treatment.[4]

Corresponding author: Fatih Çelebi, e-mail: fatihcelebi5860@gmail.com

Received: June 17, 2021
Accepted: October 31, 2021

Orthodontic pain can be present both in the initial alignment phase[4] and at the end of the treatment.[5] Previous studies showed that pain that occurred during the initial alignment phase usually begins at the second hour of treatment and increases gradually with time. It reaches the peak level at 24-36 hours, then gradually decreases until it disappears on the seventh day.[1-3,6] Although opinions vary, the most widely accepted hypothesis about how orthodontic pain occurs is related to the algogenes.[6] According to this hypothesis, orthodontic tooth movement causes the release of algogenes—such as leukotrienes, histamine, substance P, dopamine, prostaglandin E's (PGEs), serotonin, glycine, glutamate gamma-aminobutyric acid, and cytokines—at the site of the periodontium. These chemicals create a hyperalgesic response, and as a result of hyperalgesia, pain occurs when the orthodontic force is applied.[6] Additionally, orthodontic pain is affected by many factors such as age, gender, pain threshold, the magnitude of the applied force, and cultural differences.[6,7]

To date, many methods have been used to eliminate orthodontic pain. These approaches can be grouped into 2 subsets: pharmacological and non-pharmacological interventions. While pharmacological methods are effective at relieving pain, it was shown that some of them have adverse effects on tooth movement.[8,9] Also, their usage may lead to other side effects that might be detrimental to the whole body such as bleeding disorders, allergies, duodenal or gastric ulceration, asthma, renal insufficiency, congestive heart problems, atherosclerosis, and hypertension.[10] Due to this, researchers have recently been focusing on non-pharmacological methods. Vibration devices, transcutaneous electrical nerve stimulation (TENS), chewing gum, low-level laser therapy (LLLT), and viscoelastic bite wafers have all been investigated as alternative pain relief to drugs.[11-13]

Various vibration devices have been launched by manufacturers with claims that they reduce orthodontic pain and accelerate tooth movement. Yet, publications related to the effectiveness of these devices are very limited, and the results of the existing literature are also contradictory.[11,14-16] In addition, they are expensive devices compared to other pain-relief methods. Chewing gum is a similar method to the use of vibration devices in terms of its pain-relieving mechanism; however, research relating to them is equally scarce.

The aim of this study was to analyze the effects of mechanical vibration and chewing gum on orthodontic pain caused by an initial archwire and also to examine whether chewing gum can be a viable alternative to mechanical vibration devices. The hypothesis of the study was that both methods are effective in relieving orthodontic pain.

METHODS

This study was approved by the Clinical Research Ethics Committee of Tokat Gaziosmanpaşa University (19-KAEK-121). Based on the previously reported effect size for pain,[17] power analysis showed that 19 participants were necessary per group for an alpha of 0.05 and a power of 80%. Power calculation was performed by using the PASS Power Analysis and Sample Size Software (NCSS, Kaysville, Utah, USA). The minimum amount of subjects per group was calculated to be 19 participants to achieve a power of 80% for a clinically significant difference. In this study, 57 patients aged between 12 and 24 years, who had 3-6 mm maxillary crowding, non-extraction treatment modality, and permanent dentition were selected from the patient population of the orthodontic department. Patients who used painkiller for medical causes and were planned to use an orthodontic appliance that could be a source of pain such as band, transpalatal arch, headgear, and mini-screw were excluded from the study. Informed consent was obtained from the patients and parents who accepted to participate in the research.

Fifty-seven patients were randomly divided into 3 groups: those using mechanical vibration, those utilizing chewing gum, and the control group. Nineteen subjects were allocated into each group in such a way that they all included 10 females and 9 males. Randomization was provided by using a blue raffle box containing the names of the males and a red raffle box holding the names of their female counterparts. The pressure pain thresholds of the participants were measured using an algometer device (JTECH Medical, Salt Lake City, Utah, USA). In case, the pain thresholds of the participants were not equally distributed among the groups, plans were made to exclude any disruptive subjects from the sets and include new patients. Pressure algometry was introduced as a means of measuring pain thresholds in muscles, joints, tendons, and ligaments. The pressure algometer device is an apparatus that quantifies the sensitivity levels of muscles, joints, tendons, and ligaments, thereby documenting an individual's pain threshold. The measurement is performed by applying continuous pressure at a constant rate on the patient's skin.

In all of the patients, a non-extraction fixed treatment was started by placing 0.018 × 0.025-inch Roth prescription brackets and tubes (American Orthodontics, Sheboygan, Wis, USA). Only the upper arch was included in the study, and bracket bonding was implemented to a total of 12 teeth, from the right first molar to the left first molar. No application took place on mandibular teeth. Elastic ties were used to engage the 0.014-inch-round nickel–titanium archwire (TP Orthodontics, La Porte, Ind, USA) in the bracket slots. Then, the residual tips of the archwire were cut at the distal aspect of the first molar tubes in such a way that they did not irritate the buccal mucosa. The patients were instructed about oral hygiene maintenance and were warned to refrain from taking painkillers.

In the first group, mechanical vibration (Good vibrations, Dentsply Sirona, Charlotte, NC) was applied for 20 minutes just after the beginning of treatment (Figure 1). The procedure was also repeated 24 and 48 hours later and administered for a total of 60 minutes. The vibration device was operated with a battery-powered motor and ran within a set of 111 Hz and 0.06 N parameters. All vibration sessions were conducted at the clinic under the same supervisor. Meanwhile, the second group was assigned as the chewing gum group. Just after initiating fixed orthodontic treatment, patients chewed sugar-free gum for 20 minutes. As was the case with the vibration group, the procedure was

Figure 1. Application of the mechanical vibration

repeated 24 and 48 hours later, and the gum was chewed for a total of 60 minutes. All chewing gum sessions were conducted at the clinic and under the same supervisor. Lastly, the third group served as the control. No procedure was implemented on these participants aside from routine orthodontic treatment.

Ten-centimeter Visual Analog Scale (VAS) diaries, each with 6 sheets, were prepared to evaluate the pain perceptions that occurred at the second and sixth hours of treatment, and on the first, second, third, and seventh day of treatment. The Visual Analog Scale was stated as suitable for dental pain measurement and children's use in terms of mental status.[18,19] Therefore, we have preferred VAS for measuring the degree of pain. Participants were instructed about how they must mark the VAS forms. Before the measurements were taken, they were asked to tap their teeth 10 times by opening and closing their mouths and applying pressure to each tooth using their thumb.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY, USA: IBM Corp.). The distribution of the data was evaluated using the Shapiro–Wilk test. The Kruskal–Wallis test was utilized for the comparison of age, algometer scores, and pain levels among the groups, since the parametric test preconditions were not met. Repeated measurements were evaluated by means of the Friedman test. *P* values of less than .05 were considered statistically significant.

RESULTS

There was no statistically significant difference between groups in terms of age (*P* = .138) and pressure pain threshold (*P* = .155) (Table 1). The mean ages were 15.20, 15.10, and 14.11 years in the control, chewing gum, and mechanical vibration groups, respectively. The mean algometer scores were 15.5, 17.2, and 14.1 in the control, chewing gum, and mechanical vibration groups, respectively.

Table 1. Comparison of the age and algometer score among the groups

	Group	Mean ± Standard Deviation	P^a
Age (year)	Control	15.2 ± 1.9	.138
	Chewing gum	15.10 ± 2.5	
	Mechanical vibration	14.11 ± 2.9	
Algometer score	Control	15.5 ± 5.7	.155
	Chewing gum	17.2 ± 3.0	
	Mechanical vibration	14.1 ± 4.7	

[a]Evaluated by Kruskal–Wallis test.

At all of the time points, there were no statistically significant differences among the groups in terms of pain levels (2nd hour = .814, 6th hour = .126, 24th hour = .279, 2nd day = .204, 3rd day = .620, 7th day = .440) (Table 2).

For all groups, the peak points of VAS scores were recorded at the twenty-fourth hour of treatment (Figure 2 and Table 2). Additionally, the general pattern of the pain experienced

Table 2. Comparison of the VAS scores among the groups

	Group	Mean ± Standard Deviation (cm)	P^a
Second hour	Control	1.39 ± 1.88	.814
	Chewing gum	0.89 ± 1.06	
	Mechanical vibration	1.25 ± 1.34	
Sixth hour	Control	3.75 ± 2.93	.126
	Chewing gum	2.92 ± 2.00	
	Mechanical vibration	2.13 ± 2.18	
First day	Control	5.26 ± 2.11	.279
	Chewing gum	5.21 ± 2.42	
	Mechanical vibration	4.03 ± 2.95	
Second day	Control	4.40 ± 2.23	.204
	Chewing gum	4.28 ± 2.08	
	Mechanical vibration	3.25 ± 2.49	
Third day	Control	3.50 ± 2.29	.620
	Chewing gum	2.94 ± 1.66	
	Mechanical vibration	2.89 ± 2.41	
Seventh day	Control	1.27 ± 1.82	.440
	Chewing gum	1.47 ± 1.52	
	Mechanical vibration	0.96 ± 1.33	

[a]Evaluated by Kruskal–Wallis test.
VAS, Visual Analog Scale.

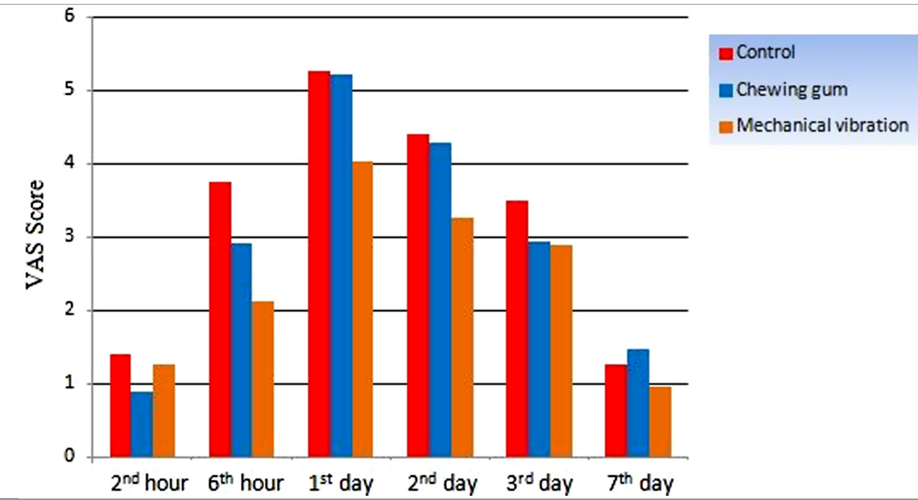

Figure 2. Graphic representation of pain patterns of the groups

was similar in all 3 groups. The pain detected at the 2nd hour increased gradually and reached the highest point at the 24th hour. It progressively decreased after reaching the peak level and came down to a clinically insignificant degree around the seventh day.

DISCUSSION

Mechanical vibration, chewing gum, and bite wafers are actually similar methods and they are based on the same principle. It was claimed that all of these methods displace the teeth temporarily and loosen the compressed periodontal areas including nerve fibers and occluded blood vessels, thus enabling the blood to flow more easily. In this way, biochemical agents that cause the pain process are removed more quickly by means of increased blood flow, and their actions at the site are prevented.

Various methods such as photobiomodulation, desensitizing agents, non-steroidal anti-inflammatory drugs (NSAIDs), bite wafers, TENS, and vibratory stimulation have been proposed to reduce orthodontic pain, showing moderate results.[6,20,21] One of the most effective of these methods is the use of NSAIDs. However, it has been reported that this method can cause some detrimental effects on the whole body such as allergy, bleeding disorders, gastric or duodenal ulceration, renal insufficiency, asthma, congestive heart problems, hypertension, and atherosclerosis.[10] That is why researchers began to investigate noninvasive methods. Alternatively, the present study tested vibrational and chewing forces, and it can be questioned why a comparison of 2 similar methods on orthodontic pain was performed in the present study.

In answer to the aforementioned query, the research had 2 main objectives. The first aim was to contribute to the existing literature by testing whether these processes are actually useful. This is because there are conflicting results in previous studies about the efficacy of the principle.[11,14,15,22,23] While some articles have reported no effect,[14,23] there are also some examples of research which suggest that vibration has particularly positive repercussions on both pain and tooth movement.[16,22] Based on the studies reporting positive outcomes, manufacturers have started to produce expensive devices. However, their effectiveness has not been fully proven in the relevant literature.

The second objective was to determine whether chewing gum can be an alternative to vibration devices. The thought process behind this is that generally high-cost vibration devices are difficult to find, especially in countries where low incomes are prevalent. Moreover, there are significant advantages of using chewing gum instead of other non-pharmacological methods. First of all, it is easy to supply and is low cost. Unlike TENS, LLLT, and mechanical vibration, it does not require the use of a device. Additionally, it was shown that chewing gum stimulates saliva flow, contributes to oral hygiene with the potential to promote remineralization, and helps to reduce white spot lesion formation relating to fixed orthodontic appliances.[24] Researchers have also been interested in the different ingredients contained in chewing gums, such as fluoride, xylitol, and chlorhexidine, since it is thought that they may contribute to oral hygiene in orthodontic patients.[25,26] Also, there is no remarkable evidence that chewing gum causes breakages to appliances.[27]

There is no clear consensus on how mechanical vibration must be applied. Marie et al.[11] used the vibration device just once for 15 minutes, immediately after archwire placement. Meanwhile, Miles et al.[14] made their subjects use the vibration device for 20 minutes per day during the 10-week study period. We thought that multiple applications could be more effective than a single application in terms of pain management, because it is not likely that a single application immediately after archwire placement, and before algogens are released, could alleviate orthodontic pain. On the other hand, it would be unnecessary to intervene the pain after the third day, as there seems to be a trend where orthodontic pain decreases notably after the second day, even if there is no intervention.[6] Consequently, our preferred protocol of applications was 3 times: immediately after engagement of the initial archwire, 24 hours later, and then 48 hours later. The gum was chewed utilizing the same protocols performed in the vibration group to ensure the equality of the applications.

The hypothesis of this study was rejected. A statistically significant decrease in pain could not be detected in both the vibration and chewing gum groups; an outcome that is inconsistent with some of the articles in related literature.[11,12,16,27] Those publications have shown that vibration and chewing gum are effective in alleviating orthodontic pain, but we think that this conflict between our results and their outcomes is due to differences in study design. In the design of these studies, individual variations, such as gender distribution, amount of dental crowding, and the pain threshold of the participants, were not taken into consideration. Benson et al.[27] concluded that chewing gum significantly decreased the pain caused by fixed appliances. Nevertheless, gender equality between the groups was not considered in their research. While 9 females and 19 males were included in the non-chewing gum group, there were 17 females and 12 males in the chewing gum group.

Lobre et al.[16] also found that micropulse vibration devices significantly lowered pain scores. However, gender-age distributions between the experimental and control groups, as well as dental crowding of the participants, were not mentioned in their study. Similar drawbacks existed in other studies.[12,15] One of the great challenges associated with researching pain is that it is a subjective phenomenon and can be greatly affected by individual variations. It has been stated that orthodontic pain is affected by gender, initial tooth positions and force levels, and physiological and psychological susceptibility.[6] In this study, we tried to preclude these conditions and to make the groups homogeneous in terms of individual variability. The groups constituted of an equal number of female and male participants, and only patients with 3-6 mm maxillary crowding were included in the study. Moreover, patients' pressure pain thresholds were measured, and subjects who disrupted the homogeneity of the groups were excluded from the study, with new participants being brought in their place.

As well as the studies that present opposing outcomes,[11,12,16,27] there are also studies that exhibited similar findings to the results of our own research.[14,15,23,28] Miles et al.[14] have stated that there appears to be no clinical advantage in using vibrational appliances for the alleviation of pain during initial alignment. Woodhouse et al.[15] have found that the use of a vibration device had no remarkable effect on orthodontic pain and analgesic consumption, during initial alignment with fixed appliances. Furthermore, Alqareer et al.[28] investigated the efficacy of chewing gum to reduce orthodontic pain, and they determined that chewing gum 3 times a day did not seem to reduce pain significantly.

In terms of our own research, we believe there may be a few noteworthy reasons why we attained negative results regarding the usefulness of the investigated methods (mechanical vibration and chewing gum). First, temporary displacement of teeth does not really work with regards to being a reliever of orthodontic pain. In some musculoskeletal disorders, the vibration method has especially been shown to increase blood flow and alleviate pain,[29] but this does not prove that vibration will also work in relation to orthodontic discomfort. Due to anatomical difficulties, even if the occluded blood vessels and nerves at the crown proportion of the root surface loosen in a limited manner, the vibration effect may not reach the compressed vessels and nerves in the deeper region.

Another possible reason for obtaining negative results may be the low number of participants in our study. We might have achieved statistically significant differences with a larger number of patients. Yet, when the number of participants of previous studies that obtained meaningful outcomes is examined, it becomes clear that the number of subjects in this study was sufficient. Farzanegan et al.[12] used just 10 patients per group, and they have determined that chewing gum is effective for pain alleviation. Moreover, even if we had achieved statistically significant differences with more patients, we do not think that these differences would have been clinically significant.

We think that there are 2 main limitations of the present study. The first limitation is that we could not control whether the participants used painkillers throughout the study. Prior to the study, we have advised them to avoid taking a painkiller and excluded subjects who needed medication for medical reasons from the study. Nevertheless, there may be subjects who used the painkiller and did not report it. The second limitation is the pain measurement method we have used in the study. Unfortunately, a method that can measure pain with objective data and that can be used in orthodontic pain has not been developed yet. In this study, we had to use the VAS, which is one of the subjective methods. However, we could have studied chemical substances present in the gingival crevicular fluid and considered as pain biomarkers. Thus, we would have had the opportunity to support our subjective outcomes with objective data.

CONCLUSION

The results of this study suggest that both chewing gum and mechanical vibration have no pain-relief effect on orthodontic pain.

Ethics Committee Approval: Ethics committee approval has been received from the Clinical Research Ethics Committee of Tokat Gaziosmanpasa University (19-KAEK-121).

Informed Consent: Written informed consent was obtained from the patients and parents.

Peer-review: Externally peer-reviewed.

Declaration of Interests: The author has no conflicts of interest to declare.

Funding: The author declared that this study has received no financial support.

REFERENCES

1. Erdinç AM, Dinçer B. Perception of pain during orthodontic treatment with fixed appliances. *Eur J Orthod*. 2004;26(1):79-85. [CrossRef]
2. Bergius M, Berggren U, Kiliaridis S. Experience of pain during an orthodontic procedure. *Eur J Oral Sci*. 2002;110(2):92-98. [CrossRef]

3. O'Connor PJ. Patients' perceptions before, during, and after orthodontic treatment. *J Clin Orthod*. 2000;34(10):591-592.
4. Aksoy A, Cesur MG, Dağdeviren BH, Özkaynak YA, Karacin G, Gültekin F. Assessment of pain, anxiety, and cortisol levels during the initial aligning phase of fixed orthodontic treatment. *Turk J Orthod*. 2019;32(1):34-40. [CrossRef]
5. Scribante A, Gallo S, Celmare RL, et al. Orthodontic debonding and tooth sensitivity of anterior and posterior teeth. *Angle Orthod*. 2020;90(6):766-773. [CrossRef]
6. Krishnan V. Orthodontic pain: from causes to management—a review. *Eur J Orthod*. 2007;29(2):170-179. [CrossRef]
7. Bergius M, Kiliaridis S, Berggren U. Pain in orthodontics: a review and discussion of the literature. *J Orofac Orthop*. 2000;61(2):125-137. [CrossRef]
8. Polat O, Karaman AI. Pain control during fixed orthodontic appliance therapy. *Angle Orthod*. 2005;75(2):214-219. [CrossRef]
9. Bernhardt MK, Southard KA, Batterson KD, Logan HL, Baker KA, Jakobsen JR. The effect of preemptive and/or postoperative ibuprofen therapy for orthodontic pain. *Am J Orthod Dentofacial Orthop*. 2001;120(1):20-27. [CrossRef]
10. Polat O, Karaman AI, Durmus E. Effects of preoperative ibuprofen and naproxen sodium on orthodontic pain. *Angle Orthod*. 2005;75(5):791-796. [CrossRef]
11. Marie SS, Powers M, Sheridan JJ. Vibratory stimulation as a method of reducing pain after orthodontic appliance adjustment. *J Clin Orthod*. 2003;37(4):205-208.
12. Farzanegan F, Zebarjad SM, Alizadeh S, Ahrari F. Pain reduction after initial archwire placement in orthodontic patients: A randomized clinical trial. *Am J Orthod Dentofacial Orthop*. 2012;141(2):169-173. [CrossRef]
13. Murdock S, Phillips C, Khondker Z, Hershey HG. Treatment of pain after initial archwire placement: a noninferiority randomized clinical trial comparing over-the-counter analgesics and bite-wafer use. *Am J Orthod Dentofacial Orthop*. 2010;137(3):316-323. [CrossRef]
14. Miles P, Smith H, Weyant R, Rinchuse DJ. The effects of a vibrational appliance on tooth movement and patient discomfort: a prospective randomised clinical trial. *Aust Orthod J*. 2012;28(2):213-218.
15. Woodhouse NR, DiBiase AT, Papageorgiou SN, et al. Supplemental vibrational force does not reduce pain experience during initial alignment with fixed orthodontic appliances: a multicenter randomized clinical trial. *Sci Rep*. 2015;5(1). [CrossRef]
16. Lobre WD, Callegari BJ, Gardner G, Marsh CM, Bush AC, Dunn WJ. Pain control in orthodontics using a micropulse vibration device: a randomized clinical trial. *Angle Orthod*. 2016;86(4):625-630. [CrossRef]
17. Celebi F, Bicakci AA, Kelesoglu U. Effectiveness of low-level laser therapy and chewing gum in reducing orthodontic pain: a randomized controlled trial. *Korean J Orthod*. 2021;51(5):313-320. [CrossRef]
18. Huskisson EC. Measurement of pain. *Lancet*. 1974;2(7889):1127-1131. [CrossRef]
19. Seymour RA, Simpson JM, Charlton EJ, Phillips ME. An evaluation of length and end-phrase of visual analogue scales in dental pain. *Pain*. 1985;21(2):177-185. [CrossRef]
20. Sfondrini MF, Vitale M, Pinheiro ALB, et al. Photobiomodulation and pain reduction in patients requiring orthodontic band application: randomized clinical trial. *BioMed Res Int*. 2020;2020:7460938. [CrossRef]
21. Vatturu S, Ganugapanta VR, Teja NR, Singaraju GS, Mandava P, Priyanka JY. Comparative evaluation of the efficacy of the desensitizing and remineralizing agent in the reduction of dentin hypersensitivity after orthodontic debonding - a randomized clinical trial. *Med Pharm Rep*. 2021;94(2):229-238. [CrossRef]
22. Kacprzak A, Strzecki A. Methods of accelerating orthodontic tooth movement: a review of contemporary literature. *Dent Med Probl*. 2018;55(2):197-206. [CrossRef]
23. Celebi F, Turk T, Bicakci AA. Effects of low-level laser therapy and mechanical vibration on orthodontic pain caused by initial archwire. *Am J Orthod Dentofacial Orthop*. 2019;156(1):87-93. [CrossRef]
24. Ozen N, Aydin Sayilan A, Mut D, et al. The effect of chewing gum on dry mouth, interdialytic weight gain, and intradialytic symptoms: a prospective, randomized controlled trial. *Hemodial Int*. 2021;25(1):94-103. [CrossRef]
25. Cocco F, Carta G, Cagetti MG, Strohmenger L, Lingström P, Campus G. The caries preventive effect of 1-year use of low-dose xylitol chewing gum. A randomized placebo-controlled clinical trial in high-caries-risk adults. *Clin Oral Investig*. 2017;21(9):2733-2740. [CrossRef]
26. Cosyn J, Verelst K. An efficacy and safety analysis of a chlorhexidine chewing gum in young orthodontic patients. *J Clin Periodontol*. 2006;33(12):894-899. [CrossRef]
27. Benson PE, Razi RM, Al-Bloushi RJ. The effect of chewing gum on the impact, pain and breakages associated with fixed orthodontic appliances: a randomized clinical trial. *Orthod Craniofac Res*. 2012;15(3):178-187. [CrossRef]
28. Alqareer A, Alyahya A, Al-Anezi SA, AlAwadhi A, Al Qabandi S, Alyaseen M. Efficacy of chewing gum to reduce orthodontic pain compared to placebo: a blinded, parallel-group, preliminary clinical trial. *J Oral Facial Pain Headache*. 2019;33(3):301–307. [CrossRef]
29. Lu X, Wang Y, Lu J, et al. Does vibration benefit delayed-onset muscle soreness?: a meta-analysis and systematic review. *J Int Med Res*. 2019;47(1):3-18. [CrossRef]