Article

Comparative Analysis of Periodontal Pain Using Two Different Orthodontic Techniques, Fixed Multibrackets and Removable Aligners: A Longitudinal Clinical Study with Monthly Follow-Ups for 12 Months

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Abstract: The aim of this study was to evaluate the perception of periodontal pain in patients treated with either fixed multibrackets or removable alignment systems with a monthly follow-up over a period of twelve months. **Materials and Methods:** This longitudinal clinical study comprised a sample of 140 patients (72 women; 68 men) divided into two groups of 70 patients each: the bracket group (BG) with conventional fixed brackets using the MBT technique with a 0.022" slot and the Invisalign group (IG) with aligners (Invisalign). The visual analog scale (VAS) was used to quantify patient-reported pain. Pain analysis was conducted monthly at 4 (T1), 8 (T2), and 24 h (T3) post-follow-up as well as at 2 (T4), 3 (T5), 4 (T6), 5 (T7), 6 (T8), and 7 days (T9) post-follow-up during the first twelve months after starting orthodontic treatment. **Results:** Statistically significant differences ($p < 0.05$) were observed between both study groups in the mean pain scores on the visual analog scale (VAS) during the twelve-month follow-up period, except for during the eighth month of treatment. In the first month, the group with conventional brackets reported higher pain scores. From the second month onwards, we observed that patients with aligners described a higher level of pain compared to the group of patients with conventional brackets. In both experimental groups, though at different evaluation periods, we found that the peak of maximum pain occurred between 24 and 48 h (T3–T4) after monthly follow-up appointments; from this point, the pain decreased until reaching minimum values from the fifth day onwards (T7). **Conclusions:** In the first month of treatment, the patients with conventional fixed multibrackets reported the highest levels of pain compared to those with removable aligners. From the second month on, this trend changed. The patients with removable aligners reported the highest levels of pain. Therefore, the orthodontic system used influenced the perception of pain in patients.

Keywords: pain; orthodontic; oral health; aligners; brackets; visual analog scale; tooth movement

1. Introduction

The painful and uncomfortable experiences described by orthodontic patients are common side effects related to dental therapy involving either fixed multibrackets braces or plastic aligners. The maximum peak of pain described by patients was observed within the first 24 h after starting treatment and gradually decreased from the second day and onward [1]. Pain is a subjective experience that is influenced by a patient's age, sex, or emotional factors. It has a negative effect on patient oral hygiene and compliance that may

be indicated during orthodontic treatment. At times, specialists have underestimated the level of pain perceived by patients during treatment [2].

Published studies on pain during orthodontic treatment have concluded that the majority of patients, between 91% and 95%, have described significant discomfort and pain during orthodontic treatment, regardless of the techniques used [3,4].

For tooth movement to occur during orthodontic treatment, it is essential that the periodontal tissue and the alveolar bone tissue be remodeled. When a gentle force is applied over a period of time, inflammation of the periodontal tissue occurs, which then leads to bone resorption. During bone resorption, which is essential for tooth movement, various biochemical mediators such as prostaglandin E2, tumor necrosis factor alpha, and epidermal growth factor are released [5–7]. The forces applied during the first phases of orthodontic treatment produce an increase in various biochemical mediators. This increase in the concentration of biochemical factors reaches its maximum value in the first twenty-four h after the start of orthodontic treatment, and from this initial twenty-four h onwards, the levels decrease [8]. The intensity of the applied force is related to the induced pain. The interleukin-1beta levels that increase within the first twenty-four hours after the start of orthodontic treatment were correlated with increased pain intensity [9].

Among the scientific literature, studies evaluating pain during orthodontic treatment have previously been published. In orthodontic treatments using fixed multibrackets, we observed that patients treated with a conventional bracket system described a higher level of pain compared to patients treated with self-ligating brackets [10–12]. However, there are other authors who have concluded that there were no statistically significant differences between patients' pain scores when comparing both bracket systems [13–15].

In recent years, orthodontic treatments with transparent aligners such as Invisalign (Align Technology, Santa Clara, CA, USA) have become one of the most demanded treatment options by patients as a therapeutic alternative to fixed-bracket treatments. The main advantages of aligner treatments, compared to fixed brackets, are superior aesthetics, improved oral hygiene, and greater comfort [16–19].

A systematic review by Cardoso PC et al. found that patients undergoing treatment with aligners (e.g., Invisalign) described a lower level of pain, especially during the first phases of treatment than those with fixed-multibracket appliances. In more advanced stages, however, no statistically significant differences in pain levels were observed between the two treatment techniques [20].

A study by White DW et al. in 2017 concluded that patients undergoing orthodontic treatment with aligners consume fewer analgesic drugs during treatment compared to patients undergoing treatment with fixed multibrackets [16].

The objective of this longitudinal, clinical study was to evaluate the levels of periodontal pain in patients treated with two different orthodontic techniques, fixed-multibracket appliances, and removable aligners during the first 12 months of treatment. The null hypothesis of this study was that there were no statistically significant differences in pain levels as described by orthodontic patients undergoing treatment with fixed multibrackets and aligners.

2. Materials and Methods

2.1. Ethics Approval and Patients Consent

This research project was approved by the Bioethics Committee of the University of Salamanca (USAL_20/516). The study followed the guidelines established by the Declaration of Helsinki for research involving humans. Participants were informed regarding the study procedures, and only those who gave their written informed consent were included in the study.

2.2. Study Design

The sample consisted of 140 patients grouped into 2 study groups. The first group (BG) consisted of 70 patients in orthodontic treatment with fixed multibracket appliances

using the MBT technique and a 0.022" slot (Diamond Plus[®], Cimbis Orthodontics, Madrid, Spain), and the second group (IG) consisted of 70 patients in orthodontic treatment with removable aligners (Invisalign). All patients were treated by the same specialist during the 2019–2020 period. The study participants were selected from a non-probability convenience sampling with efforts made to balance the sample in age and sex between each orthodontic treatment group.

Previous research was considered when calculating the sample size. With an error rate of 5% and a confidence level of 95%, the minimum sample size required was considered to be 67 patients for each treatment group. Therefore, the final sample consisted of 140 participants.

The inclusion criteria were the following: adult patients over 18 years of age; patients with permanent dentition; patients without previous orthodontic treatment; patients with a negative bone-dental discrepancy between -6 and -2 mm in both arches (TSALD) [21]; without missing teeth except for the third molars; skeletal class I or slight skeletal classes II and III (ANB between 0 and 5 degrees) [22]; and patients for whom an IPR between 0.1 and 0.5 mm per tooth was predicted in the treatment plan.

The exclusion criteria were as follows: patients with physical or mental disabilities; patients diagnosed with psychological problems such as anxiety or stress; patients with orthodontic-surgical treatment; patients being treated with analgesics, anti-inflammatories, anxiolytics and/or antidepressants; patients with dental caries; patients with gingival or periodontal pathology; pregnant patients; and those with auxiliary orthodontic appliances.

Before beginning orthodontic treatment, the treatment protocol was explained to the patient, both verbally and via written literature, as well as their voluntary and impartial inclusion in this study. Once a patient gave their written consent, orthodontic treatment began. Due to the design of this study, blinding of either patient or operator was not possible.

2.3. Methodology

During the first appointment for members of the BG group, the upper and lower brackets, as well as the vestibular tubes, were cemented in the first and second molars. The initial treatment arch was a 0.014" thermal CuNiTi archwire (Bio Low Force[®], Cimbis Orthodontics, Madrid, Spain). Elastic ligatures with an internal diameter of 1.3 mm (3M, Saint Paul, USA) were used. In the fourth month of treatment, a 0.016" $\times$ 0.022" thermal CuNiTi archwire was placed, and in the eighth month, a Thermal NiTi Cooper archwire of 0.019" $\times$ 0.025" was installed in all patients with fixed appliances.

During the first appointment, the IG group underwent impressions with polyvinyl-siloxane silicone (Aquasil, Denstply Sirona) using plastic trays that were then submitted to Align Technology, Inc. for subsequent scanning and aligner creation using ClinCheck. During the second visit, the attachments prescribed by the digital treatment planning were cemented, and the aligners, along with the treatment recommendations, were delivered to the patients. The IPR was performed progressively during treatment as planned, with a maximum of 0.5 mm per tooth.

2.4. Assessment of Pain

The visual analog scale (VAS) was used to quantify the pain described by the patients. Patients were instructed to mark their pain level on a 10 cm long VAS. Each centimeter was assigned a score of 1 on the VAS so that a score of 0 on the left end of the scale indicated no pain, a score of 10 on the right end of the scale indicated maximum pain, and a score out of 5 in the center of the scale indicated moderate pain. This was explained to each patient prior to the study. The VAS was widely used in various orthodontic studies [23]. Pain analysis was performed every month after the patient's monthly follow-up visit at 4 h (T1), 8 h (T2), 24 h (T3), 2 days (T4), 3 days (T5), 4 days (T6), 5 days (T7), 6 days (T8) and, finally, 7 days (T9), during the twelve-months study.

2.5. Statistical Analysis

The data were analyzed with the statistical package IBM SPSS, version 25 (SPSS Inc., Chicago, IL, USA). For each variable included in the study, simple descriptive statistics were initially calculated, including frequencies and percentages for categorical variables, as well as the means and the standard deviations for quantitative variables. In order to verify the match of the patients to the variables included in the study, the Pearson's χ^2 test and the Student's *t*-test were used for independent samples according to their typology. Significance levels α of 0.05 and 0.01 were used.

We used the Student's *t*-test for the analysis of the differences in pain perceived by the two treatments groups for each of the monthly follow-ups (12 total). When comparing pain scores between the treatment groups, an analysis of variance (ANOVA) model was used, and we considered the time intervals separately. When the results obtained were statistically significant, the Bonferroni post hoc test was applied.

3. Results

3.1. Characteristics of the Sample

The sample comprised 140 patients, with a mean age of 29.36 years (± 9.80). Of the total number of patients, 68 were men (48.60%) and 72 women (51.40%), with no statistically significant differences in relation to sex ($p > 0.05$). No statistically significant differences were observed regarding the bone–dental discrepancy between the two study groups. While statistically significant differences were observed in relation to the mean age of the participants per experimental group, all the participants were adult patients, and this significance neither directly influenced the results of the study nor impacted their clinical care (Table 1).

Table 1. Demographic characteristics of the participants ($n = 140$).

Variables			Groups			
			Brackets (BG) (<i>n</i> = 70)	Invisalign (IG) (<i>n</i> = 70)	<i>p</i>	Total (<i>n</i> = 140)
Age ¹	Mean		26.97	31.74	0.004 **	29.36
	SD		7.23	11.39		9.80
Sex ²	Men	N	35	33	0.735	68
		%	50	47.10		48.60
	Women	N	35	37		72
		%	50	52.9		51.40
Osteodental discrepancy ³	Superior	Mean	−3.38	−3.30	0.797	−3.34
		SD	1.31	2.26		1.86
	Inferior	Mean	−3.47	−3.38	0.708	−3.42
		SD	1.14	1.85		1.54

SD: standard deviation. ¹: Student's *t*-test. ²: Pearson's χ^2 test. ³: Student's *t*-test. ** Statistically significant at $p < 0.01$.

3.2. Pain Analysis

When analyzing the mean pain scores per month, statistically significant differences were observed between the two study groups for most months; month 8 was the exception, where no statistically significant differences were found between the two groups (Table 2).

Table 2. Comparison of pain between both treatment groups during the 12-month follow-up.

Month	Conventional Brackets (BG) (<i>n</i> = 70)		Invisalign (IG) (<i>n</i> = 70)		<i>p</i>
	Mean	SD	Mean	SD	
1 *	2.175	1.984	1.976	2.295	0.047
2 **	0.869	1.159	1.288	1.835	0.000
3 **	0.642	1.009	1.197	1.904	0.000
4 **	0.607	1.004	0.998	1.675	0.001
5 **	0.405	0.792	0.884	1.483	0.000
6 **	0.430	0.852	0.926	1.510	0.000
7 **	0.331	0.731	0.791	1.442	0.000
8	0.573	0.962	0.691	1.369	0.291
9 *	0.386	0.807	0.627	1.318	0.038
10 **	0.380	0.761	0.740	1.510	0.002
11 *	0.269	0.657	0.525	1.246	0.028
12 **	0.202	0.580	0.452	1.145	0.031

SD: standard deviation. Comparisons between groups applying the Student's *t*-test. * Statistically significant at $p < 0.05$. ** Statistically significant at $p < 0.01$.

The highest pain scores were described during the first month of treatment, and during the second month, the pain level decreased considerably.

When analyzing the mean pain scores on the VAS during the 12-month follow-up period, the BG patients described the highest level of pain during the first month post-treatment compared to the IG patients (BG: 2.175 ± 1.984 ; IG: 1.976 ± 2.295). However, the IG patients described the highest levels of pain ($p < 0.05$) for each month thereafter compared to the BG patients who reported decreasing pain scores. This trend of decreasing pain scores for the BG group was interrupted during the eighth month, where their pain scores increased briefly. This was attributed to the change in the orthodontic arch that occurred in that month (Figure 1).

Figure 1. Comparison of the mean pain scores between both treatment groups during the 12-month follow-up period.

During the first month of treatment (Table 3), we observed that there were statistically significant differences between the two study groups at 4 h (T1) ($p < 0.01$), at 3 days (T5) ($p < 0.01$), and at 4 days (T6) ($p < 0.01$). During the first month, a trend appeared in which BG patients had described a higher level of pain compared to IG patients, except for the first 4 h (T1), 8 h (T2), and 7 days (T9). The maximum pain peak occurred at 24 h (T3) in both treatment groups (BG: 4.366 ± 1.947 ; IG: 3.729 ± 2.716). Upon the fifth day (T7), the level of pain decreased, reaching minimum levels (Figure 2).

Table 3. Comparison of pain between both treatment groups during the first month of treatment.

Moment (Month 1)	Brackets (BG) (n = 70)		Invisalign (IG) (n = 70)		p between Groups
	Mean	SD	Mean	SD	
T1 ^{a **}	1.537	1.220	2.550	2.390	0.002
T2 ^b	3.231	1.754	3.424	2.475	0.606
T3 ^c	4.366	1.947	3.729	2.716	0.108
T4 ^b	3.679	1.906	3.003	2.521	0.072
T5 ^{b **}	3.351	1.588	2.259	2.121	0.001
T6 ^{d **}	2.328	1.447	1.557	1.703	0.004
T7 ^a	1.649	1.387	1.201	1.546	0.071
T8 ^a	1.119	1.197	1.006	1.561	0.615
T9 ^e	0.425	0.698	0.629	1.235	0.241

** Statistically significant at $p < 0.01$. The different superscript letters in the rows indicate which groups show significant differences according to the Bonferroni post hoc tests.

Figure 2. Comparison of pain between both treatment groups during the first month of treatment.

During the fourth month after the initial orthodontic treatment (Table 4), statistically significant differences were observed in pain scores at 4 h (T1) ($p < 0.01$), 8 h (T2) ($p < 0.05$), 4 days (T6) ($p < 0.05$), 5 days (T7) ($p < 0.05$), and 7 days (T9) ($p < 0.05$). During this month, it was expected that BG patients would report a lower pain score compared to IG patients. The BG patients described their highest pain levels at 24 h (1.381 ± 1.265), while the IG patients reported their highest pain score on the visual analog scale at 8 h (1.905 ± 1.970). At the fourth month after the initial treatment, BG patients had a new $0.016'' \times 0.022''$ thermal CuNiTi orthodontic archwire installed, which likely influenced the pain score in

this group of patients. In addition, in this month, from the fifth day (T7) after the check-up appointment, the level of pain decreased to almost zero (Figure 3).

Table 4. Comparison of pain between both treatment groups during the fourth month of treatment.

Moment (Month 4)	Brackets (BG) (<i>n</i> = 70)		Invisalign (IG) (<i>n</i> = 70)		<i>p</i> between Groups
	Mean	SD	Mean	SD	
T1 ^{a **}	0.724	0.942	1.655	2.067	0.001
T2 ^{a *}	1.201	1.132	1.905	1.970	0.011
T3 ^a	1.381	1.265	1.843	2.057	0.114
T4 ^a	1.269	1.350	1.453	1.874	0.521
T5 ^b	0.709	0.930	0.912	1.619	0.379
T6 ^{bc *}	0.343	0.635	0.775	1.442	0.025
T7 ^{bc *}	0.201	0.515	0.569	1.127	0.015
T8 ^{bc}	0.194	0.696	0.405	1.034	0.172
T9 ^{c *}	0.045	0.272	0.336	0.994	0.021

* Statistically significant at $p < 0.05$. ** Statistically significant at $p < 0.01$. The different superscript letters in the rows indicate which groups show significant differences according to the Bonferroni post hoc tests.

Figure 3. Comparison of pain between both treatment groups during the fourth month of treatment.

At 8 months (Table 5), statistically significant differences were observed in pain scores at 4 h (T1) ($p < 0.01$), 5 days (T7) ($p < 0.05$), and 7 days (T9) ($p < 0.05$). At this time, IG patients described higher levels of pain compared to BG patients, except for the first 24 h (T3) and at 3 days (T5). In addition, as previously stated, the archwire was changed in BG patients with multibracket fixed appliances. This arch change may have influenced pain scores, as seen in Table 5.

As in the fourth month, the peak of maximum pain in the BG patients was at 24 h (1.5 ± 1.285) and, in the IG patients, at 8 h (1.401 ± 1.722). From the fifth day (T7), the pain described by the patients was almost nil (Figure 4).

Table 5. Comparison of pain between both treatment groups during the eighth month of treatment.

Moment (Month 8)	Brackets (BG) (<i>n</i> = 70)		Invisalign (IG) (<i>n</i> = 70)		<i>p</i> between Groups
	Mean	SD	Mean	SD	
T1 ^{ac} **	0.739	0.845	1.387	1.838	0.008
T2 ^b	1.328	1.140	1.401	1.722	0.779
T3 ^b	1.500	1.285	1.387	1.863	0.665
T4 ^a	0.940	1.054	1.004	1.622	0.799
T5 ^{ac}	0.694	0.973	0.579	1.249	0.534
T6 ^{cd}	0.358	0.727	0.408	0.953	0.751
T7 ^d *	0.082	0.321	0.339	0.821	0.016
T8 ^d	0.075	0.429	0.196	0.061	0.149
T9 ^d *	0.015	0.122	0.189	0.550	0.012

* Statistically significant at $p < 0.05$. ** Statistically significant at $p < 0.01$. The different superscript letters in the rows indicate which groups show significant differences according to the Bonferroni post hoc tests.

Figure 4. Comparison of pain between both treatment groups during the eighth month of treatment.

4. Discussion

This study analyzed whether there were statistically significant differences between a removable orthodontic treatment using aligners (Invisalign) and a treatment with conventional, fixed multibracket appliances in relation to the pain described by a nonprobability sample of patients during a 12-month study, in which patients reported their pain scores each month post-follow-up appointment at 4, 8, and 24 h, and then at 2–7 days.

The VAS is a useful tool to assess the intensity of pain experienced by patients in dentistry. This scale has been the most widely used in clinical studies. It is a very descriptive system that is easy for patients to complete. Most of the publications that have assessed orthodontic pain have used this scale [1,14,24,25].

Regarding the follow-up time, most of the published studies that have quantified pain in patients during orthodontic treatments have had limited follow-up periods [1,23,26].

The low patient motivation before starting orthodontic treatment may condition patients to describe a higher level of pain during treatment, as well as a higher level of anxiety and discomfort than they would have otherwise [27]. The pain and discomfort that patients have reported during their orthodontic treatments were shown to influence their commitment to oral hygiene negatively [28]. The satisfaction of patients with treatments using transparent aligners (e.g., Invisalign) may be related to the patient's perceived improvement in appearance and their food choices compared to those with fixed multibrackets [29]. Other authors concluded that there were no statistically significant differences between patients with removable aligners and patients with fixed multibrackets appliances. After six months of treatment, patient satisfaction was shown to be similar between both treatment systems [30,31].

Patients with fixed appliances described greater discomfort compared to patients treated with removable aligners during the first week of treatment. During this period, Shalish M et al. observed that there were statistically significant differences between both groups. In this study, however, the pain was only evaluated during the first fourteen days of orthodontic treatment [32].

Regarding the consumption of analgesic drugs during orthodontic treatments, we observed a trend where patients undergoing treatment with fixed appliances consumed more analgesics during their treatments compared to patients with aligners [16,33].

Other studies that evaluated pain when comparing the use of aligners versus fixed appliances with conventional brackets also observed that the maximum peak of pain reported by patients was within the first 24 h after starting treatment [23,26,33]. In 2021, Gao M et al. analyzed the oral pain and the oral health-related quality of life in patients during the first fourteen days after starting orthodontic treatment with either conventional brackets or transparent aligners. They concluded that the patients that were treated with aligners described a lower level of pain, a lower level of anxiety, and a lower impact on their oral health-related quality of life compared to the results obtained in our study [33].

The peak of pain appears to diminish until reaching minimum values, seven days post-initial treatment. These results were consistent with the results we obtained in our study. Patients, regardless of the orthodontic system used, indicated their pain peak within the first 24 h and at different times of evaluation. As in the present study, other authors obtained statistically significant differences when comparing pain scores between patients with aligners and patients with fixed multibracket appliances. In this study, patients with aligners indicated a lower level of pain compared to those in [34,35]. Fujiyama K et al. also observed that patients with aligners described a lower level of pain in the first phases of orthodontic treatment compared to those with conventional fixed appliances. They indicated that the main cause of pain in patients with aligners was their deformation during treatment [36].

In 2018, Almasoud also carried out a study using the VAS that analyzed the perception of pain in patients undergoing treatment with a system of passive self-ligating brackets and aligners (e.g., Invisalign) with a seven-day follow-up period. In this study, the observed statistically significant differences in pain scores between both systems, at 4 hours, 24 h, 3 days, and 7 days after starting treatment. This study described a higher level of pain in the group of patients with passive self-ligating brackets compared to the patients with aligners. It concluded, in accordance with the present study, that the level of pain had increased within the first hours after starting orthodontic treatment and was considerably reduced after seven days [35].

In 2020, a study by Meazzini MC et al. evaluated pain in a sample of patients affected by fissures and craniofacial anomalies, and they analyzed the orthodontic treatments by comparing the pain scores of patients with conventional fixed appliances versus those with transparent aligners. They observed that patients undergoing treatment with fixed multibrackets appliances reported a higher level of pain and higher consumption of drugs compared to those with the transparent aligners. This study suggested that treatment with aligners may be a valuable option in patients with fissures and craniofacial anomalies due

to the reduction in pain [37]. Other studies also concluded that the consumption of anti-inflammatory and/or analgesic drugs was higher in patients receiving fixed multibracket appliances compared to patients receiving clear aligners [19,35,37].

In the present study, both treatment groups had a similar degree of oral crowding. This may have ensured similar amounts of tooth movement in the two study groups during the follow-up period. In addition, patients in both groups received their treatments via the same experienced orthodontist; therefore, their perception of pain could not be influenced by the treatment received from an inexperienced orthodontist or by any variable related to variations between orthodontists.

When assessing the influence of age on the level of pain described by patients during their orthodontic treatments, published studies indicated that there were no statistically significant differences in the level of pain when analyzing the influence of age [15,38,39]. In 2018, Johal A et al. concluded that neither the age nor the gender of patients undergoing orthodontic treatment had influenced their levels of pain, nor had it influenced their consumption of analgesic drugs [38].

A periodontal inflammatory reaction can occur during orthodontic treatment; therefore, it is necessary to use gentle and intermittent force during treatment to avoid excessive periodontal irritation to protect periodontal health. Recently, there has been a high demand for orthodontic treatment in adult patients. In these patients, there can be a high prevalence of periodontal pathology. Careful attention should be paid to patients with reduced periodontium, in whom there is a higher risk of gingival recession [40,41]. The periodontal biotype and the health status of the periodontium may influence the level of pain described by patients during orthodontic treatment [42,43].

According to the scientific literature, the pain described by patients during their orthodontic treatment in the first week of treatment has been extensively analyzed, but there have been few studies evaluating pain over a longer follow-up period.

The novelty of this study was to evaluate patient pain scores on the visual analog scale each month during a follow-up period of 12 months while comparing conventional brackets and aligners (Invisalign) and, at different time periods of each month, to analyze the pain described by the patients.

Limitations

One of the main limitations of this study was the lack of homogeneous samples in regard to the age of the patients, as potential differences in pain perception may exist across age groups. Age can be a factor that influences the perception of pain by patients. A narrower age range may have favored a better analysis of the influence of other factors on patient pain. Another limitation of this study was not assessing the patient's periodontal biotype and periodontal health status, which would have allowed us to analyze its influence on pain during orthodontic treatment. An additional limitation of this study was the follow-up period; in relation to the time of the initial orthodontic treatment, future clinical studies should consider a longer follow-up period. It would also be beneficial in future research to expand the sample size, evaluate different bracket systems, and examine the influence of the consumption of analgesic and/or anti-inflammatory drugs during orthodontic treatment.

5. Conclusions

During the 12-month follow-up period, statistically significant differences were observed in both treatment groups, with the exception of the eighth month. In the first month, patients with conventional brackets reported the highest pain scores, while from the second month onwards, patients with aligners described higher levels of pain.

In both orthodontic systems, patients reported their highest levels of pain on the visual analog scale within the first 24–48 h after each follow-up appointment. Afterward, the pain decreased until reaching minimum values from the fifth day after the follow-up appointment.

Therefore, we concluded that the orthodontic technique, either conventional fixed multibrackets or removable aligners, influenced the patient's perception of pain.

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Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. Written informed consent has been obtained from the patients to publish this paper.

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Conflicts of Interest: The authors declare no conflict of interest.

References

1. Jawaid, M.; Qadeer, T.A.; Fahim, M.F. Pain perception of orthodontic treatment—A cross-sectional study. *Pak. J. Med. Sci.* **2020**, *36*, 160–165. [\[CrossRef\]](#) [\[PubMed\]](#)
2. Krukemeyer, A.M.; Arruda, A.O.; Inglehart, M.R. Pain and orthodontic treatment. *Angle Orthod.* **2009**, *79*, 1175–1181. [\[CrossRef\]](#) [\[PubMed\]](#)
3. Lew, K.K. Attitudes and perceptions of adults towards orthodontic treatment in an Asian community. *Community Dent. Oral Epidemiol.* **1993**, *21*, 31–35. [\[CrossRef\]](#)
4. Scheurer, P.A.; Firestone, A.R.; Bürgin, W.B. Perception of pain as a result of orthodontic treatment with fixed appliances. *Eur. J. Orthod.* **1996**, *18*, 349–357. [\[CrossRef\]](#) [\[PubMed\]](#)
5. Sioustis, I.A.; Martu, M.A.; Aminov, L.; Pavel, M.; Cianga, P.; Kappenberg-Nitescu, D.C.; Luchian, I.; Solomon, S.M.; Martu, S. Salivary metalloproteinase-8 and metalloproteinase-9 evaluation in patients undergoing fixed orthodontic treatment before and after periodontal Therapy. *Int. J. Environ. Res. Public Health* **2021**, *18*, 1583. [\[CrossRef\]](#)
6. Kyrkanides, S.; Huang, H.; Faber, R.D. Neurologic regulation and orthodontic tooth movement. *Front. Oral Biol.* **2016**, *18*, 64–74.
7. Reichow, A.M.; Melo, A.C.; de Souza, C.M.; Castilhos, B.B.; Olandoski, M.; Alvim-Pereira, C.C.; Alvim-Pereira, F.; Trevilatto, P.C. Outcome of orthodontic mini-implant loss in relation to interleukin 6 polymorphisms. *Int. J. Oral Maxillofac. Surg.* **2016**, *45*, 649–657. [\[CrossRef\]](#)
8. Luppapornlarp, S.; Kajii, T.S.; Surarit, R.; Lida, J. Interleukin-1beta levels, pain intensity, and tooth movement using two different magnitudes of continuous orthodontic force. *Eur. J. Orthod.* **2010**, *32*, 596–601. [\[CrossRef\]](#) [\[PubMed\]](#)
9. Dudic, A.; Kiliaridis, S.; Mombelli, A.; Giannopoulou, C. Composition changes in gingival crevicular fluid during orthodontic tooth movement: Comparisons between tension and compression sides. *Eur. J. Oral Sci.* **2006**, *114*, 416–422. [\[CrossRef\]](#) [\[PubMed\]](#)
10. Pringle, A.M.; Petrie, A.; Cunningham, S.J.; McKnight, M. Prospective randomized clinical trial to compare pain levels associated with 2 orthodontic fixed bracket systems. *Am. J. Orthod. Dentofac. Orthop.* **2009**, *136*, 160–167. [\[CrossRef\]](#)
11. Tecco, S.; D'Attilio, M.; Tetè, S.; Festa, F. Prevalence and type of pain during conventional and self-ligating orthodontic treatment. *Eur. J. Orthod.* **2009**, *31*, 380–384. [\[CrossRef\]](#) [\[PubMed\]](#)
12. Miles, P.G.; Weyant, R.J.; Rustveld, L. A clinical trial of Damon 2 vs. conventional twin brackets during initial alignment. *Angle Orthod.* **2006**, *76*, 480–485.
13. Rahman, S.; Spencer, R.J.; Littlewood, S.J.; O'Dwyer, L.; Barber, S.K.; Russell, J.S. A multicenter randomized controlled trial to compare a self-ligating bracket with a conventional bracket in a UK population: Part 2: Pain perception. *Angle Orthod.* **2016**, *86*, 149–156. [\[CrossRef\]](#)
14. Fleming, P.S.; Dibiasi, A.T.; Sarri, G.; Lee, R.T. Pain experience during initial alignment with a self-ligating and a conventional fixed orthodontic appliance system. A randomized controlled clinical trial. *Angle Orthod.* **2009**, *79*, 46–50. [\[CrossRef\]](#)
15. Scott, P.; Sherriff, M.; Dibiasi, A.T.; Cobourne, M.T. Perception of discomfort during initial orthodontic tooth alignment using a self-ligating or conventional bracket system: A randomized clinical trial. *Eur. J. Orthod.* **2008**, *30*, 227–232. [\[CrossRef\]](#)
16. White, D.W.; Julien, K.C.; Jacob, H.; Campbell, P.M.; Buschang, P.H. Discomfort associated with Invisalign and traditional brackets: A randomized, prospective trial. *Angle Orthod.* **2017**, *87*, 801–808. [\[CrossRef\]](#)
17. Gu, J.; Tang, J.S.; Skulski, B.; Fields, H.W.J.; Beck, F.M.; Firestone, A.R.; Kim, D.G.; Deguchi, T. Evaluation of Invisalign treatment effectiveness and efficiency compared with conventional fixed appliances using the Peer Assessment Rating index. *Am. J. Orthod. Dentofac. Orthop.* **2017**, *151*, 259–266. [\[CrossRef\]](#) [\[PubMed\]](#)
18. Buschang, P.H.; Shaw, S.G.; Ross, M.; Crosby, D.; Campbell, P.M. Comparative time efficiency of aligner therapy and conventional edgewise braces. *Angle Orthod.* **2014**, *84*, 391–396. [\[CrossRef\]](#) [\[PubMed\]](#)

19. Miller, K.B.; McGorray, S.P.; Womack, R.; Quintero, J.C.; Perelmutter, M.; Gibson, J.; Dolan, T.A.; Wheeler, T.T. A comparison of treatment impacts between Invisalign aligner and fixed appliance therapy during the first week of treatment. *Am. J. Orthod. Dentofac. Orthop.* **2007**, *131*, e1–e9. [\[CrossRef\]](#)
20. Cardoso, P.C.; Espinosa, D.G.; Mecnas, P.; Flores-Mir, C.; Normando, D. Pain level between clear aligners and fixed appliances: A systematic review. *Prog. Orthod.* **2020**, *21*, 3. [\[CrossRef\]](#)
21. Warren, J.J.; Bishara, S.E.; Yonezu, T. Tooth size-arch length relationships in the deciduous dentition: A comparison between contemporary and historical samples. *Am. J. Orthod. Dentofac. Orthop.* **2003**, *123*, 614–619. [\[CrossRef\]](#)
22. Steiner, C.C. Cephalometrics for you and me. *Am. J. Orthod. Dentofac. Orthop.* **1953**, *39*, 729–755. [\[CrossRef\]](#)
23. Bergius, M.; Kiliaridis, S.; Berggren, U. Pain in orthodontics A review and discussion of the literature. *J. Orofac. Orthop.* **2000**, *61*, 125–137. [\[CrossRef\]](#)
24. Otasevic, M.; Naini, F.B.; Gill, D.S.; Lee, R.T. Prospective randomized clinical trial comparing the effects of a masticatory bite wafer and avoidance of hard food on pain associated with initial orthodontic tooth movement. *Am. J. Orthod. Dentofac. Orthop.* **2006**, *130*, 9–15. [\[CrossRef\]](#)
25. Klumper, G.T.; Hiser, D.G.; Rayens, M.K.; Jay, M.J. Efficacy of a wax containing benzocaine in the relief of oral mucosal pain caused by orthodontic appliances. *Am. J. Orthod. Dentofac. Orthop.* **2002**, *122*, 359–365. [\[CrossRef\]](#)
26. Koritsánszky, N.; Madléna, M. Pain and discomfort in orthodontic treatments. Literature review. *Fogorv. Sz.* **2011**, *104*, 117–121. [\[PubMed\]](#)
27. Bergius, M.; Broberg, A.G.; Hakeberg, M.; Berggren, U. Prediction of prolonged pain experiences during orthodontic treatment. *Am. J. Orthod. Dentofac. Orthop.* **2008**, *133*, 339.e1–339.e8. [\[CrossRef\]](#) [\[PubMed\]](#)
28. Marques, L.S.; Paiva, S.M.; Vieira-Andrade, R.G.; Pereira, L.J.; Ramos-Jorge, M.L. Discomfort associated with fixed orthodontic appliances: Determinant factors and influence on quality of life. *Dent. Press J. Orthod.* **2014**, *19*, 102–107. [\[CrossRef\]](#) [\[PubMed\]](#)
29. Pacheco-Pereira, C.; Brandelli, J.; Flores-Mir, C. Patient satisfaction and quality of life changes after Invisalign treatment. *Am. J. Orthod. Dentofacial Orthop.* **2018**, *153*, 834–841. [\[CrossRef\]](#)
30. Flores-Mir, C.; Brandelli, J.; Pacheco-Pereira, C. Patient satisfaction and quality of life after 2 treatment modalities: Invisalign and conventional fixed appliances. *Am. J. Orthod. Dentofacial Orthop.* **2018**, *154*, 639–644. [\[CrossRef\]](#)
31. Cooper-Kazaz, R.; Ivgi, I.; Canetti, L.; Bachar, E.; Tsur, B.; Chaushu, S.; Shalish, M. The impact of personality on adult patients' adjustability to orthodontic appliances. *Angle Orthod.* **2013**, *83*, 76–82. [\[CrossRef\]](#)
32. Shalish, M.; Cooper-Kazaz, R.; Ivgi, I.; Canetti, L.; Tsur, B.; Bachar, E.; Chaushu, S. Adult patients' adjustability to orthodontic appliances. Part I: A comparison between Labial, Lingual, and Invisalign™. *Eur. J. Orthod.* **2012**, *34*, 724–730. [\[CrossRef\]](#)
33. Gao, M.; Yan, X.; Zhao, R.; Shan, Y.; Chen, Y.; Jian, F.; Long, H.; Lai, W. Comparison of pain perception, anxiety, and impacts on oral health-related quality of life between patients receiving clear aligners and fixed appliances during the initial stage of orthodontic treatment. *Eur. J. Orthod.* **2021**, *43*, 353–359. [\[CrossRef\]](#)
34. Casteluci, C.E.V.F.; Oltramari, P.V.P.; Conti, P.C.R.; Bonjardim, L.R.; de Almeida-Pedrin, R.R.; Fernandes, T.M.F.; de Almeida, M.R.; de Castro Ferreira Conti, A.C. Evaluation of pain intensity in patients treated with aligners and conventional fixed appliances: Randomized clinical trial. *Orthod. Craniofac. Res.* **2021**, *24*, 268–276. [\[CrossRef\]](#)
35. Almasoud, N.N. Pain perception among patients treated with passive self-ligating fixed appliances and Invisalign® aligners during the first week of orthodontic treatment. *Korean J. Orthod.* **2018**, *48*, 326–332. [\[CrossRef\]](#)
36. Fujiyama, K.; Honjo, T.; Suzuki, M.; Matsuoka, S.; Deguchi, T. Analysis of pain level in cases treated with Invisalign aligner: Comparison with fixed edgewise appliance therap. *Prog. Orthod.* **2014**, *15*, 64. [\[CrossRef\]](#)
37. Meazzini, M.C.; Tortora, C.; Mazzoleni, F.; Autelitano, L. Comparison of pain perception in patients affected by cleft and cranio facial anomalies treated with traditional fixed appliances or Invisalign. *Cleft Palate Craniofac. J.* **2020**, *57*, 35–42. [\[CrossRef\]](#) [\[PubMed\]](#)
38. Johal, A.; Ashari, A.B.; Alamiri, N.; Fleming, P.S.; Qureshi, U.; Cox, S.; Pandis, N. Pain experience in adults undergoing treatment: A longitudinal evaluation. *Angle Orthod.* **2018**, *88*, 292–298. [\[CrossRef\]](#) [\[PubMed\]](#)
39. Brown, D.F.; Moerenhout, R.G. The pain experience and psychological adjustment to orthodontic treatment of preadolescents, adolescents, and adults. *Am. J. Orthod. Dentofac. Orthop.* **1991**, *100*, 349–356. [\[CrossRef\]](#)
40. Sioustis, I.A.; Axinte, M.; Preliceanu, M.; Martu, A.; Kappenberg-Nitescu, D.C.; Teslaru, S.; Luchian, I.; Solomon, S.M.; Cimpoesu, N.; Martu, S. finite element analysis of mandibular anterior teeth with healthy, but reduced periodontium. *Appl. Sci.* **2021**, *11*, 3824. [\[CrossRef\]](#)
41. Luchian, I.; Martu, M.A.; Tatarciuc, M.; Scutariu, M.M.; Ioanid, N.; Pasarin, L.; Kappenberg-Nitescu, D.C.; Sioustis, I.A.; Solomon, S.M. Using fem to assess the effect of orthodontic forces on affected periodontium. *Appl. Sci.* **2021**, *11*, 7183. [\[CrossRef\]](#)
42. Osada, A.; Hitomi, S.; Nakajima, A.; Hayashi, Y.; Shibuta, I.; Tsuboi, Y.; Motoyoshi, M.; Iwata, K.; Shinoda, M. Periodontal acidification contributes to tooth pain hypersensitivity during orthodontic tooth movement. *Neurosci. Res.* **2021**, *21*, 241–248. [\[CrossRef\]](#) [\[PubMed\]](#)
43. Lv, D.; Zhang, J.; Gu, X.; Shen, H.; Shao, S.; Hou, W.; Wang, K.; Svensson, P.; Chen, W. Transient pain following orthodontic fixed appliances induces sensitization of gingival and periodontal tissues. *J. Oral Facial Pain Headache* **2016**, *30*, 228–233. [\[CrossRef\]](#) [\[PubMed\]](#)