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Assessment Of Orthodontic Pain And Quality Of Life Of Patients Undergoing Conventional, Ceramic, Self-Ligating And Aligners

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Abstract:
Background: *Orthodontic treatment improves oral health and aesthetics but often results in pain and discomfort, which can affect patient's quality of life. Pain perception varies based on the type of orthodontic appliance used, influencing patient satisfaction and compliance.*
Objective: *This prospective study aims to assess and compare pain levels and oral health impact among patients undergoing orthodontic treatment with ceramic brackets, conventional MBT brackets, self-ligating brackets, and clear aligners.*
Materials and Methods: *A total of 60 participants were divided into four groups, with 15 participants each. Pain was measured using the Visual Analog Scale (VAS) and the Oral Health Impact Profile (OHIP-14). VAS scores were recorded at six time points over six months, while OHIP-14 was administered at the first and sixth months. Statistical analysis was conducted using ANOVA, post hoc tests, and Chi-square tests.*
Results: *Significant differences in pain levels were observed at T3, T4, and T6, with Group 4 (Aligners) consistently reporting the lowest pain scores. OHIP-14 scores revealed that Aligners group had the least impact on quality of life, while Ceramic brackets reported the highest impact at T1 and continued to show high severity at T6.*
Conclusion: *Aligners caused the least pain and had the least impact on oral health-related quality of life compared to other orthodontic treatments. Ceramic brackets caused the most discomfort and had the most significant impact on quality of life, especially in the early stages of treatment.*
Keywords: *Aligners, Conventional metal MBT brackets, Self-ligating brackets, Ceramic brackets, Pain*

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I. Introduction

Orthodontic treatment improves oral health, function, and aesthetics, but it often comes with pain and discomfort. Defined by the International Association for the Study of Pain (IASP) as an "unpleasant sensory and emotional experience associated with actual or potential tissue damage," orthodontic pain results from forces applied to teeth, causing inflammatory responses in the periodontal ligament and surrounding tissues. Although temporary, this pain can significantly affect oral health-related quality of life (OHRQoL), influencing satisfaction, compliance, and the overall treatment experience.[1]

Pain is prevalent across various orthodontic treatments, including conventional fixed appliances, ceramic braces, self-ligating systems, and clear aligners. The intensity, duration, and perception of pain depend on the appliance type, force applied, and patient characteristics and previous pain experiences.[1,2] Fixed appliances, are

linked to greater discomfort, especially during initial placement and adjustments, while clear aligners are often marketed as more comfortable alternatives, promising reduced pain and enhanced aesthetics. Understanding these differences helps clinicians customize treatment plans and manage pain effectively.

Conventional fixed appliances have been the foundation of orthodontic treatment for decades. While effective, these braces cause significant discomfort during the initial treatment phase and after adjustments. This pain arises from the compression of periodontal tissues, leading to inflammation, soreness, and tension.[2]

In the 1970s, the introduction of ceramic brackets offered a discreet, metal-free alternative for patients prioritizing aesthetics. Made from alumina, these brackets provided enhanced strength, and while similar in function to metal braces, they still caused pressure-related pain during adjustments.[3] The self-ligating brackets, first introduced by Stolzenberg in the 1930s, improved orthodontic treatments by eliminating the need for elastic bands. These brackets reduce friction, enhance control, and shorten treatment times, though they come with a larger profile and higher costs. Despite applying gentler forces and reducing friction compared to traditional braces, some discomfort persists, particularly in the early stages of treatment.[4]

The emergence of clear aligners in 1998, such as Invisalign, revolutionized orthodontics by providing nearly invisible, removable appliances for minor tooth movements. Offering excellent aesthetics, comfort, and hygiene, clear aligners are considered the least painful option due to their gradual, controlled movement using custom-made trays. However, patients may still experience mild discomfort during the first few days of wearing a new aligner.[5]

Orthodontics is increasingly focused on personalized, less visible treatments, with innovations like ceramic brackets, self-ligating systems, and clear aligners. However, challenges such as cost, complexity, and limitations for severe cases remain. Pain management, including pharmacological and non-pharmacological methods, is essential to ensure a positive patient experience. Advances in appliance design and materials aim to minimize discomfort while maintaining effectiveness. The impact of orthodontic pain extends to OHRQoL, affecting speech, chewing, and hygiene, and causing psychological stress, particularly for adolescents and adults concerned with aesthetic limitations. Hence, evaluating pain and its effects on OHRQoL is vital for optimizing treatment outcomes.[6,7]

Thus this study aims to evaluate and compare the pain levels and oral health impact of different orthodontic appliances: ceramic brackets (Group 1), conventional MBT brackets (Group 2), self-ligating brackets (Group 3), and aligners (Group 4).

II. Materials And Methods

This is a prospective, comparative study conducted among patients seeking orthodontic treatment at the Department of Orthodontics. A total of 60 participants were recruited and evenly distributed into four groups, each comprising 15 participants, based on the specific orthodontic modality utilized. Group 1 consisted of patients treated with ceramic brackets (3M Clear) (Figure 1A), Group 2 involved those using conventional MBT brackets (ORMCO Mini Diamond) (Figure 1B), Group 3 included individuals with self-ligating brackets (DAMON Q2) (Figure 1C), and Group 4 comprised patients utilizing in-house aligners (Figure 1D).

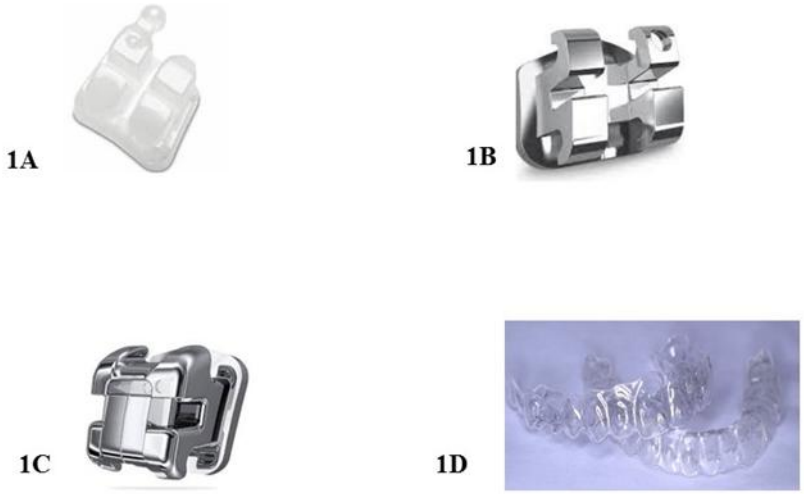

Figure 1.1A: *Ceramic brackets (3M Clear); 1B: Conventional MBT brackets (ORMCO Mini Diamond); 1C: Self-ligating brackets (DAMON Q2); 1D: In-house aligners*

Participants aged 18–30 years with mild to moderate dental crowding or spacing, no prior orthodontic treatment, and no systemic or dental conditions that could affect pain perception were included. Additionally,

patients were included only if therapeutic extractions or the use of other intra-oral or extra-oral devices was not planned as part of their treatment.

Patients taking analgesics or anti-inflammatory medications that could influence pain perception, as well as those with craniofacial anomalies that might affect pain experience or treatment outcomes were excluded. Patients with supernumerary teeth, missing teeth, or impacted teeth requiring special orthodontic management were also excluded from the study.

The wire sequence varied according to the type of appliance used. For ceramic and conventional MBT brackets, the sequence included 0.014 NiTi, 0.016 NiTi, 0.016×0.022 NiTi, 0.016×0.022 SS, and 0.019×0.025 NiTi wires, with E-chains employed for space closure. The self-ligating bracket protocol utilized 0.013 CuNiTi, 0.014×0.025 CuNiTi, 0.018×0.025 CuNiTi, and 0.019×0.025 CuNiTi wires. In-house aligners were fabricated using Maestro 3D software with Zendura aligner sheets, allowing for 0.3–0.5 mm of movement per tray.

Pain during treatment was assessed using the Visual Analog Scale (VAS) and the Oral Health Impact Profile (OHIP-14). The VAS measured pain intensity on a scale of 0 to 10, where scores of 0 indicates no pain, 1–3 indicated mild pain, 4–7 indicated moderate pain, and 8–10 indicated severe pain. VAS scores were recorded at baseline, after seven days of bracket placement, and seven days after each monthly wire change, for six months (T1, T2, T3, T4, T5, T6). Patients who reported severe pain (VAS scores of 8–10) were given analgesics and excluded from the study, leaving a total of 48 patients for analysis. The final distribution of patients across groups was as follows: Group 1 had 11 patients, Group 2 had 12, Group 3 had 12, and Group 4 had 13.

The OHIP-14 assessed the impact of oral health conditions on the quality of life, including physical, psychological, and social aspects. The questionnaire comprised 14 items grouped into seven domains: functional limitation, physical pain, psychological discomfort, physical disability, psychosocial disability, handicap, and self-consciousness. Each item was rated on a 5-point Likert scale. The scores for each of the 14 items are aggregated, yielding a total score ranging from 0 to 56. Elevated scores indicate increased discomfort and a more profound effect on the patient's daily functioning, emotional well-being, and social interactions as a result of orthodontic treatment. A score between 0 and 14 suggests minimal impact on quality of life, 15 to 28 indicates moderate impact, 29 to 42 reflects high impact, and 43 to 56 represents very high impact on quality of life. The questionnaire is administered at the end of the first month following the placement of the appliance and again at the end of the sixth month to assess any variations in pain and discomfort over time (T1, T6).

The data were analyzed using IBM SPSS 20.0 to evaluate pain levels and their impact across the four treatment groups. One-way ANOVA followed by Bonferroni post hoc test was performed to compare pain scores, as measured by the OHIP-14 and VAS, between the four groups. The Chi-square test was used to assess the distribution of pain intensity categories and OHIP-14 severity impact. Level of significance is set at $p<0.05$.

III. Results

The overall mean age of the study participants across all groups is 22.65±3.33 years. The sex ratio is balanced, with males constituting 58.3% of the total sample and females 41.7%. (Table 1)

***Table 1**. Demographic details of the study population*

	Group 1 (n=11)	**Group 2 (n=12)**	**Group 3 (n=12)**	**Group 4 (n=13)**	**Overall (n=48)**
Age in years, (Mean ± SD)	22.73±3.26	22.08±3.23	23.42±3.85	22.38±3.23	22.65±3.33
Male, n (%)	6 (54.5%)	7 (58.3%)	7 (58.3%)	8 (61.5%)	28 (58.3%)
Female, n (%)	5 (45.5%)	5 (41.7%)	5 (41.7%)	5 (38.5%)	20 (41.7%)

VAS scores across the four groups show significant differences at T3 ($p = 0.004$), T4 ($p = 0.036$), and T6 ($p = 0.002$), with Group 4 consistently reporting the lowest scores. No significant differences were found at T1, T2, or T5. (Table 2, Figure 2)

***Table 2.** Comparison of VAS Scores across Four Groups at Different Time Points*

Group	**Group 1 (n=11)**	**Group 2 (n=12)**	**Group 3 (n=12)**	**Group 4 (n=13)**	**F**	**p value**
T1	6.55±2.02	6.58±1.24	5.33±1.03	6.46±1.66	1.833	0.155
T2	5.91±1.45	5.17±1.85	4.92±1.08	5.00±1.41	1.073	0.370
T3	6.27±1.55	5.67±1.07	5.50±1.17	4.23±1.42	5.218	0.004*
T4	5.73±1.55	5.08±1.08	5.17±1.85	4.00±1.15	3.095	0.036*
T5	5.09±1.64	4.83±1.40	4.83±1.40	4.77±1.24	0.116	0.950
T6	5.18±1.94	5.08±0.99	4.83±0.84	3.38±0.87	5.923	0.002*

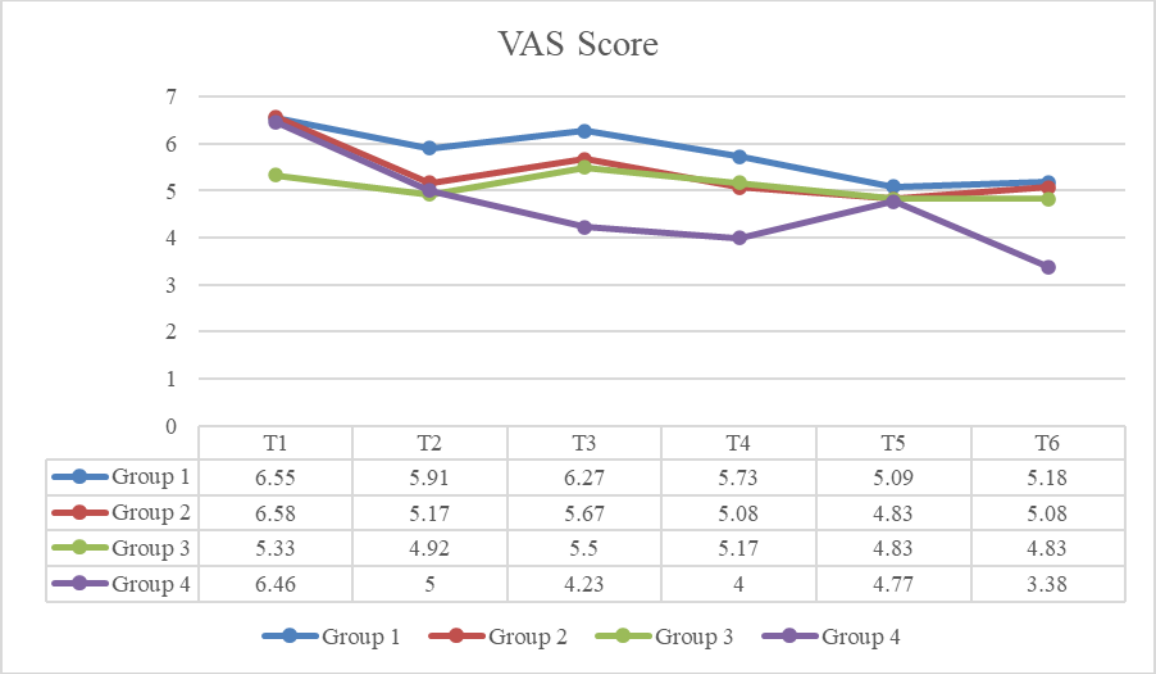

Figure 2. *Mean pain scores of four different groups at various timelines*

The post hoc test of VAS scores reveals significant differences at specific time points across groups. At T3, Group 1 significantly differs from Group 4 (mean difference 2.042, p = 0.003). At T4, Group 1 significantly differs from Group 4 (mean difference 1.727, p = 0.032). At T6, significant differences are observed between Group 1 and Group 4 (mean difference 1.797, p = 0.005), Group 2 and Group 4 (mean difference 1.699, p = 0.007), and Group 3 and Group 4 (mean difference 1.449, p = 0.029). Other comparisons do not show significant differences. (Table 3).

Table 3.*Post hoc test of VAS scores across Four Groups*

Timeline	Group	Mean diff	Sig.
T3	Group 1 vs Group 2	0.606	1.000
	Group 1 vs Group 3	0.773	0.999
	Group 1 vs Group 4	2.042	0.003*
	Group 2 vs Group 3	0.167	1.000
	Group 2 vs Group 4	1.436	0.055
	Group 3 vs Group 4	1.269	0.121
T4	Group 1 vs Group 2	0.644	1.000
	Group 1 vs Group 3	0.561	1.000
	Group 1 vs Group 4	1.727	0.032*
	Group 2 vs Group 3	-0.083	1.000
	Group 2 vs Group 4	1.083	0.397
	Group 3 vs Group 4	1.167	0.291
T6	Group 1 vs Group 2	0.098	1.000
	Group 1 vs Group 3	0.348	1.000
	Group 1 vs Group 4	1.797	0.005*
	Group 2 vs Group 3	0.250	1.000
	Group 2 vs Group 4	1.699	0.007*
	Group 3 vs Group 4	1.449	0.029*
	Group 2 vs Group 4	11.994	0.012
	Group 3 vs Group 4	9.994	0.000

The comparison of OHIP 14 scores across the four groups at different time points shows significant differences. At T1, Group 1 has the highest score (29.27), and Group 4 has the lowest (6.85), with a significant overall difference (F = 49.713, p = 0.000). At T6, Group 1 again has the highest score (19.73), and Group 4 the lowest (2.92), with a significant overall difference (F = 24.965, p = 0.000). (Table 4, Figure 3)

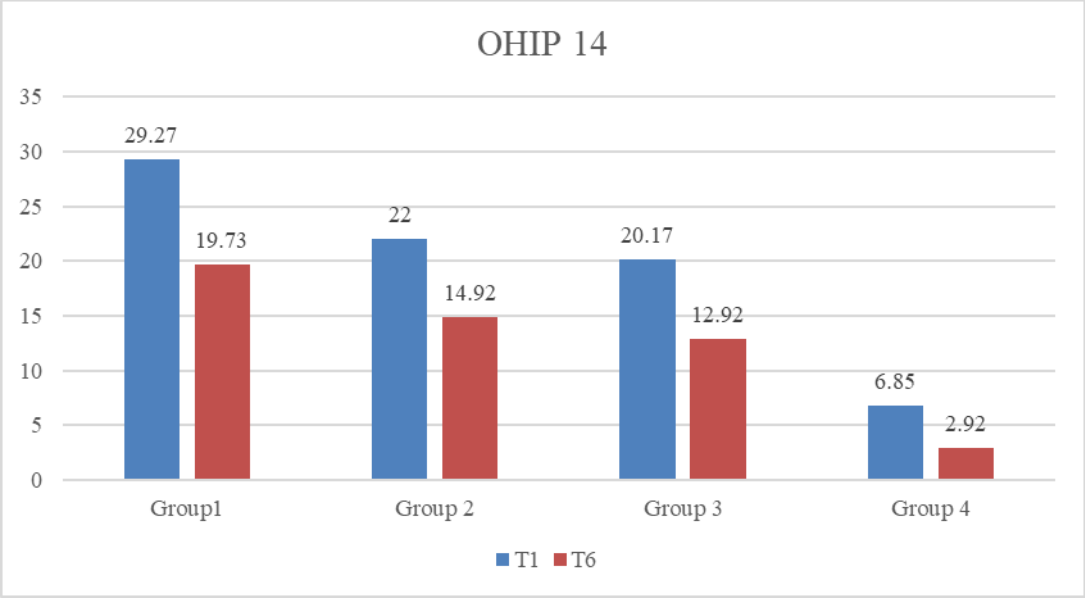

Figure 3. *Mean OHIP Scores of four different groups at T1 and T6*

Table 4. *Comparison of OHIP 14 scores across four Groups at Different Time Points*

Group	Group 1 (n=11)	Group 2 (n=12)	Group 3 (n=12)	Group 4 (n=13)	F	p value
T1	29.27±6.96	22.00±4.28	20.17±4.06	6.85±2.54	49.713	0.000*
T6	19.73±7.95	14.92±4.25	12.92±4.52	2.92±1.38	24.965	0.000*

The post hoc test at T1 reveals significant differences between Group 1 and all other groups (Group 1 vs Group 2: p = 0.003, Group 1 vs Group 3: p = 0.000, Group 1 vs Group 4: p = 0.000). Similarly, at T6, significant differences are found between Group 1 and Group 4 (p = 0.000), and Group 2 and Group 4 (p = 0.012). No significant differences are observed between Group 1 and Group 2 at T6 (p = 0.148) or Group 2 and Group 3 at both time points (p = 1.000). (Table 5)

Table 5. *Post hoc test of OHIP 14 scores across Four Groups*

Timeline	Group	Mean diff	Sig.
T1	Group 1 vs Group 2	7.273	0.003*
	Group 1 vs Group 3	9.106	0.000*
	Group 1 vs Group 4	22.427	0.000*
	Group 2 vs Group 3	1.833	1.000
	Group 2 vs Group 4	15.154	0.000*
	Group 3 vs Group 4	13.321	0.000*
T6	Group 1 vs Group 2	4.811	0.148
	Group 1 vs Group 3	6.811	0.012*
	Group 1 vs Group 4	16.804	0.000*
	Group 2 vs Group 3	2.000	1.000
	Group 2 vs Group 4	11.994	0.012*
	Group 3 vs Group 4	9.994	0.000*

The severity of VAS scores at different time points across the four groups shows significant differences at T3,T4,T6. At T3, there is a significant difference (χ^2 = 25.242, p = 0.000), with Group 4 showing a higher number of participants reporting mild severity. At T4, a significant difference is observed (χ^2 = 13.872, p = 0.031), with Group 4 again reporting more mild cases. At T6, a significant difference is noted (χ^2 = 19.681, p = 0.003), with Group 4 reporting the highest number of mild cases. Group 1, 2 and Group 3 reported a higher number of moderate to severe cases at different timelines. No significant differences are found at T1, T2, and T5. (Table 6)

Table 6. *Severity of VAS scores at different timelines*

Timeline	Severity	Group				Chi square value	p value
		1	2	3	4		
T1	**Mild**	0	0	0	0	5.177	0.159
	Moderate	7	9	12	9		
	Severe	4	3	0	4		
T2	**Mild**	0	3	0	2	10.320	0.112

	Moderate	10	7	12	11		
	Severe	1	2	0	0		
T3	**Mild**	0	0	0	5	25.242	0.000*
	Moderate	8	12	12	8		
	Severe	3	0	0	0		
T4	**Mild**	0	0	3	5	13.872	0.031*
	Moderate	10	12	7	8		
	Severe	1	0	2	0		
T5	**Mild**	1	1	1	2	4.829	0.566
	Moderate	8	10	11	11		
	Severe	2	1	0	0		
T6	**Mild**	3	0	1	7	19.681	0.003*
	Moderate	6	12	11	6		
	Severe	2	0	0	0		

The severity of OHIP 14 scores at T1, there is a significant difference ($\chi^2 = 17.151$, $p = 0.009$), with Group 4 reporting the highest number of minimal severity cases. Group 1, 2, and 3 primarily reported minimal to moderate severity. At T6, a significant difference is observed ($\chi^2 = 55.887$, $p = 0.000$), with Group 4 again showing a higher number of minimal severity cases. Group 1, 2, and 3 reported mostly moderate and high severity, while Group 4 showed a shift toward minimal severity. (Table 7)

Table 7. *Severity of OHIP 14 at different timeline*

Timeline	**Severity**	**Group**				**Chi square value**	**p value**
		1	**2**	**3**	**4**		
T1	**Minimal**	4	6	8	13	17.151	0.009*
	Moderate	5	6	4	0		
	High	2	0	0	0		
T6	**Minimal**	0	0	1	13	55.887	0.000*
	Moderate	6	11	11	0		
	High	5	1	0	0		

IV. Discussion

Orthodontic pain is widely recognized as an inevitable and common consequence of tooth movement, and most orthodontic patients accept this discomfort as part of the treatment process. Typically, orthodontic pain is described as tooth discomfort resulting from the movement of teeth, but it can also encompass a wider range of painful sensations, such as tongue irritation, mucosal ulcers, and gingival lesions, which are induced by orthodontic appliances.[8-10] Research indicates that self-ligating brackets tend to cause less pain and have a less detrimental effect on oral quality of life compared to traditional fixed orthodontic treatments. On the other hand, lingual orthodontics, while offering improved aesthetics, tends to be associated with greater pain and functional impacts. The Invisalign system, similarly, has been found to significantly reduce perceived pain after just two days of treatment, as compared to conventional braces. As Chandel N et al. observed, pain is a leading cause of patient non-compliance and appointment cancellations, ultimately compromising treatment outcomes.[11] It is reported that approximately 8% of patients discontinue treatment due to the discomfort experienced during the early stages.[12,13] The severity of this pain can vary depending on the type of orthodontic appliance used. A comprehensive evaluation of the prevalence and nature of pain associated with different orthodontic treatment methods is crucial, as it can help identify the least painful options and improve overall patient comfort. Therefore, the present study aims to evaluate and compare the pain levels and oral health impact of different orthodontic appliances: ceramic brackets (Group 1), conventional MBT brackets (Group 2), self-ligating brackets (Group 3), and aligners (Group 4).

In the present study at the beginning of the treatment pain levels were similar across all groups, signifying that the initial discomfort caused by orthodontic treatment was comparable. However, as treatment progressed, significant differences in pain levels emerged at various time points. Especially, Group 4 constantly reported the lowest pain scores, particularly at T3, T4, and T6, suggesting that the treatment in Group 4 may be more comfortable or less painful over time compared to the others. While pain reduction was observed in all groups, by T5, the differences in pain scores was insignificant, indicating that the pain levels across the groups started to converge toward the later stages of treatment. Thus, the pain levels from lowest to highest across the groups are as follows: Aligners < Self-ligating brackets < Conventional MBT brackets < Ceramic brackets.

With regard to Oral health impact profile, Group 4 consistently had the least severity of oral health impact throughout the study, both at T1 and T6. At T1, Group 4 reported the highest number of participants with minimal severity and the least with moderate or high severity. By T6, Group 4 continued to show the most improvement, with all participants reporting minimal severity. In contrast, Group 1 experienced the highest severity, particularly at T1, with a significant portion reporting moderate or high severity. While there was some

improvement by T6, Group 1 still had many participants in the moderate and high severity categories. Group 2 showed moderate severity, with participants reporting a mix of minimal and moderate severity at both time points. Group 3 was similar to Group 2, but with a slightly higher distribution of moderate and high severity at both T1 and T6. Therefore, aligners group experienced the least negative impact on oral health and the most improvement over time, while Ceramic group had the most significant challenges. Thus the OHIP 14 severity from least to most severe across the four groups are as follows: Group 4 < Group 2 < Group 3 < Group 1.

Orthodontic forces must be applied continuously for optimal tooth displacement, with a minimum of 6 hours per day required to achieve minimal movement. The optimal displacement rate is typically 1 mm per month, influenced by factors such as the intensity of the applied force-lower-intensity forces are more effective due to reduced periodontal ligament hyalinization-and the patient's age, with adults experiencing slower displacement due to denser alveolar bone and reduced cellular response.[14-16] This process of tooth movement is closely linked to orthodontic pain, which is believed to be closely linked to the release of substance P (SP), a neuropeptide that heightens pain perception. This delayed pain response, occurring hours after the application of orthodontic forces, results from increased sensitivity of nerve fibers to harmful stimuli such as histamines, prostaglandins, and SP. These substances are released by nociceptors in damaged tissues, exacerbating nerve damage. The primary cause of orthodontic pain is the compression of the periodontal ligament during the early stages of tooth movement, where forces applied to the teeth generate pressure on surrounding tissues, leading to discomfort.[17-19]

This finding aligns with Sahoo N et al., who noted that metal brackets typically cause less pain than ceramic brackets due to lower friction. Ceramic brackets generate greater friction, which intensifies the compression on the periodontal ligament (PDL), leading to more pain and prolonged discomfort. While ceramic brackets offer superior aesthetic benefits, being tooth-colored and less visible than metal counterparts, the increased friction they produce results in higher pain levels, a key factor to consider when deciding between metal and ceramic options.[2] Almasoud NN et al. demonstrated that patients undergoing treatment with Invisalign aligners reported considerably lower pain levels than those receiving passive self-ligating fixed appliances. Pain peaked at 24 hours but swiftly diminished, reaching its minimal intensity by the seventh day for both treatment groups.[20] Tecco et al. reported that patients treated with conventional brackets experienced notably more persistent pain, while those with self-ligating brackets primarily reported intermittent discomfort, particularly during chewing and biting.[21]

The results diverge from the observations of Shalish M et al., who found that patients using Invisalign experienced greater pain than those with buccal appliances, akin to the discomfort reported by lingual patients. This inconsistency may be attributed to the higher initial mechanical forces exerted by the Invisalign system during the early phases of treatment.[22] Furthermore, Lopes GC et al. observed no significant difference in pain parameters, including substance P release and pressure, between conventional and self-ligating appliances and concluded that factors such as pain, discomfort, and masticatory efficiency should not drive the choice between these orthodontic options.[18]

Clear Aligners offers several advantages that make it less painful and more compliant compared to other orthodontic appliances. One key reason for its popularity is its aesthetic appeal and comfort. Aligners are virtually invisible, which is particularly beneficial for individuals who feel self-conscious about traditional metal braces in social or professional settings. Made from flexible materials like polyurethane or ethylene vinyl acetate, aligners are gentler on the gums and oral tissues, enhancing comfort.[23,24]

Additionally, aligners are removable, allowing patients to eat, drink, brush, and floss with ease. This not only improves comfort but also promotes better oral hygiene by eliminating food buildup around brackets, a common issue with fixed braces. The ability to remove aligners ensures more effective oral care compared to other orthodontic appliances.[25]

Regarding pain, aligners apply gentle, controlled pressure to gradually move teeth, leading to less discomfort, especially during the initial stages of treatment. In contrast, fixed appliances often cause immediate discomfort due to the continuous tension from wires and brackets. Studies support that patients using aligners report lower pain levels than those with traditional braces. Furthermore, aligners generate less friction, reducing tissue irritation compared to ceramic brackets, which cause more friction and discomfort.[26] While patient compliance is crucial for success, many find aligners easier to follow due to their comfort and convenience.[24]

The Study does have limitations. This include relatively small sample size, which may limit the external validity and generalizability of the findings. Additionally, the exclusion of patients with severe dental conditions or craniofacial anomalies restricts the applicability of the results to a wider patient demographic. Furthermore, pain perception is inherently subjective, and the study did not fully account for individual variations in pain thresholds or psychological factors, which could have influenced the reported outcomes.

Future research should focus on larger, more diverse samples, including patients with severe dental conditions or craniofacial anomalies. Studies can also examine the influence of psychological factors on pain perception and conduct longer follow-ups to assess the long-term effects of orthodontic appliances. Additionally, incorporating objective pain measurement methods could offer more precise insights into pain mechanisms.

V. Conclusion

Aligners caused the least pain over time, followed by self-ligating brackets, conventional MBT brackets, and ceramic brackets, which caused the most discomfort. With regard to quality of life, Clear aligners (Group 4) showed the least negative impact on oral health-related quality of life, both at T1 and T6. In contrast, ceramic brackets (Group 1) had the most significant impact, particularly at T1. The self-ligating and conventional MBT brackets reported moderate levels of pain and quality of life impacts, with self-ligating brackets showing slightly better outcomes. Thus, Clear aligners offer significant benefits in terms of reduced pain and better quality of life, making them a preferable option for patients concerned with aesthetics and comfort. Ceramic brackets, despite their aesthetic appeal, cause more discomfort and a greater impact on quality of life, particularly during the early phases of treatment.

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