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Original Article

Comparison of Pain Levels on Patients Undergoing Fixed Orthodontic Treatment with 2 Different Self-Ligating Bracket Systems

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Main Points
- SmartClip group reported less pain at the 2nd and the 6th hours while chewing.
- Pain levels were the highest at the 6th h and the 2nd day for the Damon Q and SmartClip SL3 groups respectively.
- The SmartClip group reported more pain for the first two days, and after the 2nd day, pain scores were very similar to the Damon group.
- No statistically significant differences were reported between the groups at any time interval while biting on anterior or posterior teeth.

ABSTRACT

Objective: Comparison of pain levels of patients treated with 2 different passive self-ligating bracket systems right after initial archwire placement.

Methods: A total of 34 patients with mild crowding were allocated randomly to 2 groups to be treated using 2 different self-ligating brackets. 0.014 inch copper nitinol and 0.014 inch superelastic nitinol archwires were selected as the initial archwire for Damon Q and SmartClip SL3 systems respectively. Seven page questionnaires that consisted of 3 visual analogue scales were handled to patients to mark their pain levels while chewing, biting with anterior teeth, and biting with posterior teeth at 2nd hour, 6th hour, 2nd day, 3rd day, and 7th day time intervals. Pain scores were measured manually using a ruler and noted.

Results: The SmartClip group reported less pain at the 2nd and the 6th hours while chewing. Pain levels were the highest at the 6th h and the 2nd day for the Damon Q and SmartClip SL3 groups respectively. The SmartClip group reported more pain for the first two days, and after the 2nd day, pain scores were very similar to the Damon group. No statistically significant differences were reported between the groups.

Conclusion: The highest pain sensation was reported for the 2nd day and decreased toward the 7th day. The SmartClip SL3 group reported lower pain scores in the first two days, but the levels were equaled on the 2nd day and after.

Keywords: Pain, quality of life, self-ligating brackets

INTRODUCTION

According to the International Association for the Study of Pain, pain is an unpleasant emotional experience that can accompany or be associated with existing or possible tissue damage. The first week of orthodontic treatment does cause some degree of pain, which may be quite disturbing for some individuals.[1,2] The pain experienced by most of the orthodontic patients is a negative experience, which may even lead to the patient leaving the treatment. During the treatment, brackets and teeth are moved through the alveolar bone via the force generated by archwires. The applied force causes the vasospasm of the periodontium to compress, resulting in pain. This

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is a finding of hyalinized areas in the periodontal ligament. The use of light forces is recommended to reduce hyalinization and achieve a more physiological tooth movement. When it is considered biologically, applying a force that starts off slightly and resets itself to a lesser extent allows the tooth movement to occur more simply and physiologically.[3]

With self-ligating (SL) brackets, it is aimed to obtain less and more physiological force that will not irritate the periodontal tissues. By preventing indirect resorption, more effective tooth movement is obtained.[4] This may also reduce the pain sensation. In SL brackets, the bracket cap has two main tasks. The first is to lock the archwire by creating a slight force and less friction, and the second is to create a low force that controls the rotation, tipping and torque forces.[5] With SL systems, control appointment intervals are longer and appointments can be arranged in 8-10-week periods. The aim is to give acquired time to periodontal tissues for healing. SL brackets have been proposed to shorten the chair time and overall treatment duration.[6]

The most significant advantage of SL brackets compared to conventional brackets is believed to be reduced friction resistance.[7] Particularly passive SL brackets have been claimed to produce less friction force than those with active design. Thus, less force is required during tooth movement.[8] If less forces are generated with SL brackets, then one may assume that the discomfort and pain levels may also be less than expected. The aim of this study was to compare the pain levels of patients treated with 2 different passive SL bracket systems right after initial archwire placement. The null hypothesis is that the pain levels of patients treated with 2 different passive SL bracket systems right after initial archwire placement are the same.

METHODS

This study was approved by the Başkent University Non-Invasive Clinical Research Ethics Committee (project no: D-KA 16/13, date: 10.08.2016) that the rights of the human or animal subjects were protected and supported by the Başkent University Research Fund. Power analysis (GPower 3.1.0, Universität Düsseldorf, Düsseldorf, Germany), was performed to determine the sample size, and it was found that at least 10 patients for each group were needed to verify an effect with 80% power (α=0.05). Therefore, a total of 34 patients were included in the study.

Thirty four patients who sought orthodontic treatment with fixed appliances were selected. The inclusion criteria for this study were as follows: (1) absence of any systemic disease and/or allergy of the patient, (2) permanent dentition with no dental pathology (3) class I malocclusion with mild or moderate crowding (4) Non-extracion orthodontic treatment need (5) 10 to 19 years of age.

Detailed medical and dental history of all patients were taken before the beginning of the treatment. All patients were informed about this study verbally and in writing. Thirty four patients -17 in each group- who met the criteria were included in the study after reviewing the files of patients who were ready to start the treatment. Gender differences were not considered when creating groups. Each participant who agreed to participate in the study was asked to draw randomly one of the bracket systems.

Damon Q (Ormco, CA, USA) (Group 1) and Smartclip SL3 (3M, MN, USA) SL3 (Group 2) passive SL bracket systems, both with 0.022 inch slots and have standard torque values for MBT prescriptions were selected. All permanent teeth between the 2nd molar to 2nd molar in the upper and lower jaws were bonded at the same session using the direct bonding technique. Archwires were selected according to the recommendations of the manufacturers. In Group 1, a 0.014 inch Cu NiTi and for Group 2, a 0.014 inch HANT archwires were used for initial levelling and alignment. Apart from the closure mechanism differences of the Damon Q and SmartClip SL3 brackets, the slot dimensions of both brackets were the same. The CONSORT diagram displaying the flow of our work was shown in Figure 1.

As soon as the brackets were placed, a 7-page booklet was given to the patients. Each page of this form contained 3 visual analogue scales (VAS) of 100 mm. Patients were asked to mark these forms by drawing a vertical line that was closest to their pain levels during chewing, biting on the anterior teeth, and

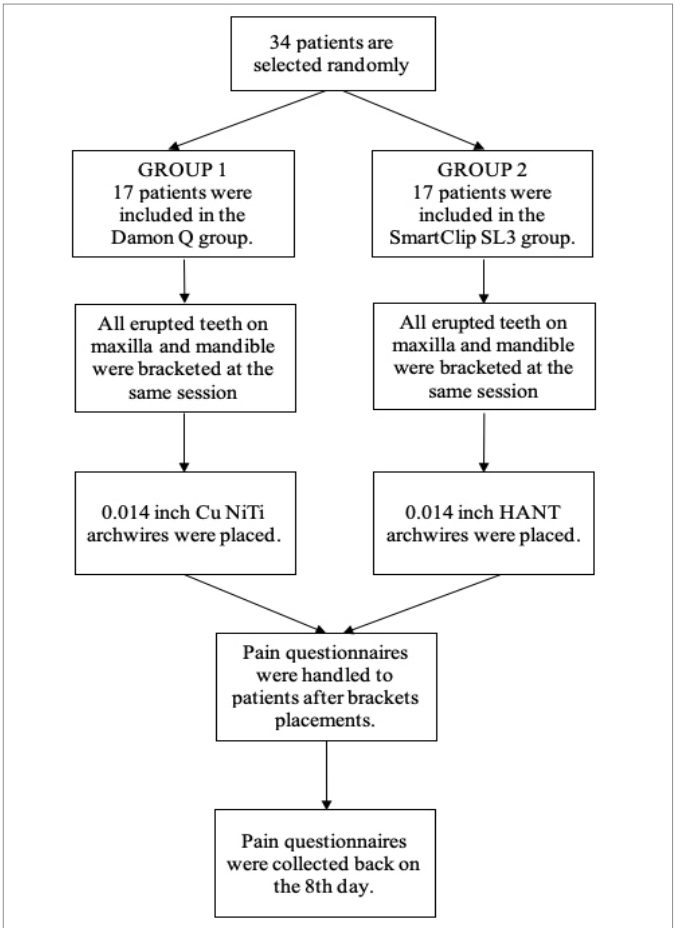

Figure 1. The CONSORT diagram shows the flow of the study

biting on the posterior teeth at 7 different time intervals. The evaluated time intervals were determined as the 2nd hour, the 6th h, the 2nd day, the 3rd day and the 7th day. Participants were asked to return their completed forms on the 8th day. The VAS scores collected from the patients were measured manually with a ruler and recorded by the same investigator. During the measurements, the names of the patients were covered to provide partial blinding.

Statistical Analysis

The data obtained in this study were analyzed with the IBM SPSS Statistics Version 20 (IBM Armonk,New York, USA) program. A Shapiro Wilk Test was used to determine the normal distribution of the variables. For pain intensity, non-parametric statistics (Mann-Whitney U test) were computed to determine any significance between the groups. To investigate repeated pain assessments, Friedman's two-way analysis of variance was calculated and the individual differences were estimated using Multiple Comparison Tests. Significant values were defined as $p<0.05$.

The VAS scores of 10 patients randomly selected for the determination of the reliability of the measurements were measured again after 2 weeks from the initial measurements. Correlation data of intraclass correlation coefficients for each variable was obtained, and it was seen that the lowest value was found to be 0.96.

RESULTS

The age distribution of Group 1 was 14.94±1.92; Group 2 was 13.65±1.66. The general age distribution was 14.29±1.88.

The perception of pain was assessed by three parameters: biting on the anterior teeth, biting on the posterior teeth, and chewing. The pain measurements that are reported according to these parameters at various time intervals are shown in Table 1.

In both groups, the pain started at the 2nd h and gradually increased, reaching the highest level in the parameters of chewing and biting on the anterior teeth on the 2nd day. The biting on the posterior teeth parameter reached the highest level at the 6th hour. According to all parameters, pain gradually decreased after 2nd day and reached the lowest values on 7th day (Table 1).

The results of the Mann-Whitney U test, that was used to assess differences between groups in terms of VAS values, are shown in Table 2.

There was a statistically significant difference between the groups in terms of the 2nd hour chewing parameter VAS values ($p<0.05$). The VAS values of Group 2 at the 2nd hour chewing and biting parameters were significantly lower than Group 1.

There was a statistically significant difference between the groups in terms of VAS values in the 6th h chewing parameter ($p<0.05$). The VAS value in the 6th h chewing parameter of Group 2 was significantly lower than that in Group 1.

There was no statistically significant difference between the groups in terms of other VAS values ($p>0.05$) (Table 2).

There was a statistically significant difference between the groups in terms of VAS values for chewing parameters in Group 1 ($p<0.05$).

In Group 1, the VAS value on the 7th day chewing parameter is significantly lower than VAS values of 6th hour and 2nd day chewing parameters and VAS value on the 3rd day chewing parameter is significantly lower than that of the VAS value on

Table 1. Distribution of VAS values

	n	Mean	Median	Min.	Max.	SD
2nd hour chewing	34	26.76	15.5	2	91	24.39
2nd hour biting on anterior teeth	34	23.93	12.5	1	92	26.25
2nd hour biting on posterior teeth	34	21.88	12.5	1	92	23.87
6th hour chewing	34	45.84	50	4.5	97	29.79
6th hour biting on anterior teeth	34	45.49	45.5	6.5	94	26.4
6th hour biting on posterior teeth	34	41.35	36.25	1.5	91	26.68
2nd day chewing	34	48.47	40.5	1	92	28.98
2nd day biting on anterior teeth	34	48.19	46.75	0.5	94.5	30.12
2nd day biting on posterior teeth	34	41.04	42.75	2	93	24.96
3rd day chewing	34	35.88	27.5	1	80.5	26.42
3rd day biting on anterior teeth	34	38.54	40	0.5	89	28.24
3rd day biting on posterior teeth	34	27.38	24.25	1	86	22.91
7th day chewing	34	15.13	9	2	70	16.52
7th day biting on anterior teeth	34	24.51	12	0	86	24.74
7th day biting on posterior teeth	34	12.38	6.25	1	60.5	14.65

Descriptive statistics of the overall VAS scores
VAS, visual analogue scale; SD, standard deviation; Min., minimum; Max., maximum

Table 2. Mann-Whitney U test regarding VAS score difference between groups

		Group						Mann-Whitney U test		
		n	Mean	Median	Min.	Max.	SD	Raw ave.	z	p value
	Group 1	17	36.62	29	5	91	28.15	21.47		
2nd hour chewing	Group 2	17	16.91	12.5	2	48	15.12	13.53	-2.32	0.02*
	Total	34	26.76	15.5	2	91	24.39			
	Group 1	17	24.26	15	1	92	25.87	17.79		
2nd hour biting on anterior teeth	Group 2	17	23.59	10	4	90.5	27.42	17.21	-0.17	0.86
	Total	34	23.93	12.5	1	92	26.25			
	Group 1	17	22.03	16	1	92	23.08	17.82		
2nd hour biting on posterior teeth	Group 2	17	21.74	11	2	90	25.34	17.18	-0.19	0.85
	Total	34	21.88	12.5	1	92	23.87			
	Group 1	17	61.82	64.5	9.5	97	25.68	22.97		
6th hour chewing	Group 2	17	29.86	19.5	4.5	79	25.06	12.03	-3.20	**0.001****
	Total	34	45.84	50	4.5	97	29.79			
	Group 1	17	49.38	46	6.5	94	23.92	18.88		
6th hour biting on anterior teeth	Group 2	17	41.59	45	7.5	91	28.86	16.12	-0.81	0.41
	Total	34	45.49	45.5	6.5	94	26.4			
	Group 1	17	48.88	46	1.5	90	24.6	20.82		
6th hour biting on posterior teeth	Group 2	17	33.82	24	4	91	27.26	14.18	-1.94	0.05
	Total	34	41.35	36.25	1.5	91	26.68			
	Group 1	17	46.59	40	12	92	25.54	17.32		
2nd day chewing	Group 2	17	50.35	50.5	1	91	32.75	17.68	-0.10	0.91
	Total	34	48.47	40.5	1	92	28.98			
	Group 1	17	50.5	60	1	92	25.18	18.26		
2nd day biting on anterior teeth	Group 2	17	45.88	45	0.5	94.5	35	16.74	-0.44	0.65
	Total	34	48.19	46.75	0.5	94.5	30.12			
	Group 1	17	42.21	47	2	71.5	21	18.47		
2nd day biting on posterior teeth	Group 2	17	39.88	35.5	2	93	29	16.53	-0.56	0.57
	Total	34	41.04	42.75	2	93	24.96			
	Group 1	17	34.24	26	2	80.5	25.71	16.76		
3rd day chewing	Group 2	17	37.53	34	1	79	27.79	18.24	-0.43	0.66
	Total	34	35.88	27.5	1	80.5	26.42			
	Group 1	17	36.76	40	0.5	80	24.31	16.88		
3rd day biting on anterior teeth	Group 2	17	40.32	33	1	89	32.36	18.12	-0.36	0.71
	Total	34	38.54	40	0.5	89	28.24			
	Group 1	17	26.56	25.5	1	86	24.89	16.59		
3rd day biting on posterior teeth	Group 2	17	28.21	23	1.5	69	21.48	18.41	-0.53	0.59
	Total	34	27.38	24.25	1	86	22.91			
	Group 1	17	18.09	9	2.5	70	20.23	18.65		
7th day chewing	Group 2	17	12.18	9	2	43	11.62	16.35	-0.67	0.50
	Total	34	15.13	9	2	70	16.52			
	Group 1	17	25.29	16	0	86	25.04	17.74		
7th day biting on anterior teeth	Group 2	17	23.74	11	2	74	25.17	17.26	-0.13	0.89
	Total	34	24.51	12	0	86	24.74			
	Group 1	17	14.09	6.5	1	60.5	17.43	18.18		
7th day biting on posterior teeth	Group 2	17	10.68	6	1	42	11.53	16.82	-0.39	0.69
	Total	34	12.38	6.25	1	60.5	14.65			

p<0.05 (*): Statistically significant, p<0.001 (**): Statistically significant. Mann-Whitney U test regarding VAS score difference between groups
VAS, visual analogue scale; SD, standard deviation; Min., minimum; Max., maximum

the 6th h chewing parameter. In Group 2, there was a statistically significant difference in time points between VAS values in chewing parameter ($p<0.05$). In Group 2, VAS values at 2nd hour and 2nd day chewing parameters were significantly lower than the VAS value at 2nd day chewing parameter (Table 3).

In Group 1, there was a statistically significant difference between the time points of VAS values for the biting on anterior teeth parameter ($p<0.05$). In Group 1, the VAS value of 2nd hour biting on anterior teeth parameters was significantly lower than that of the VAS value on the 6th hour and 2nd day biting on anterior teeth parameters and also the VAS value of 7th day biting on anterior teeth parameter was significantly lower than 2nd day biting on anterior teeth parameters. In Group 2, there was a statistically significant difference between the time points of VAS values in biting on anterior teeth parameter ($p<0.05$). In Group 2, VAS values at 7th h biting on anterior teeth parameters were significantly lower than the VAS value at 2nd day biting on anterior teeth parameter (Table 4).

In Group 1, there was a statistically significant difference between the time points of VAS values for the biting on anterior teeth parameter ($p<0.05$). In Group 1, the VAS value of 2nd hour and 7th day biting on posterior teeth parameters were significantly lower than that of the VAS values on the 6th hour and 2nd day biting on posterior teeth parameters. In Group 2, there is a statistically significant difference in time points between VAS values in biting on posterior teeth parameter ($p<0.05$). In Group 2, VAS values at 7th day biting on posterior teeth parameters were significantly lower than VAS values at 6th h, 2nd day, and 3rd day biting on posterior teeth parameters (Table 5).

DISCUSSION

Compared with conventional brackets, the most significant advantage of the SL brackets is assumed as the generation of low levels of friction.[9,10] Many *in vitro* studies have been carried out on the frictional resistance of SL brackets, and most of them showed that SL brackets in the laboratory environment generate less friction resistance than conventional brackets.[11,12] Therefore, it is argued that SL brackets may be more effective in lowering the pain sensation by producing less ischemia due to the low frictional force compared to conventional bracket systems.[13,14]

Two types of SL brackets were used in this study. These were selected according to the popularity of these systems. The first one was the Damon system, which consists of passive SL brackets. According to the claims of the manufacturer, the force generated by the special archwire used in the Damon bracket system is transmitted directly to the teeth and periodontium without being absorbed by the ligature due to the bracket cap structure. It has been suggested that this optimum force achieved with the tooth movement and the bone apposition, with the minimal interruption of blood flow during tooth movement shortens the patient's treatment duration and reduces pain complaints.[15] The second system was designated as SmartClip SL3. This bracket performs ligation with the help of C-shaped nickel titanium spring clips at the mesial and distal corners of the

Table 3. The Friedman's Two-Way ANOVA test on the difference between time points of VAS values for chewing parameter

								Friedman's Two-Way ANOVA			Multiple comparison
		n	Mean	Median	Min.	Max.	SD	Raw av.	Chi-square test	p value	
Group 1	2nd hour chewing	17	36.62	29	5	91	28.15	2.85	23.25	**0.001 (*)**	5-3 5-2 4-2
	6th hour chewing	17	61.82	64.5	9.5	97	25.68	4.21			
	2nd day chewing	17	46.59	40	12	92	25.54	3.62			
	3rd day chewing	17	34.24	26	2	80.5	25.71	2.38			
	7th day chewing	17	18.09	9	2.5	70	20.23	1.94			
Group 2	2nd hour chewing	17	16.91	12.5	2	48	15.12	2.26	23.77	**0.001 (*)**	5-3 1-3
	6th hour chewing	17	29.86	19.5	4.5	79	25.06	3.29			
	2nd day chewing	17	50.35	50.5	1	91	32.75	4.29			
	3rd day chewing	17	37.53	34	1	79	27.79	3.21			
	7th day chewing	17	12.18	9	2	43	11.62	1.94			

p<0.001 (*): Statistically significant. The Friedman's Two-Way ANOVA test on the difference between time points of VAS values for chewing parameter
VAS, visual analogue scale; SD, standard deviation; Min., minimum; Max., maximum

Table 4. Friedman's Two-Way ANOVA test on the difference between time points of VAS values for biting on the anterior teeth parameter

								Friedman's Two-Way ANOVA		Multiple comparison
		n	Mean	Median	Min.	Max.	SD	Raw av.	Chi-square test	p value	
Group 1	2nd hour biting on anterior teeth	17	24.26	15	1	92	25.87	2.18	19.67	**0.001 (**)**	1-2 1-3 5-3
	6th hour biting on anterior teeth	17	49.38	46	6.5	94	23.92	3.74			
	2nd day biting on anterior teeth	17	50.5	60	1	92	25.18	4			
	3rd day biting on anterior teeth	17	36.76	40	0.5	80	24.31	2.85			
	7th day biting on anterior teeth	17	25.29	16	0	86	25.04	2.24			
Group 2	2nd hour biting on anterior teeth	17	23.59	10	4	90,5	27.42	2.44	13.79	**0.008 (*)**	5-3
	6th hour biting on anterior teeth	17	41.59	45	7.5	91	28.86	3.53			
	2nd day biting on anterior teeth	17	45.88	45	0.5	94.5	35	3.85			
	3rd day biting on anterior teeth	17	40.32	33	1	89	32.36	3			
	7th day biting on anterior teeth	17	23.74	11	2	74	25.17	2.18			

p<0.01 (*): Statistically significant, p<0.001 (**): Statistically significant. Friedman's Two-Way ANOVA test on the difference between time points of VAS values for biting on the anterior teeth parameter
VAS, visual analogue scale; SD, standard deviation; Min., minimum; Max., maximum

Table 5. Friedman's Two-Way ANOVA test on the difference between time points of VAS values for biting on the posterior teeth parameter

								Friedman's Two-Way ANOVA		Multiple comparison
		n	Mean	Median	Min.	Max.	SD	Raw av.	Chi-square test	p value	
Group 1	2nd hour biting on posterior teeth	17	22.03	16	1	92	23.08	2.5	26.55	**0.001 (***)**	5-2 5-3 1-2 1-3
	6th hour biting on posterior teeth	17	48.88	46	1.5	90	24.6	4.03			
	2nd day biting on posterior teeth	17	42.21	47	2	71.5	21	4.03			
	3rd day biting on posterior teeth	17	26.56	25.5	1	86	24.89	2.56			
	7th day biting on posterior teeth	17	14.09	6.5	1	60.5	17.43	1.88			
Group 2	2nd hour biting on posterior teeth	17	21.74	11	2	90	25.34	2.88	20.50	**0.001 (***)**	5-4 5-2 5-3
	6th hour biting on posterior teeth	17	33.82	24	4	91	27.26	3.32			
	2nd day biting on posterior teeth	17	39.88	35.5	2	93	29	3.94			
	3rd day biting on posterior teeth	17	28.21	23	1.5	69	21.48	3.24			
	7th day biting on posterior teeth	17	10.68	6	1	42	11.53	1.62			

p<0.001: Statistically significant (***)
VAS, visual analogue scale; SD, standard deviation; Min., minimum; Max., maximum

bracket slot. SmartClip brackets offer both passive SL and active SL options when needed, with 4 distinct and easily accessible tie wings similar to conventional brackets. The archwires used in the current study were of the same dimension, but the material compositions were different due to the recommendations of the manufacturers.

One of the undesirable effects that can occur during fixed orthodontic treatment is pain. Pain, patient co-operation, the course of treatment, and the result can affect negatively. The sensation of pain is subjective, so it is impossible to precisely determine the duration, nature, or severity of the pain. Therefore, the patient's statement gives the most accurate information and is accepted as the gold standard.[2] Several methods have been developed for measuring pain severity. However, most of these methods are used in other medical fields rather than orthodontic studies due to various application difficulties. VAS are the most preferred for orthodontic studies. To evaluate the pain perception of the patients in our study, VAS of 100 mm lines were placed on each form which consisting of chewing, biting on the anterior teeth, and biting on the posterior teeth parameters for different time points. Patients were asked to mark their pain levels by drawing a vertical straight line on each scale for every parameter. The reason why we used VAS in our study was that it was a fast, simple and reliable method and it was easy to compare with the previous orthodontic pain studies.[16,17]

A through literature review showed that the pain reaches the highest level the day after the application of an active orthodontic force.[18,19] Erdinç and Dinçer[20] reported that the pain started to be perceived in the first 2 h, reached the highest level at the end of 24 h, continued for 3 days, and then gradually decreased. Polat and Karaman[21] reported that the orthodontic pain started at the first 2 h, reached the maximum value at 24 h, decreased afterwards, and reached very low levels at the end of the 7th day. Similar study by Scheurer et al.[22] Showed that very few patients continued to suffer from pain at the end of the 7th day.

Similar to the findings in the literature, our study found that the highest pain in chewing and biting on the anterior teeth was on the 2nd day. When biting on the posterior teeth, the pain reached the highest level at 6th hour, tended to decrease on the 3rd day and reached low levels on the 7th day. The pain felt in biting on the posterior teeth at all the time intervals evaluated in our study was felt lower by other movements and did not increase further after the first 6 h. The reason for this situation is; the force transmitted to the teeth may be too low, especially to create significant tooth movement in the posterior region since passive brackets are chosen in addition to being very thin and resilient.

The most important property of the nickel-titanium alloy (nitinol), which has a martensite stable structure and consists of 50% nickel and 50% titanium, shows low strength during the back spring.[23] Light and continuous force is applied due to its more flexible structure. The greatest advantage of nitinol is its good springiness and elasticity, which makes wide elastic deflections possible. When activated, it exhibits more springback properties than stainless steel and beta titanium wires and has higher energy. Thus, less arch-induced exchange or activation is required.[24] Sachdeva[25] claimed that the addition of copper element to nickel-titanium alloy creates more homogeneous force loads in the heat conduction, making more effective tooth movement possible. Cu NiTi wires are manufactured in three different types, at 27 °C, 35 °C and 40 °C, depending on the intended use of the orthodontic treatment. Damon claimed that using the sequence of 0.014 inches, 0.014x0.025 inches and 0.018x0.025 inches Cu NiTi at 35 °C, respectively, for more effective and rapid treatment would reduce the treatment time by 70% by applying slight forces at the bioone boundaries. Gravina et al.[26], on the other hand reported that, despite to Damon's claims, the loading forces of 35 °C Cu NiTi wires during deactivation and the percentage of deformation at the limit of neutrality were higher than 7 other types of NiTi archwires (superelastic or thermally shaped and NiTi or Cu NiTi) and they were less suitable for clinical use. They also reported that the thermoformed nitinol wires generated less deactivation force than the superelastic nitinol arch wires and that 27 °C Cu NiTi arch wires produced deactivation force of 1/3 of 35 °C Cu NiTi archwires.

In our study, pain levels for chewing parameter at 2nd hour and 6th h time points were lower in Group 2 than in Group 1. The highest pain in Group 1 was felt at 6th hour, and in Group 2, it was felt on 2nd day. According to this data, it can be said that the time to reach the highest pain level in Group 2 was shorter than Group 1. This situation is thought to be related to the structure of the archwires used. A number of research have been carried out which show that different archwire materials used in orthodontic treatment exhibit different friction characteristics.[26,27] In our study, the use of Cu NiTi archwires at 35 °C that generates more force than those of the HANT archwires could explain the significantly higher pain sensation in Group 1.

It can be considered that the surface roughness of the wire is also the effect of the applied force. Gravina et al.[26] studied 8 different archwires using SEM in terms of their chemical compositions and surface morphology. Because of the study, it was found that those with the lowest surface roughness were superelastic nitinol and those with the highest surface roughness were 27 °C and 35 °C Cu NiTi archwires. There are opinions in the literature that surface roughness increases the friction force.[28] In the same study, 35 °C Cu NiTi was found to have inadequate properties in terms of surface topography. This can be attributed to higher reported pain scores for the Damon brackets we obtained in our study.

Another reason for the highest pain level to be reached later in Group 2 may be the width difference between the Damon Q and SmartClip brackets. There are also studies in the literature that suggest that narrow brackets cause less friction between the wire and bracket, as well as those suggest that larger brackets cause less friction.[29] The bracket width has an important role in determining the interbracket distance. The interbracket distance increases as the width of the bracket-used decreases. Increasing

the wire length of brackets increases the elastic deformation capability of the archwire.[30] The SmartClip SL3 brackets used in our work were wider mesiodistally than Damon Q brackets. The difference in pain perception results obtained in our study may be due to the width differences in the brackets.

Data collected in our study that the pain perception was evaluated using two different bracket systems according to their cap designs should be supported by other studies in which the number of participants is kept higher to increase the reliability of our findings.

Study Limitations

The most important limitations of this study is that the differences that may occur between genders were not examined when evaluating the sensation of pain. Females are traditionally thought to be "fragile" and sensitive to pain, whereas males are more tough and can withstand greater pain. However, there have been conflicting findings, with some indicating that men are more willing to withstand pain than women, while others claim that there are no differences between men and women when it comes to describe how much pain they feel. During fixed appliance therapy, girls experienced more discomfort/pain and ulcerations than boys, according to two studies that addressed this topic.[31] A future study must be designed considering gender - based pain sensation differences during orthodontic treatment.

CONCLUSION

The highest pain sensation was reported for the 2nd day for the patients participating in the study, and decreased toward the 7th day.

The SmartClip SL3 group reported lower pain scores in the first two days, but the levels were equaled on the 2nd day and after. Therefore, the null hypothesis is accepted.

Ethics

Ethics Committee Approval: This study was approved by the Başkent University Non-Invasive Clinical Research Ethics Committee (project no: D-KA 16/13, date: 10.08.2016).

Informed Consent: All patients were informed about this study verbally and in writing.

Peer-review: Externally peer-reviewed.

Author Contributions: Concept - Ö.P.Ö.; Design - Ö.P.Ö.; Data Collection and/or Processing - M.D.; Analysis and/or Interpretation - M.D.; Writing - M.D., Ö.P.Ö.

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REFERENCES

1. Oliver RG, Knapman YM. Attitudes to orthodontic treatment. Br J Orthod. 1985;12(4):179-188. [CrossRef]
2. Carr DB, Goudas LC. Acute pain. Lancet. 1999;353(9169):2051-2058. [CrossRef]
3. Polat Ö. Pain and Discomfort After Orthodontic Appointments. Semin Orthod. 2007;13(4):292-300. [CrossRef]
4. Tselepis M, Brockhurst P, West VC. The dynamic frictional resistance between orthodontic brackets and arch wires. Am J Orthod Dentofacial Orthop. 1994;106(2):131-138. [CrossRef]
5. Berger JL. The influence of the SPEED bracket's self-ligating design on force levels in tooth movement: a comparative in vitro study. Am J Orthod Dentofacial Orthop. 1990;97(3):219-228. [CrossRef]
6. Voudouris JC, Suri S, Tompson B, Voudouris JD, Schismenos C, Poulos J. Self-ligation shortens chair time and compounds savings, with external bracket hygiene compared to conventional ligation: Systematic review with meta-analysis of randomized controlled trials. Dent Oral Craniofac Res. 2018;4. [CrossRef]
7. Bolender Y. Randomized Controlled Trials And Split- « The irrational orthodontist ». 2016;(March).
8. Li H, Stocker T, Bamidis Ep, et al. Effect of different media on frictional forces between tribological systems made from self-ligating brackets in combination with different stainless steel wire dimensions. Dent Mater J. 2021;40(5):1250-1256. [CrossRef]
9. Hamilton R, Goonewardene MS, Murray K. Comparison of active self-ligating brackets and conventional pre-adjusted brackets. Aust Orthod J. 2008;24(2):102-109.
10. Pizzoni L, Ravnholt G, Melsen B. Frictional forces related to self-ligating brackets. Eur J Orthod. 1998;20(3):283-291. [CrossRef]
11. Griffiths HS, Sherriff M, Ireland AJ. Resistance to sliding with 3 types of elastomeric modules. Am J Orthod Dentofacial Orthop. 2005;127(6):670-675; quiz 754. [CrossRef]
12. Budd S, Daskalogiannakis J, Tompson BD. A study of the frictional characteristics of four commercially available self-ligating bracket systems. Eur J Orthod. 2008;30(6):645-653. [CrossRef]
13. Pringle AM, Petrie A, Cunningham SJ, McKnight M. Prospective randomized clinical trial to compare pain levels associated with 2 orthodontic fixed bracket systems. Am J Orthod Dentofacial Orthop. 2009;136(2):160-167. [CrossRef]
14. 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(4):380-384. [CrossRef]
15. Siva S. The Value of Self-Ligating Brackets in Orthodontics: About the Damon Protocol. In: Kishore S, ed. IntechOpen; 2021:Ch.19. [CrossRef]
16. Bergius M, Berggren U, Kiliaridis S. Experience of pain during an orthodontic procedure. Eur J Oral Sci. 2002;110(2):92-98. [CrossRef]
17. Bradley RL, Ellis PE, Thomas P, Bellis H, Ireland AJ, Sandy JR. A randomized clinical trial comparing the efficacy of ibuprofen and paracetamol in the control of orthodontic pain. Am J Orthod Dentofacial Orthop. 2007;132(4):511-517. [CrossRef]
18. Jones ML. An investigation into the initial discomfort caused by placement of an archwire. Eur J Orthod. 1984;6(1):48-54. [CrossRef]
19. Giannopoulou C, Dudic A, Kiliaridis S. Pain discomfort and crevicular fluid changes induced by orthodontic elastic separators in children. J Pain. 2006;7(5):367-376. [CrossRef]
20. Erdinç AME, Dinçer B. Perception of pain during orthodontic treatment with fixed appliances. Eur J Orthod. 2004;26(1):79-85. [CrossRef]
21. Polat O, Karaman AI. Pain control during fixed orthodontic appliance therapy. Angle Orthod. 2005;75(2):214-219. [CrossRef]

22. Scheurer PA, Firestone AR, Bürgin WB. Perception of pain as a result of orthodontic treatment with fixed appliances. Eur J Orthod. 1996;18(4):349-357. [CrossRef]
23. Kusy RP. A review of contemporary archwires: their properties and characteristics. Angle Orthod. 1997;67(3):197-207. [CrossRef]
24. Maizeray R, Wagner D, Lefebvre F, Lévy-Bénichou H, Bolender Y. Is there any difference between conventional, passive and active self-ligating brackets? A systematic review and network meta-analysis. Int Orthod. 2021;19(4):523-538. [CrossRef]
25. Sachdeva R. Sure-Smile: technology-driven solution for orthodontics. Tex Dent J. 2002;119(7):608-615. [CrossRef]
26. Gravina MA, Canavarro C, Elias CN, das Graças Afonso Miranda Chaves M, Brunharo IHVP, Quintão CCA. Mechanical properties of NiTi and CuNiTi wires used in orthodontic treatment. Part 2: Microscopic surface appraisal and metallurgical characteristics. Dental Press J Orthod. 2014;19(1):69-76. [CrossRef]
27. Malik DES, Fida M, Afzal E, Irfan S. Comparison of anchorage loss between conventional and self-ligating brackets during canine retraction – A systematic review and meta-analysis. Int Orthod. 2020;18(1):41-53. [CrossRef]
28. Sfondrini MF, Gandini P, Castroflorio T, et al. Buccolingual Inclination Control of Upper Central Incisors of Aligners: A Comparison with Conventional and Self-Ligating Brackets. Falconi M, ed. Biomed Res Int. 2018;2018:9341821. [CrossRef]
29. Alsayegh E, Balut N, Ferguson DJ, et al. Maxillary Expansion: A Comparison of Damon Self-Ligating Bracket Therapy with MARPE and PAOO. Mehta S, ed. Biomed Res Int. 2022;2022:1974467. [CrossRef]
30. Thushar BK, Mathur AK, Diddige R, Verma S, Chitra P. Torque Comparison Between Two Passive Self-Ligating Brackets with Respect to Interbracket Wire Dimensions and Types: A Finite Element Analysis. Journal of Indian Orthodontic Society. 2021;56(2):164-170. [CrossRef]
31. Bergius M, Kiliaridis S, Berggren U. Pain in orthodontics. Journal of Orofacial Orthopedics / Fortschritte der Kieferorthopädie. 2000;61(2):125-137. [CrossRef]