

Clinical comparisons of different fixed orthodontic retainers

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ABSTRACT

Objective: The aim of this prospective clinical study was to compare the clinical outcomes of three different fixed lingual retainers, in terms of effects on periodontal health and success rate.

Methods: Forty five patients aged 13 to 25 years were randomly assigned into three groups, using bonded upper and lower lingual retainers. The study groups were as follows: Group 1- Bond-A-Braid®, Group 2- everStick® ORTHO, Group 3- Super-Splint. The follow-up appointments were performed two weeks (Baseline=T0), one month (T1), three months (T2), and six months (T3) after the application of retainers. Plaque Index (PI), Gingival Index (GI), Probing Depth (PD), Bleeding in Probing (BOP) and Retainer Failure were assessed at each appointment.

Results: The everStick Ortho group showed significantly lower PI values on the upper-lower lingual side after three ($p=0.008$) and six ($p=0.001$) months. The everStick Ortho group had significantly lower upper lingual (GI) levels after six months, and lower lingual side levels after one month. The Super-Splint group showed significantly lower PD values on the upper lingual side after six months. The everStick Ortho group presented significantly lower BOP levels after six months on the upper lingual side. No significant differences between the groups ($p>0.05$) in terms of retainer failure were found.

Conclusions: The everStick Ortho group presented better results in terms of periodontal health. The failure rates of the retainers were similar.

Keywords: Retention. Fixed retainer. Stability. Bonded retainer. Orthodontics.

RESUMO

Objetivo: O objetivo do presente estudo clínico prospectivo foi comparar a taxa de sucesso de três tipos de contenção lingual fixa e seus efeitos clínicos sobre a saúde periodontal. **Métodos:** Quarenta e cinco pacientes, com idades entre 13 e 25 anos, usando contenções fixas coladas nas arcadas superior e inferior foram agrupados, aleatoriamente, nos três seguintes grupos: Grupo 1 – Bond-A-Braid®; Grupo 2 – everStick® ORTHO; e Grupo 3 – Super-Splint. As consultas de acompanhamento foram feitas após duas semanas (inicial = T0), um mês (T1), três meses (T2) e seis meses (T3) da instalação das contenções. Em todas as consultas, foram avaliados o Índice de Placa (IP), Índice Gengival (IG), Profundidade de Sondagem (PS), Sangramento à sondagem (SAS) e Falha da Contenção. **Resultados:** O grupo everStick Ortho mostrou valores de IP significativamente menores nas faces linguais dos dentes superiores e inferiores após três ($p=0,008$) e seis ($p=0,001$) meses. O grupo everStick Ortho também apresentou níveis significativamente menores de IG na face lingual dos dentes superiores após seis meses, e face lingual dos dentes inferiores após um mês. O grupo Super-Splint mostrou valores significativamente menores de PS na face lingual dos dentes superiores após seis meses. O grupo everStick Ortho apresentou níveis significativamente menores de SAS na face lingual dos dentes superiores após seis meses. Quanto à falha na contenção, não houve diferença significativa ($p>0,05$) entre os grupos. **Conclusões:** O grupo everStick Ortho apresentou os melhores resultados em termos de saúde periodontal. As taxas de falha das contenções foram semelhantes.

Palavras-chave: Contenção. Contenção fixa. Estabilidade. Contenção colada. Ortodontia.

INTRODUCTION

After fixed orthodontic treatment is completed, there is a tendency for the teeth to move back to the pre-orthodontic position.¹ Preventing relapse to maintain stable occlusion is the main goal of the retention procedure, and may be the most difficult part of the orthodontic treatment.² Fixed or removable retention procedures are options to maintain treatment results.³ Relapse has an individually unpredictable pattern⁴, and approximately 70% of patients may have alignment problems in long term after the end of orthodontic treatment.⁵ For this reason, stable solution was recommended as lifetime permanent retention.⁴ Normal age changes, occlusal relationships, periodontal-gingival factors, tongue and lip pressures or exceeding dental movement limitation may cause orthodontic relapse.⁵

Fixed, removable or dual retention procedures can be applied for retention treatment, but none of them have been recognized as the best type of retention regimen.^{4,6}

A limited number of reports have evaluated the clinical efficiency of fixed and/or removable retainers.^{3,7,8} The choice of retention type is mostly related to the pretreatment situation, followed by interdigitation after orthodontic treatment, oral hygiene, treatment result, health of periodontal tissue, patient motivation, and patient age.⁹

Fixed orthodontic retainers have been shown to be very effective especially in preventing relapse of anterior teeth,¹⁰ and have a very popular use in clinical orthodontics.¹¹ After the introduction of fiber materials into dentistry in 1970s, the fiber orthodontic retainers also took their place in the market.^{11,12}

Fixed retainers have some clinical undesirable aspects, such as increasing calculus accumulation, limiting physiological tooth movement, high failure rate, and increase chairside time, due to their technique-sensitive application.¹³⁻¹⁶ Fiber retainers have a high failure rate, higher limitation of tooth movement, and the repair procedure is more difficult and also more expensive than that of metallic retainers.^{14,15,17} On the other hand, fiber retainers have good engineering properties, are easily manipulated with the help of their high stiffness-weights, and they have a superiority in esthetics.^{11,18-20}

Thus, the present research was performed because there is a lack of clinical studies on the periodontal effects and failure rates of fiber retainers in the literature.^{16,21} Bond-A-Braid[®], (Reliance Orthodontic, Illinois, USA) is an 8-stranded braided stainless steel retainer wire, everStick[®] ORTHO (StickTech Ltd Oy, Turku, Finland) is produced by embedding silanized glass fibers in composite material, and Super-Splint (Hager Werken, Duisburg, Germany) is a multilayer (six layers) silanized fiber glass ribbon. The glass fibers of Super-Splint are designed in

a leno-weave and multidirectional manner that increases the strength of the material. Metallic retainers and fiber retainers have been compared in previous studies, but the superiority of the materials to each other has varied. This result was explained by the fact that different fiber materials have different biomechanical properties.²² Therefore, in the present study, two different kinds of fiber retainers were compared with a flat metallic retainer wire. The aim of this study was to compare the clinical outcomes of three different types of fixed lingual retainers, and to find out which one was the best option in terms of periodontal effects and success rate.

The null hypotheses of this study were: 1) no clinical difference in periodontal status and 2) no failure rates difference would be present between the two types of fiber and one type of metallic fixed orthodontic retainers.

MATERIAL AND METHODS

Forty-five patients (12 males, 33 females) aged 13 to 25 years, who had completed the orthodontic treatment in Istanbul Medipol University, Faculty of Dentistry, Department of Orthodontics were included in this prospective study. All patients were treated by the same researcher, with the same kind of fixed orthodontic appliances (0.018-in Gemini Series brackets; 3M Unitek, Monrovia, California, USA). The Human Ethic Committee of Istanbul Medipol University approved the

study, with the approval number 10840098-604.01.01-E.3635. Patients with full permanent dentition, sound lingual enamel surfaces and good oral hygiene were included in the study. Exclusion criteria were: history of maxillary expansion treatment, pregnancy, smoking, teeth absence, systemic disorders, caries or restorations in the six anterior teeth, medication use, diabetes mellitus, periodontal disease, short clinical crown and bruxism. Patients who did not have visible dental plaque accumulation and did not have inflammation in their gingiva, according to clinical examination, were included in the study.

An informed consent was obtained from all patients or their parents. Sample size estimation was performed using Gingival Index parameter before the study, and 11 patients were found as sufficient to have the power over 80%, with a 95% confidence interval (CI) and an α of 0.05, to find a meaningful difference of 0.8 (standard deviation) between the groups. The dropout rate was considered to be around 50%, and therefore the number was increased to 15 patients for each group.

Patients were randomly assigned to each group by another orthodontist, using a table of random numbers. Full blinding was not possible because of the nature of the study. Dropouts were considered: patients who missed the control appointments were excluded from the study. The following three study groups were created: Group 1– Bond-A-Braid® (Reliance Orthodontic,

Illinois, USA), using 8-stranded stainless steel 0.027 x 0.011-in wire; Group 2– everStick® ORTHO (StickTech Ltd Oy, Turku, Finland), a flexible and sticky fiber-reinforced composite material, with a dimension of approximately 0.24-in; Group 3– Super-Splint (Hager Werken, Duisburg, Germany), a multilayer (six layers) silanized fiber glass ribbon with 4-mm dimension.

After all brackets were debonded, full scaling and then polishing was performed with a fluoride-free pumice (Detartrine, Septodont GmbH, Niederkassel Germany), including lingual surfaces of the upper and lower six anterior teeth.

The lingual surfaces of each teeth were etched with 37% orthophosphoric acid (Etch-Royale™, Pulpdent, Watertown, USA) for 60 seconds, rinsed for 15 seconds and air-drying was performed for 15 seconds. Teeth were then primed with Transbond™ XT primer (3M Unitek, Monrovia, Calif, USA) and the application of retainers was performed with spot-bonding technique using orthodontic adhesive (Transbond™ XT, Light Cure Adhesive, 3M Unitek, Calif, USA). After that, 10 seconds light-curing was performed using 3M™ Espe Elipar™ Led Curing Light (3M ESPE, Seefeld, Germany). Before the application of the retainers, each material was cut according to the measurement of the upper and lower inter-canine widths. The width of the Super-Splint material was diminished by cutting, being decreased to 2 mm, to avoid full coverage of

the lingual surfaces of the teeth and also to equalize to the active dimensions of everStick Ortho during the adaptation period. Passive seating of the retainers was achieved by using dental floss in Group 1, and egg burnisher in Groups 2 and 3. Intra-oral pictures of the retainers are presented in Figure 1. Each patient was instructed at each appointment, not to bite into hard food directly with their anterior teeth.



Figure 1: Intraoral pictures of the upper and lower retainers. A1, B1) Bond-A-Braid. A2, B2) everStick Ortho. A3, B3) Super-Splint.

FOLLOW-UP PROCEDURE AND MEASUREMENTS

The follow-up appointments were performed at two weeks (Baseline=T0), one month (T1), three months (T2), and six months (T3) after the application of the retainers. Since temporary gingivitis can be seen in the debonding procedure, the same oral hygiene instructions were given to each patient after the retainer application, and it was planned to wait two weeks for periodontal measurements to be performed.

The periodontal evaluation (Plaque Index, Gingival Index, Probing Depth, Bleeding in Probing), and retainer failure evaluation (fully debonding or breakage) were performed in each appointment.

Patients with fully debonded retainers were excluded from the study, but detachments of the retainer at one or two teeth were repaired. Complete debonding of the retainer was admitted as retainer failure. A retainer with 1 or 2 teeth detachments was considered as broken and was thus repaired.

A) PERIODONTAL EVALUATION

Periodontal evaluation was carried out by a periodontist with 20 years of experience, and the following measurements were performed.

1. Plaque Index (PI) was measured at mesial, distal, buccal and lingual surfaces of the upper and lower six anterior

teeth, using Williams periodontal probe, according to Löe.²³ The scale classifies the plaque as follows: 0= no plaque, 1= visible plaque after probing gingival margin, 2= Presence of visible plaque, 3= Heavy accumulation of plaque, including tooth surface and gingival margin.

2. Gingival Index (GI) was assessed at mesial, distal, buccal and lingual surfaces of the upper and lower six anterior teeth, according to Löe.²³ The scale scores are as follows; 0= no inflammation, 1= mild inflammation, minimal changes in color, absence of bleeding on probing 2= moderate inflammation, moderate glazing, redness, edema and hypertrophy, presence of bleeding on probing 3= Severe inflammation, marked redness, presence of hypertrophy and spontaneous bleeding, ulceration.
3. Probing Depth (PD) was measured at mesial, distal, buccal and lingual surfaces of the upper and lower six anterior teeth, by using periodontal probe. Probing was performed on six surfaces of each teeth (buccal, lingual, mesiobuccal, mesiodistal, distobuccal, distolingual), and the average value of them was recorded in millimeters for buccal and lingual values.²⁴
4. Bleeding on Probing (BOP) was evaluated with a Florida probe, approximately 25 gr/force was applied to the mesial distal, buccal and lingual probings of each teeth.^{16,25} The bleeding was recorded as: 0= no bleeding, 1= bleeding on probing.

B) RETAINER FAILURE

Retainer Failure was assessed and recorded by a 10-year-experienced orthodontist.

STATISTICAL ANALYSIS

Statistical analysis was performed by using the Statistical Package for Social Sciences (IBM SPSS, version 22.0, IBM Co., Armonk, NY, USA). The normality of the data was tested using Shapiro-Wilk test. Descriptive statistics were presented in mean, standard deviation and frequency. Non-normally distributed data were evaluated with Kruskal-Wallis test for inter-group comparisons, and multiple comparisons were assessed using Dunn's test. Friedman and Wilcoxon signed-rank tests were used for intragroup comparisons. The survival analysis was performed with Kaplan-Meier analysis and Log-Rank test. The level of significance was set at $p < 0.05$.

RESULTS

The demographic data were not statistically significant between the groups ($p > 0.05$) (Table 1). Three patients per day, one patient from each group, were evaluated from the application to the last control.

Table 1: Age and gender comparisons of the groups.

	BOND-A-BRAID		EVERSTICK ORTHO		SUPER-SPLINT		p-value
Gender	n	%	n	%	n	%	0.316
Female	13	86.7	11	73.3	11	73.3	
Male	2	13.3	4	26.7	4	26.7	
Age (years)	Min-Max	Mean±SD	Min-Max	Mean±SD	Min-Max	Mean±SD	0.701
	13.00-23.4	17.81±3.62	13.08-23.0	18.11±2.37	14.50-25.5	18.76±3.27	

The intra-group and inter-group comparisons of plaque index (PI) levels are shown in Table 2. The upper buccal PI levels were the lowest in everStick group in all of the time intervals ($p < 0.05$). Intra-group test showed a significant decrease between baseline and the third month in upper buccal values of everStick group ($p = 0.040$). Multiple comparisons revealed the same results ($p = 0.041, p = 0.02; p = 0.020, p = 0.001$). Lower buccal PI levels were significantly lower in everStick group in third ($p = 0.034$) and sixth months ($p = 0.003$). Inter-group comparisons showed a significantly lower value in everStick Ortho group in sixth month ($p = 0.023, p = 0.04$). The everStick Ortho group showed lower PI values for the upper lingual side at the sixth month ($p = 0.09, p = 0.03$).

Table 2: Plaque index (PI) comparisons of the groups.

Plaque index	BOND-A-BRAID		EVERSTICK ORTHO		SUPER-SPLINT		p ¹	Dunn's multiple comparisons test		
	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)		BOND A BRAID/ EVERSTICK ORTHO	BOND A BRAID/ SUPER-SPLINT	EVERSTICK ORTHO/ SUPER-SPLINT
Baseline	0-2.5	0.62±0.69 (0.3)	0-1.22	0.22±0.41 (0)	0.11-1.94	0.72±0.55 (0.5)	0.002*	0.041*	1	0.002*
First (1st) month	0-2	0.51±0.62 (0.2)	0-0.89	0.17±0.3 (0)	0.11-1.78	0.66±0.51 (0.7)	0.002*	0.068	0.787	0.002*
Third (3rd) month	0-1.39	0.48±0.47 (0.2)	0-1	0.14±0.31 (0)	0.11-1.72	0.62±0.42 (0.6)	0.001*	0.020*	0.893	0.001*
Sixth (6th) month	0-2.11	0.5±0.61 (0.2)	0-0.89	0.15±0.29 (0)	0.17-1.5	0.56±0.39 (0.5)	0.001*	0.056	0.56	0.001*
Upper buccal		p ²		0.031*		0.170				
		Baseline-1st month p ³		0.176		-				
		Baseline-3rd month p ³		0.040*		-				
		Baseline-6th month p ³		0.123		-				
		1st month-3rd month p ³		0.206		-				
		1st month -6th month p ³		0.343		-				
		3rd month-6th month p ³		0.461		-				

¹Kruskal-Wallis test. ²Friedman test. ³Wilcoxon signed-rank test. * $p < 0.05$. Dunn's test. * $p < 0.05$.

Table 2: (continuation) Plaque index (PI) comparisons of the groups.

Plaque index	BOND-A-BRAID		EVERSTICK ORTHO		SUPER-SPLINT		p ¹	Dunn's multiple comparisons test			
	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)		BOND A BRAID/ EVERSTICK ORTHO	BOND A BRAID/ SUPER-SPLINT	EVERSTICK ORTHO/ SUPER-SPLINT	
Upper lingual	Baseline	0-2.5	0.86±0.68 (0.8)	0-1.5	0.44±0.49 (0.3)	0-2	0.78±0.62 (0.7)	0.129	-	-	-
	1st month	0-2	0.77±0.55 (0.8)	0-1	0.42±0.39 (0.3)	0-1.67	0.76±0.5 (1)	0.076	-	-	-
	3rd month	0-1.5	0.64±0.51 (0.5)	0-1	0.24±0.32 (0.2)	0-2	0.78±0.52 (1)	0.008*	0.064	1	0.009*
	6th month	0-2	0.67±0.48 (0.7)	0-1.33	0.22±0.37 (0)	0-2	0.72±0.49 (0.8)	0.001*	0.009*	1	0.003*
	p ²		0.422		0.134		0.909				
Lower buccal	Baseline	0-2.5	0.86±0.77 (0.7)	0-2.17	0.64±0.7 (0.3)	0.11-2.11	1.18±0.6 (1.2)	0.073	-	-	-
	1st month	0-2	0.77±0.65 (0.8)	0-1.67	0.41±0.51 (0.2)	0-2	0.86±0.69 (0.7)	0.084	-	-	-
	3rd month	0-1.55	0.52±0.53 (0.2)	0-1.72	0.36±0.54 (0.1)	0-2	0.84±0.59 (0.8)	0.034*	0.847	0.389	0.029*
	6th month	0-2.38	0.75±0.75 (0.5)	0-1	0.24±0.39 (0)	0-2	0.83±0.56 (1)	0.003*	0.023*	1	0.004*
	p ²		0.549		0.006*		0.041*				
	Baseline-1st month p ³		-		0.198		0.043*				
	Baseline-3rd month p ³		-		0.059		0.014*				
	Baseline-6th month p ³		-		0.003*		0.014*				
	1st month-3rd month p ³		-		0.476		0.861				
	1st month-6th month p ³		-		0.016*		0.889				
	3rd month-6th month p ³		-		0.075		0.637				
Lower lingual	Baseline	0-2	0.97±0.62 (1)	0-3.17	0.94±0.88 (0.8)	0-2.5	1.01±0.86 (1)	0.931	-	-	-
	1st month	0-2.33	0.75±0.73 (1)	0-2	0.81±0.71 (1)	0-2	1.11±0.62 (1)	0.434	-	-	-
	3rd month	0-2	0.81±0.55 (1)	0-2	0.49±0.6 (0.2)	0-2	1.13±0.7 (1)	0.027*	0.387	0.743	0.022*
	6th month	0-3	1.06±0.8 (1)	0-1.33	0.47±0.51 (0.2)	0.17-2	1.06±0.65 (1)	0.017*	0.052	1	0.034*
	p ²		0.247		0.175		0.777				

¹Kruskal-Wallis test. ²Friedman test. ³Wilcoxon signed-rank test. *p<0.05. Dunn's test. *p<0.05.

While the PI values of the lower lingual side showed no significant differences in the intra-group comparisons, significant differences were found between the multiple comparisons of the groups at the third ($p = 0.027$) and sixth months ($p = 0.017$). The result is associated with higher PI values of Super Splint group ($p = 0.022$, $p = 0.034$).

Significant decreases were found between baseline and sixth month ($p = 0.003$) and between the first month and sixth month ($p = 0.016$) in everStick group. In the Super-Splint group, a decrease in lower buccal PI levels was observed at first, third and sixth months ($p < 0.05$). The upper buccal gingival index (GI) levels were significantly lower in everStick group, compared to the other groups, at third and sixth months ($p = 0.030$, $p = 0.022$; $p = 0.027$, $p = 0.018$), and the same result was valid for the upper lingual side at the sixth month ($p = 0.08$). The Super-Splint group showed a significantly higher value on the lower lingual side in the first month ($p = 0.041$, $p = 0.019$). The intra-group, inter-group and multiple group comparisons of GI are shown in Table 3. A significant decrease was seen in everStick group in lower buccal measurements from baseline to first and baseline to sixth month ($p = 0.004$). Intra-group comparisons detected significant changes in terms of upper lingual GI levels ($p = 0.008$, $p = 0.020$, $p = 0.012$) in the Super-Splint group from the baseline to first, baseline to third and baseline to sixth months.

Table 3: Gingival index (GI) comparisons of the groups.

Gingival index	BOND-A-BRAID		EVERSTICK ORTHO		SUPER-SPLINT		p ¹	Dunn's multiple comparisons test			
	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)		BOND A BRAID/ EVERSTICK ORTHO	BOND A BRAID/ SUPER-SPLINT	EVERSTICK ORTHO/ SUPER-SPLINT	
Upper buccal	Baseline	0-2	0.93±0.46 (1)	0-1.78	0.87±0.53 (1)	0.44-1.56	1.04±0.31 (1)	0.658	-	-	-
	1st month	0-2	0.98±0.47 (1)	0-1.67	0.71±0.48 (0.7)	0.44-1.5	1.03±0.27 (1)	0.096	-	-	-
	3rd month	0.17-2	1±0.4 (1)	0-1.22	0.7±0.4 (0.9)	0.33-1.44	1.02±0.25 (1)	0.036*	0.030*	1	0.022*
	6th month	0.22-2	1.04±0.41 (1)	0-1.17	0.71±0.41 (1)	0.5-1.44	1.04±0.2 (1)	0.030*	0.027*	1	0.018*
	p ²		0.671		0.121		0.904				
Upper lingual	Baseline	0-1.83	0.94±0.47 (1)	0-1.83	0.71±0.6 (1)	0-1	0.62±0.42 (0.8)	0.253	-	-	-
	1st month	0-2	0.89±0.44 (1)	0-1.5	0.74±0.41 (0.7)	0.17-1.33	0.97±0.25 (1)	0.278	-	-	-
	3rd month	0.33-2	0.99±0.34 (1)	0-1.5	0.73±0.44 (1)	0.17-1	0.93±0.22 (1)	0.242	-	-	-
	6th month	0.5-2	1.08±0.34 (1)	0-1	0.76±0.35 (1)	0.33-1	0.96±0.17 (1)	0.010*	0.008*	0.818	0.173
	p ²		0.100		0.425		0.002*				
	Baseline-1st month p ³		-		-		0.008*				
	Baseline-3rd month p ³		-		-		0.020*				
	Baseline-6th month p ³		-		-		0.012*				
	1st month-3rd month p ³		-		-		0.397				
	1st month-6th month p ³		-		-		0.497				
	3rd month-6th month p ³		-		-		0.180				

¹Kruskal-Wallis test. ²Friedman test. ³Wilcoxon signed-rank test. *p<0.05. Dunn-s test. *p<0.05.

Table 3: (continuation) Gingival index (GI) comparisons of the groups.

Gingival index	BOND-A-BRAID		EVERSTICK ORTHO		SUPER-SPLINT		p ¹	Dunn's multiple comparisons test			
	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)		BOND A BRAID/ EVERSTICK ORTHO	BOND A BRAID/ SUPER-SPLINT	EVERSTICK ORTHO/ SUPER-SPLINT	
Lower buccal	Baseline	0-2	1.04±0.55 (1.1)	0-1.83	1.14±0.51 (1.2)	0.44-1.78	1.13±0.43 (1.2)	0.761	-	-	-
	1st month	0-2	1.02±0.52 (1)	0-1.67	0.76±0.44 (0.6)	0.28-1.67	1.05±0.36 (1)	0.189	-	-	-
	3rd month	0.5-2	1.03±0.35 (1)	0-1.61	0.87±0.38 (1)	0.56-1.56	1.01±0.22 (1)	0.421	-	-	-
	6th month	0.33-2	0.99±0.5 (1)	0-1.06	0.76±0.35 (1)	0.5-1.22	0.99±0.19 (1)	0.208	-	-	-
	p ²		0.889		0.004*		0.603				
	Baseline-1st month p ³		-		0.008*		-				
	Baseline-3rd month p ³		-		0.064		-				
	Baseline-6th month p ³		-		0.015*		-				
	1st month-3rd month p ³		-		0.373		-				
	1st month-6th month p ³		-		0.789		-				
3rd month-6th month p ³		-		0.293		-					
Lower lingual	Baseline	0-2	1.02±0.46 (1)	0-2	1.09±0.51 (1)	0.17-1.5	0.96±0.35 (1)	0.540	-	-	-
	1st month	0-2	0.89±0.44 (1)	0-1.5	0.84±0.4 (1)	01/01/1967	1.1±0.22 (1)	0.039*	1	0.041*	0.019*
	3rd month	0.33-2	1.03±0.35 (1)	0-1.5	0.86±0.36 (1)	01/01/2017	1.02±0.06 (1)	0.133	-	-	-
	6th month	0.67-2	1.14±0.41 (1)	0-1	0.86±0.3 (1)	01/01/1933	1.02±0.09 (1)	0.113	-	-	-
	p ²		0.080		0.092		0.324				

¹Kruskal-Wallis test. ²Friedman test. ³Wilcoxon signed-rank test. *p<0.05. Dunn's test. *p<0.05.

Probing depth (PD) comparisons are presented in Table 4. In the Super-Splint group at 6th month, significantly lower PD values were recorded on the upper lingual side in both intra-group and multiple comparisons. Intra-group comparisons showed a significant decrease in upper buccal side levels at all time intervals in the everStick group ($p=0.001$), and also made significance in Super-Splint group in upper and lower buccal sides ($p < 0.05$).

Table 4: Probing Depth (PD) comparisons of the groups.

Probing Depth	BOND A BRAID		EVERSTICK ORTHO		SUPER-SPLINT		p ¹	Dunn's multiple comparisons test			
	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)		BOND A BRAID/ EVERSTICK ORTHO	BOND A BRAID/ HAGER WERKEN	EVERSTICK ORTHO/ HAGER WERKEN	
Upper buccal	Baseline	0.61-2.5	1.61±0.64 (1.6)	1-2.17	1.73±0.38 (1.9)	1.11-2.22	1.68±0.33 (1.7)	0.861	-	-	-
	1st month	0.83-2.11	1.46±0.46 (1.3)	1-2	1.54±0.36 (1.6)	0.72-2	1.49±0.34 (1.4)	0.871	-	-	-
	3rd month	1-2.06	1.51±0.4 (1.4)	1-1.83	1.45±0.33 (1.5)	1-2	1.54±0.31 (1.5)	0.798	-	-	-
	6th month	0.89-2	1.39±0.32 (1.4)	1-1.67	1.38±0.25 (1.3)	1-2	1.43±0.29 (1.4)	0.800	-	-	-
	p ²		0.350		0.001*		0.002*				
	Baseline-1st month p ³		-		0.012*		0.026*				
	Baseline-3rd month p ³		-		0.001*		0.008*				
	Baseline-6th month p ³		-		0.003*		0.001*				
	1st month-3rd month p ³		-		0.040*		0.401				
	1st month-6th month p ³		-		0.028*		0.111				
3rd month-6th month p ³		-		0.161		0.088					

Dunn's test. * $p < 0.05$. ¹Kruskal Wallis Test. ²Friedman Test. ³Wilcoxon Sign Test. * $p < 0.05$.

Table 4: (continuation) Probing Depth (PD) comparisons of the groups.

Probing Depth	BOND A BRAID		EVERSTICK ORTHO		SUPER-SPLINT		p ¹	Dunn's multiple comparisons test			
	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)		BOND A BRAID/ EVERSTICK ORTHO	BOND A BRAID/ HAGER WERKEN	EVERSTICK ORTHO/ HAGER WERKEN	
Upper lingual	Baseline	0.72-2.67	1.29±0.51 (1.2)	0.17-2.33	1.4±0.59 (1.2)	0.5-1.67	1.01±0.31 (1)	0.062	-	-	-
	1st month	1-2	1.2±0.35 (1)	1-2	1.32±0.34 (1.2)	1-1.5	1.12±0.16 (1)	0.297	-	-	-
	3rd month	0.78-2	1.24±0.37 (1)	1-2	1.23±0.3 (1)	0.83-1.33	1.03±0.14 (1)	0.071	-	-	-
	6th month	0.83-1.83	1.08±0.24 (1)	1-2	1.29±0.33 (1.2)	0.78-1.33	1±0.11 (1)	0.004*	0.108	0.756	0.004*
	p		0.059		0.197		0.061				
Lower buccal	Baseline	0.78-2.89	1.66±0.63 (1.7)	1-2.22	1.66±0.32 (1.7)	1.06-2.33	1.73±0.33 (1.8)	0.871	-	-	-
	1st month	0.72-2.44	1.46±0.53 (1.3)	0.89-2.22	1.48±0.38 (1.5)	0.78-2	1.35±0.32 (1.3)	0.720	-	-	-
	3rd month	0.83-2.38	1.44±0.45 (1.4)	1-2	1.5±0.35 (1.4)	1-1.83	1.39±0.26 (1.4)	0.678	-	-	-
	6th month	0.78-2.38	1.44±0.49 (1.3)	1-2	1.5±0.39 (1.4)	1-2	1.42±0.32 (1.4)	0.824	-	-	-
	p ²		0.327		0.237		0.000*				
	Baseline-1st month p ³		-		-		0.004*				
	Baseline-3rd month p ³		-		-		0.001*				
	Baseline-6th month p ³		-		-		0.006*				
	1st month-3rd month p ³		-		-		0.506				
	1st month-6th month p ³		-		-		0.308				
	3rd month-6th month p ³		-		-		0.530				
Lower lingual	Baseline	0.89-7	1.57±1.54 (1.2)	1-2	1.23±0.29 (1.2)	0.17-2	1.01±0.45 (1)	0.139	-	-	-
	1st month	1-2.33	1.25±0.46 (1)	0.06-1.67	1.11±0.38 (1)	0.83-2	1.1±0.27 (1)	0.651	-	-	-
	3rd month	1-2	1.17±0.28 (1)	1-1.67	1.23±0.27 (1.2)	1-1.67	1.12±0.2 (1)	0.408	-	-	-
	6th month	1-1.67	1.12±0.2 (1)	1-2	1.26±0.37 (1.2)	1-1.5	1.08±0.15 (1)	0.215	-	-	-
	p ²		0.516		0.839		0.823				

Dunn's test. *p<0.05. ¹Kruskal-Wallis test. ²Friedman test. ³Wilcoxon Signed-rank test. *p<0.05.

Comparisons of bleeding on probing (BOP) are shown in Table 5. The everStick and Bond-A-Braid groups presented significantly lower BOP values in upper buccal side than the Super-Splint group at baseline and third month, and showed the lowest value for the sixth month. The levels of upper lingual BOP in the sixth month and lower buccal BOP at all time of the everStick group showed to be significantly lower than the Super-Splint group ($p = 0.019$). Although a significant decrease was found in Super-Splint group ($p = 0.004$) in terms of lower buccal BOP levels from baseline to third month, baseline to sixth month, and first to sixth month, the lowest values were verified for

Table 5: Bleeding on probing (BOP).

BOP	BOND A BRAID		EVERSTICK ORTHO		SUPER-SPLINT		p ¹	Dunn's multiple comparisons test			
	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)		BOND A BRAID/ EVERSTICK ORTHO	BOND A BRAID/ HAGER WERKEN	EVERSTICK ORTHO/ HAGER WERKEN	
Upper buccal	Baseline	0-0.56	0.23±0.18 (0.2)	0-0.61	0.15±0.18 (0.1)	0-0.67	0.32±0.2 (0.3)	0.023*	0.371	0.686	0.018*
	1st month	0-0.89	0.24±0.24 (0.2)	0-0.56	0.2±0.16 (0.2)	0-0.5	0.23±0.17 (0.2)	0.890	-	-	-
	3rd month	0-5	0.19±0.15 (0.2)	0-0.22	0.08±0.08 (0.1)	0.06-0.56	0.26±0.16 (0.2)	0.002*	0.021	0.711	0.001*
	6th month	0-1	0.26±0.26 (0.2)	0-0.5	0.11±0.15 (0.1)	0.11-0.61	0.25±0.13 (0.2)	0.003*	0.027*	0.755	0.001*
	p ²		0.897		0.018*		0.560				
	Baseline-1st month p ³		-		0.098		-				
	Baseline-3rd month p ³		-		0.206		-				
	Baseline-6th month p ³		-		0.069		-				
	1st month-3rd month p ³		-		0.012*		-				
	1st month-6th month p ³		-		0.012*		-				
3rd month-6th month p ³		-		0.754		-					

Dunn's test. * $p < 0.05$. ¹Kruskal-Wallis test. ²Friedman test. ³Wilcoxon signed-rank test.

Table 5: (continuation) Bleeding on probing (BOP).

BOP	BOND A BRAID		EVERSTICK ORTHO		SUPER-SPLINT		p ¹	Dunn's multiple comparisons test			
	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)	Min-Max	Mean±SD (median)		BOND A BRAID/ EVERSTICK ORTHO	BOND A BRAID/ HAGER WERKEN	EVERSTICK ORTHO/ HAGER WERKEN	
Upper lingual	Baseline	0-0.5	0.13±0.17 (0)	0-0.5	0.11±0.16 (0)	0-0.5	0.13±0.16 (0.2)	0.832	-	-	-
	1st month	0-1	0.21±0.27 (0.2)	0-0.5	0.12±0.17 (0)	0-0.5	0.21±0.2 (0.2)	0.334	-	-	-
	3rd month	0-0.33	0.17±0.14 (0.2)	0-0.5	0.11±0.14 (0.2)	0-0.5	0.23±0.2 (0.3)	0.225	-	-	-
	6th month	0-1	0.21±0.27 (0.2)	0-0.67	0.1±0.18 (0)	0-0.33	0.2±0.11 (0.2)	0.023*	0.276	0.899	0.019*
	p ²		0.934		0.937		0.363				
Lower buccal	Baseline	0-1	0.32±0.28 (0.2)	0-0.72	0.22±0.22 (0.1)	0.17-0.89	0.43±0.23 (0.3)	0.020*	0.791	0.289	0.016*
	1st month	0.06-0.72	0.27±0.22 (0.2)	0-0.67	0.23±0.22 (0.1)	0.11-0.83	0.4±0.22 (0.3)	0.039*	1	0.212	0.041*
	3rd month	0.11-0.67	0.29±0.15 (0.2)	0-0.56	0.17±0.14 (0.1)	0-0.56	0.29±0.16 (0.3)	0.019*	0.011*	1	0.021*
	6th month	0-1	0.32±0.29 (0.2)	0-0.56	0.14±0.15 (0.1)	0.06-0.5	0.27±0.13 (0.2)	0.033*	0.036*	1	0.016*
	p ²		0.521		0.207		0.004*				
	Baseline-1st month p ³		-		-		0.572				
	Baseline-3rd month p ³		-		-		0.017*				
	Baseline-6th month p ³		-		-		0.017*				
	1st month-3rd month p ³		-		-		0.164				
	1st month-6th month p ³		-		-		0.003*				
3rd month-6th month p ³		-		-		0.143					
Lingual inferior	Baseline	0-0.5	0.24±0.2 (0.2)	0-0.83	0.29±0.26 (0.2)	0-0.83	0.28±0.25 (0.2)	0.970	-	-	-
	1st month	0-1	0.27±0.26 (0.2)	0-1	0.28±0.29 (0.2)	0-1	0.28±0.35 (0.2)	0.908	-	-	-
	3rd month	0-0.67	0.2±0.19 (0.2)	0-0.67	0.28±0.22 (0.2)	0-0.83	0.34±0.29 (0.3)	0.417	-	-	-
	6th month	0-1	0.3±0.31 (0.2)	0-0.67	0.24±0.22 (0.2)	0.17-0.67	0.32±0.16 (0.3)	0.247	-	-	-
	p ²		0.922		0.621		0.808				

Dunn's test. *p<0.05. ¹Kruskal-Wallis test. ²Friedman test. ³Wilcoxon signed-rank test.

the everStick Ortho group in all time-points. These results were significantly lower than Super-splint group in baseline ($p = 0.016$) and the first month ($p = 0.041$), and those of the others, in the third ($p = 0.011$; $p = 0.021$) and sixth months ($p = 0.036$; $p = 0.016$). No significant differences were found in BOP values between the retainer groups in lower lingual side ($p > 0.05$).

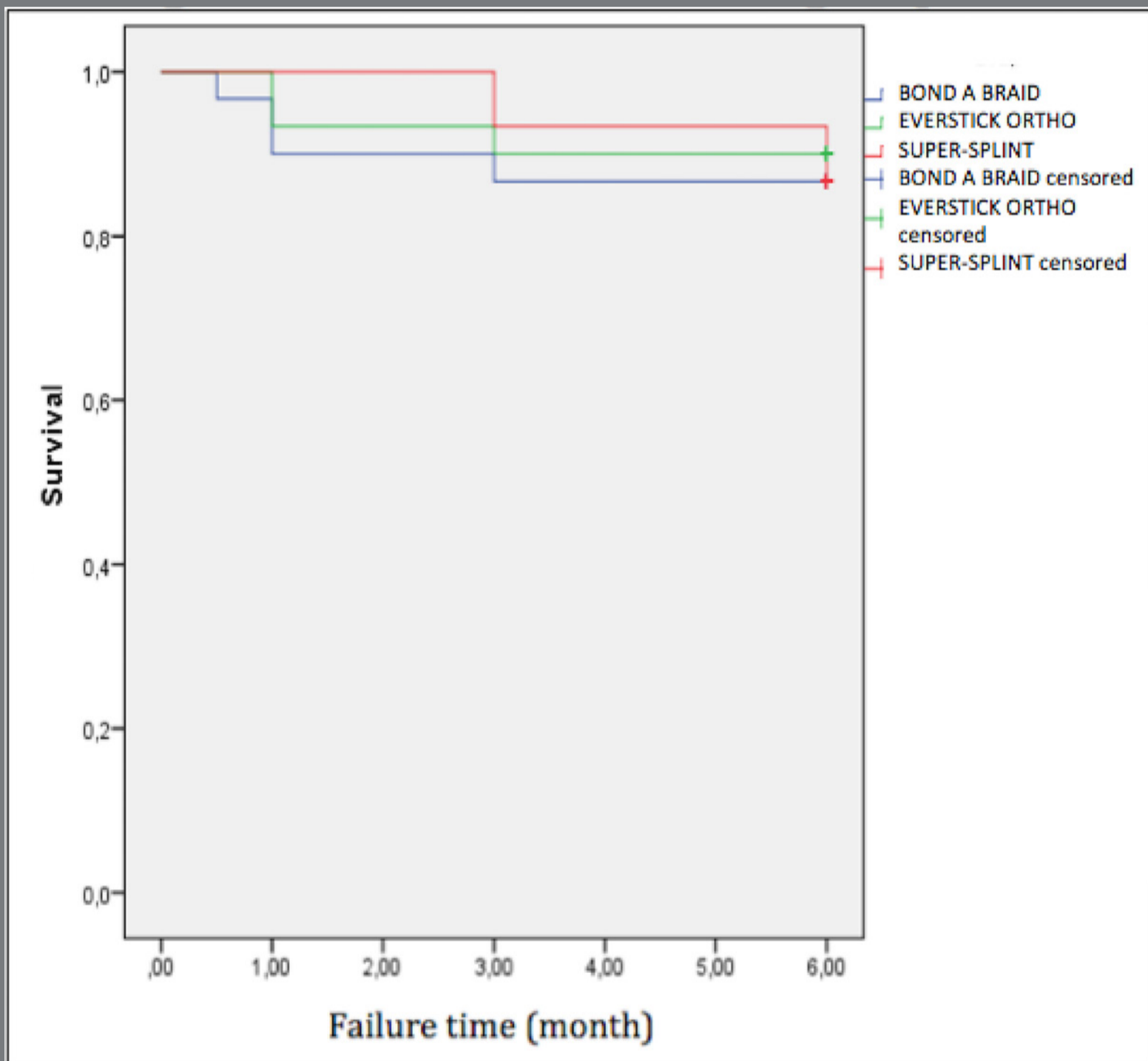
Bond-A-Braid group showed no significant differences in all periodontal parameters evaluated, in intragroup and intergroups comparisons ($p > 0.05$).

Failure analysis of the groups are presented in Table 6. Mean survival rates were 5.56 months for everStick group, 5.80 months for Super-Splint, and 5.38 months for Bond-A-Braid. Survival rates of the retainers are shown in Figure 2. Three failures were detected in everStick Ortho group, whereas four failures were seen in each of Super-Splint and Bond-A-Braid groups. Although everStick group showed less failure rates than that of Super-Splint and Bond-A-Braid groups, the difference between the groups was not statistically significant.

Table 6: Failure analysis of the groups.

Failure	BOND A BRAID (n=30)		EVERSTICK ORTHO (n=30)		SUPER-SPLINT (n=30)		p ¹
	n	%	n	%	n	%	
Yes	4	13.3	3	10	4	13.3	1.000
No	26	86.7	27	90	26	86.7	

¹Fisher-Freeman-Halton test. * p<0.05.

**Figure 2:** Survival rates of the retainer groups.

DISCUSSION

Preventing relapse is not only related to the selected retention regimen, but also to the retention materials used. Multistranded wires have a wide range of uses in clinical orthodontics.^{15,26} Some reports¹⁵⁻¹⁷ have evaluated the clinical use of fiber retainers, but we aimed to prospectively evaluate two different types of esthetic retainers compared to a conventional metallic one, based on the patients' demand for esthetic solutions in the field of orthodontics.

To standardize the method, the entire clinical procedure was carried out by the same researcher, using the same type of orthodontic adhesive (Transbond™ XT, 3M Unitek, Monrovia, Calif, USA). The use of flowable composite was avoided, due to lower filler percentage of this adhesive and the possibility of microleakage and early detachment.^{27,28} Randomization was carried out in this study and *post-hoc* analysis showed that the selected groups were similar to each other in terms of demographic data.

PI comparisons revealed that the lingual PI levels of everStick (upper 0.22, lower 0.47) were lower than the values found for Bond-A-Braid and Super-Splint groups. The lingual PI level of the everStick group was lower than those of the previous study of Torkan et al.¹⁶, which reported values of 1.66 for upper and 2.00 for lower lingual side. In the everStick group, low PI

values were detected in buccal and lingual measurements in all intervals, except for the upper lingual measurements at the first month. A significant decrease was observed in the upper buccal side at the third month and in the lower buccal side at the sixth month. The index values of the Super-Splint group also showed a significant decrease over time. However, the decreases were generally seen on the buccal side, and did not create a significant difference in the lingual index values of these retainer groups.

Although the everStick group showed significantly lower values on the upper buccal and upper lingual sides, all groups demonstrated similar GI values for the lower lingual side, but only in the first month measurements were in favor of everStick group. Considering intragroup comparisons, the GI scores of the everStick group improved over time on the lower buccal side, but this was not reflected in the lower lingual index scores for this group.

On the upper lingual side, interestingly, GI scores increased significantly in the Super-Splint group from baseline to the sixth month. In a clinical view, we think that the high occluso-gingival vertical dimension of the Super-Splint may have effected the daily plaque accumulation, and caused a temporary increase in GI values on the upper lingual side, although long-term plaque accumulation have not significantly increased.²⁹

The everStick and Super-Splint groups presented significant decreases in PD at all time-points. Furthermore, a significant decrease was seen in upper lingual PD values in the Super-Splint group, in contrast to GI scores. Pandis et al.³⁰ reported that PD was below 3 mm in almost all of their patients in the short term (3-6 months of retention), similarly, in the present study these values were lower in all retainer groups and ranged from 1 to 1.2 mm.

The superiority also belonged to the everStick group in BOP measurements, except for lower lingual side. The Super-Splint group showed a dramatic decrease in intragroup measurements from the beginning to the end of the last follow-up control on the lower buccal side. We assume that the smooth texture and highly adaptable (sticky) structure of the everStick Ortho material may have positively effected the oral hygiene around these retainers, and resulted in low scores of periodontal parameters.

There was only one *in-vivo* study in the literature about the survival rate and periodontal effects of everStick retainers. The study reported that no significant periodontal changes were observed at 24 months follow-up, and everStick was found stable during this time interval.²¹ Although the lowest failure rate of everStick group, no significant results were observed between the groups. This finding was similar with the results

of Sfondrini et al.¹⁵, but their results comprised a 1-year follow-up and the survival rate. The everStick group showed less breakages, and the last failure was seen at the third month in everStick and Bond-A-Braid groups. Super-Splint group presented failure at the sixth month. Conversely, Sobout et al.¹⁴ reported a better success rate for two kinds of twisted wires than the one found for everStick in the present study.

From a clinical point of view, the final lingual measurements may need to be considered for all groups. The everStick Ortho retainers can be preferred if the patient needs more attention to gingival health and plaque accumulation. The failure rates of the used retainers were similar, therefore fiber retainers can be applied instead of metallic ones.

This clinical trial prospectively evaluated periodontal health and survival rates of lingual retainers. Survival problems are usually seen in the first six months of the retention period,^{31,32} therefore the observation period of the study was limited to six months. Thus, the duration of the study can be considered as a limitation factor, and it would be more useful to evaluate long term results.

CONCLUSIONS

1. The everStick group presented better results in most of the periodontal measurements. The H1 null hypothesis was rejected.
2. The H2 null hypothesis was accepted, since the survival rates of the groups were similar.
3. Fiber retainers can be a good alternative to metallic retainers, especially for patients seeking esthetic solutions during the retention phase of orthodontic treatment.

AUTHORS' CONTRIBUTIONS

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ROG, GS, HT

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ROG, GS, HT

Fundraising:

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Overall responsibility:

GS

Patients displayed in this article previously approved the use of their facial and intraoral photographs.

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