



Comparison of Safe-T separators and Conventional Elastomeric Separators for the Amount of Separation, Pain and Gingival Health: A randomized controlled trial

Pasupureddi Keerthana¹, Meghna Mukhopadhyay¹, Rajasri Diddige¹, Shubhnita Verma¹, Pradeep Raj¹, Prasad Chitra^{1*}

¹Department of Orthodontics and Dentofacial Orthopaedics, Army College of Dental Sciences, Secunderabad, India

*Corresponding author: Department of Orthodontics and Dentofacial Orthopaedics, Army College of Dental Sciences, Secunderabad, India. Email: prasadchitra@yahoo.co.uk

Received: 2021 July ; Revised: 2021 September ; Accepted: 2021 September

Abstract

Objectives: The objective of the current study was to compare the amount of separation obtained by two various elastomeric separators, as well as the pain perception and gingival health.

Methods: A randomized split-mouth study was performed on 60 patients receiving fixed orthodontic treatment who were put randomly in one of two separator groups (Group 1: Elastomeric separators; Group 2: Safe-T separators). At the end of the 5-day study, the amount of separation was evaluated using a feeler gauge. Qualitative and quantitative pain assessment was performed using a patient-filled VAS (visual analogue scale) score and a questionnaire. Loe and Silness gingival index was used to examine gingival health at the time of placement and removal of separators. Student t-Test was used to compare mean VAS scores and the amount of separation followed by repeated measures of ANOVA and Bonferroni's post hoc analysis. Chi Square Test was utilized to compare gingival index scores followed by the marginal homogeneity test comparing the 1st and 5th day. Reproducibility of measurements underwent assessment using intra-class correlation coefficients.

Results: Greater statistically significant amounts of separation (0.126 mm) was achieved by Safe-T separators than conventional elastomeric separators. Patients experienced maximum pain and discomfort with the use of conventional elastomeric separators. Amount of soft tissue injury and bleeding was greater with elastomeric separators with a mean gingival score of 3.

Conclusion: Safe-T separators separate teeth optimally with minimal injury and discomfort to soft tissues, which makes them the better choice for clinicians.

Keywords: Elastomeric Separators, VAS, Banding, Gingival index, Safe-T

1. Introduction

In fixed orthodontic therapy, separation of adjacent teeth is done primarily to obtain adequate space for the precise placement of orthodontic bands (1-2). Band placement in the posterior region is preferable to bonding in certain instances due to greater masticatory forces (3).

Improper tooth separation may result in severe hard and soft tissue injuries that inevitably elicit pain in patients (4). Ngan et al. in a clinical trial found that pain correlated with the placement of separators, beginning within 4 hours of insertion and rising over the next 24 hours, ultimately affects the patient's attitude towards further orthodontic treatment (5-7).

Over the years, the armamentarium used by orthodontists has evolved from originally used brass wire separators to elastomeric, Kessler and nickel titanium alloy springs. These separators differ in their efficacy, perception of pain, and amount of soft tissue injury (8).

An ideal property of a separator is to achieve a sufficient amount of separation between teeth with reduced patient discomfort (9-10). Dislodgement of separators leads to additional appointments, which is inconvenient for both patients and clinicians (11-12).

Elastomeric separators have been the method of choice for clinicians in recent times. However, a design drawback of these separators is that they often slip and result in periodontal conditions like bone loss or tooth

mobility, which may then need periodontal intervention (13-14). These drawbacks have led to the introduction of Safe-T separators (Dynaflex, Missouri, USA) which have an additional knob on either side of the ring (15).

Even though the use of bondable molar tubes is more common, separation and band placement is required for molars with short clinical crowns, fixed functional therapy and in patients with poor enamel quality.

Specific objectives and hypothesis

A search in databases (PubMed, Cochrane and Science Direct) showed no studies done till date on Safe-T separators. The goal was to evaluate the effectiveness, perception of pain and gingival health in both the conventional elastomeric and the Safe-T separators. The null hypothesis was that there would be no distinction in the clinical effectiveness between the two separator types.

2. Methods

Trial design and alternations in the design after trial beginning

This study is a single-blind, split-mouth randomized clinical trial. All sides were allocated in

a 1:1 allocation ratio. No modifications were made after the commencement of the trial.

Participants, eligibility criteria, and settings

This split-mouth randomized clinical trial was approved by the Institutional Ethical Committee (ACDS/IEC/9/Aug2019). The study was conducted on 60 patients in our institution from October 2019 to February 2020. A detailed information sheet was recorded for each potential participant and all subjects fulfilling the research criteria signed an informed consent form (Figure 1). All sixty patients were randomly placed in either of the two separator groups using computer generated random numbers. Patients requiring fixed orthodontic treatment with the following criteria were included: crowding in the lower arch, permanent dentition with all teeth erupted including the second molars in the lower arch with tight contacts allowing the placement of separators. Patients with poor oral hygiene, periodontal conditions and those taking any form of medication were excluded.

Figure 1. Research participation sheet and informed consent form.

Interventions

All sixty patients were randomly assigned to either of the two separator groups: Group 1: Elastomeric separators (G & H Orthodontics, Franklin, Indiana, USA) and Group 2: Safe-T separators (Dynaflex, Missouri, USA) to measure the amount of separation, pain perception and gingival index (Figure 2). The initial thickness of Safe-T separators was 1mm,

while the thickness of the elastomeric separators was 1.2 mm. Both separators were placed in each patient on either side of the lower arch (Figure 3). Thus, each type of separator was used in 120 sites with a total of 240 sites in the lower arch. A separator placing plier was used to place the separators. The study period was 5 days in accordance with previously published literature (11).

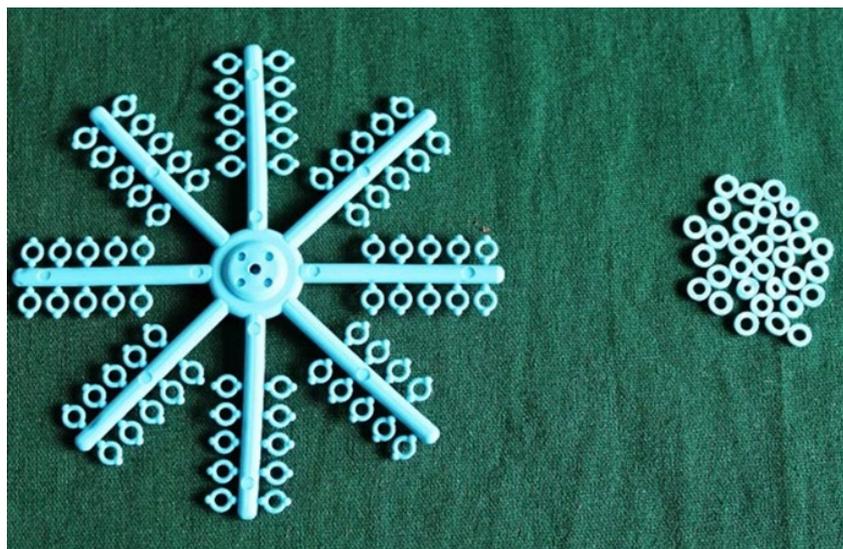


Figure 2. Types of separators used.



Figure 3. Intraoral placement of separators.

Outcomes and changes to the trial outcomes

The primary result was the assessment of the amount of separation achieved using both separators, which was analysed using a feeler gauge (Waltzer, India) at the end of the 5-day study period (Figure 4). Pain perception was then assessed as a secondary outcome, using a VAS (Visual analogue scale) scale and questionnaire (Figure 5). VAS is a straightforward tool for explaining discomfort experienced by a patient (16). This procedure uses a scale ranging from 1 to 10, varying from no discomfort to the most extreme discomfort. On this scale, the patients were requested to identify a point every day, indicating the

intensity of perceived pain until the removal of separators. The Loe and Silness gingival index was used to examine gingival health during separator placement and removal. The grade was as follows; a scale of 0 to 3 was used from stable or mild colour changes with no bleeding on placement/removal to significant colour change with bleeding on placement/removal or spontaneous bleeding and ulceration.

Sample size calculation

The sample size was calculated by the G Power software v. 3.1.9.4 with (d) at 80 percent for a two-tailed hypothesis with 95

percent confidence interval, study power at 80 percent and error margin at 5 percent, the total

sample size required being 56. 60 participants were thus included to account for attrition bias.



Figure 4. Feeler gauge.

<p>RECORDING</p> <p>A. GINGIVAL INDEX</p> <p>LEFT RIGHT</p> <p>1. AT THE TIME OF PLACEMENT</p> <table border="1"><tr><td> </td><td> </td><td> </td><td> </td></tr></table> <p>2. AT THE TIME OF REMOVAL</p> <table border="1"><tr><td> </td><td> </td><td> </td><td> </td></tr></table> <p>B. PAIN PERCEPTION</p> <p>Did you experience any discomfort during placement of separator? YES NO</p> <p>In case of yes, which side? LEFT RIGHT BOTH</p> <p>Did you have pain during chewing of food? If yes, on which side _____</p> <p>Did you modify or limit your usual diet? YES NO</p> <p>Did you use any medication for pain? YES NO</p> <p>If yes, when _____</p> <p>Did you experience any difficulty while sleeping at night? YES NO</p>									<p>Locate the pain on rating scale, by circling the score for each side</p> <p>LEFT SIDE</p> <p>No pain Moderate pain Unbearable pain</p> <p>1 2 3 4 5 6 7 8 9 10</p> <p>RIGHT SIDE</p> <p>No pain Moderate pain Unbearable pain</p> <p>1 2 3 4 5 6 7 8 9 10</p>

Figure 5. Screening and recording form.

Randomization: sequence generation, type, allocation concealment mechanism

Randomization was conducted using computer-generated numbers of 60 patients to automatically assign the separator type to the right or left side of the mouth. Allocation was hidden until the intervention was implemented so that no patient's side could be excluded based on base characteristic before the intervention. Two authors were in charge of the randomization process.

Blinding

The current study is a single-blinded trial. Neither the patients nor the orthodontist could be blinded; however, the assessment of the results was blinded and performed by clinicians who not involved in the therapy of patients in the study.

Statistical methods

Statistical Package for Social Sciences [SPSS] (Version 22.0, 2013. Armonk, NY: IBM Corp) was utilized in order to achieve the statistical analyses. Descriptive analysis of all the explanatory and outcome parameters was performed using mean and standard deviations for quantitative variables and frequency and proportions for categorical variables. Independent Student t-Test was then used to compare mean VAS scores at different time intervals, questionnaire assessment in addition to the mean amount of separation on the mesial and distal sides between the two study groups. Chi Square Test was used to compare the GI scores between the two study groups on the 1st and 5th day.

Repeated measures of ANOVA and then Bonferroni's post hoc analysis were used to analyse the mean VAS scores between different time intervals in Group 1 and Group 2. Marginal Homogeneity Test was used to compare GI scores between the 1st day and 5th day in Groups 1 and 2. The level of significance (p-Value) was considered to be $P < 0.05$. Reproducibility of the measurements was measured using intra-class correlation coefficient (ICC).

3. Results

This Seventy-two prospective participants were screened; 7 of them were excluded from the study since they did not fulfil the inclusion criteria and 2 subjects refused to agree to a fixed orthodontic treatment. Three patients refused to participate. 120 sides were then allocated randomly to either Group 1: elastomeric separators or Group 2: Safe-T separators at the outset. Figure 6 depicts a CONSORT diagram which shows the flow of patients during the study. The comparative and demographic details for both categories are displayed in Table 1. It displays that there was no significant difference between the two groups in relation to gender and age.

The amount of separation obtained by Safe-T separators was higher than the elastomeric separators with a mean difference of 0.126 mm on the mesial and distal sides (0.130 mm) at $p < 0.001$ (Table 2). Qualitative assessment of VAS scores depicted higher intensity of pain in patients with elastomeric separators relative to Safe-T separators, which was statistically significant (Table 3). Several patients even had to shift their side of mastication to the site where the Safe-T separators were placed. All other responses were reasonably similar between the two groups.

Table 1. Age and gender distribution among both groups.

Variable	Category	Group 1		Group 2		P value
		Mean	SD	Mean	SD	
Age	Mean & SD Range	20.4	1.5	20.5	1.2	0.48 ^a
		18-23		18-23		
Gender	Males	n	%	n	%	0.71 ^b
	Females	18	30	18	30	
		42	70	42	70	

* a, independent student t-test; b, Chi square test

Table 2. Comparison of mean amount of separation on the mesial and distal sides between both groups.

Comparison of mean amount of separation on the mesial and distal sides b/w 2 study groups using Independent Student t-Test (mm).

Sides	Group	N	Mean	SD	Mean Diff	P-Value
Mesial	Group 1	30	0.352	0.019	-0.126	<0.001*
	Group 2	30	0.477	0.022		
Distal	Group 1	30	0.379	0.018	-0.130	<0.001*
	Group 2	30	0.508	0.027		

*Statistically significant at $p < 0.05$

Table 3. Objective pain assessment using a questionnaire.

Questionnaire	Elastomeric (N-60)	Safe-T (N-60)	p value
Q1) Did you experience discomfort during the placement of the separator? If yes, on which side?	36	18	0.008*
Q2) Did you change your side of mastication?	36	13	0.004*
Q3) Did you modify or limit your usual diet?	43	16	0.234
Q4) Did you use any medication for pain?	20	19	0.213
Q5) Did you experience any difficulty while sleeping at night?	38	15	0.142

*Statistically significant at p<0.05

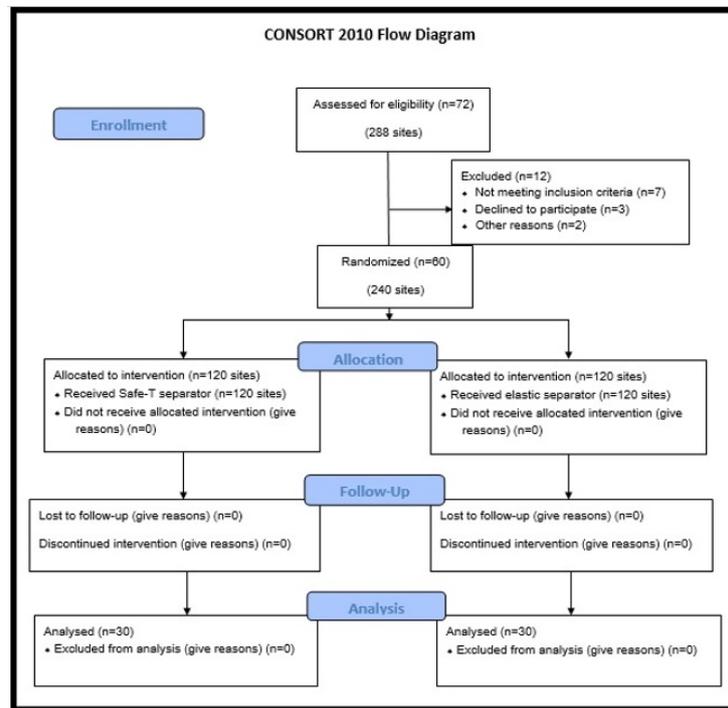


Figure 6. CONSORT flow diagram.

On intergroup comparison of VAS scores using student t-test, maximum pain was noted with elastomeric separators when compared to Safe-T separators (Figure 7, Table 4). On intragroup comparison using repeated measures of ANOVA, there was a statistically significant decrease in pain noted for both groups over the 5-day study period, but the amount of pain perceived by patients with elastomeric separators was higher on all 5 days (Table 5).

On gingival health assessment using Loe and Silness gingival index, more patients with elastomeric separators had a mean score of 3 on the 1st day which reduced to score 1, whereas with

Safe-T separators, the mean score was 1 on both the 1st and 5th days (Figure 8). Comparison of GI scores was done using Chi square test which showed more spontaneous gingival bleeding on placement in elastomeric separators at p<0.001 (Table 6).

Both measurements were reviewed repeatedly by two authors to test the reproducibility of measurements. ICC measured the reproducibility of these repeated measurements. It depicted good repeatability for the amount of separation and gingival index (Table 7).

Table 4. Comparison of mean VAS scores between 2 study groups at different time intervals.

Comparison of mean VAS scores between 2 study groups at different time intervals using Independent Student t-Test						
Time	Group	N	Mean	SD	Mean Diff	P-Value
Day 1	Group 1	30	6.73	0.79	3.30	<0.001*
	Group 2	30	3.43	0.57		
Day 2	Group 1	30	5.80	0.66	3.63	<0.001*
	Group 2	30	2.17	0.38		
Day 3	Group 1	30	3.73	0.58	2.26	<0.001*
	Group 2	30	1.47	0.57		
Day 4	Group 1	30	2.73	0.45	1.60	<0.001*

Table 4. Comparison of mean VAS scores between 2 study groups at different time intervals.
Comparison of mean VAS scores between 2 study groups at different time intervals using Independent Student t-Test

Time	Group	N	Mean	SD	Mean Diff	P-Value
Day 5	Group 2	30	1.13	0.35	0.20	0.009*
	Group 1	30	1.20	0.41		
	Group 2	30	1.00	0.00		

*Statistically significant at p<0.05

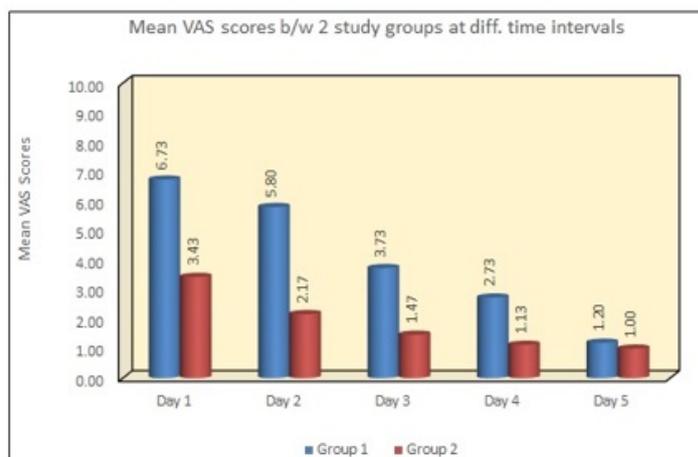


Figure 7. Mean VAS scores between both groups.

Table 5. Comparison of mean VAS scores between different time intervals in Group 1 and Group 2 using repeated measures of ANOVA Test.

Comparison of mean VAS scores between different time intervals in Group 1 and Group 2 using repeated measures of ANOVA Test

Group 1 (Time)	N	Mean	SD	Min	Max	P-Value
Day 1	30	6.73	0.79	5	8	<0.001*
Day 2	30	5.80	0.66	4	7	
Day 3	30	3.73	0.58	2	5	
Day 4	30	2.73	0.45	2	3	
Day 5	30	1.20	0.41	1	2	
Group 2 (Time)	N	Mean	SD	Min	Max	P-Value
Day 1	30	3.43	0.57	3	5	<0.001*
Day 2	30	2.17	0.38	2	3	
Day 3	30	1.47	0.57	1	3	
Day 4	30	1.13	0.35	1	2	
Day 5	30	1.00	0.00	1	1	

*Statistically significant at p<0.05

Table 6. Comparison of GI scores between 2 study groups on 1st day and 5th day using Chi Square Test.

Comparison of GI scores between 2 study groups on 1st day and 5th day using Chi Square Test

Time	GI Scores	Group 1		Group 2		c ² Value	P-Value
		n	%	n	%		
1st day	Score 0	0	0.0%	0	0.0%	40.190	<0.001*
	Score 1	0	0.0%	22	73.3%		
	Score 2	13	43.3%	8	26.7%		
	Score 3	17	56.7%	0	0.0%		
5th day	Score 0	0	0.0%	23	76.7%	37.939	<0.001*
	Score 1	26	86.7%	7	23.3%		
	Score 2	4	13.3%	0	0.0%		
	Score 3	0	0.0%	0	0.0%		

* - Statistically significant

Note: Score 0 - Healthy gingiva

Score 1 - Minor changes in colour with no bleeding

Score 2 - Moderate colour changes with bleeding on placement

Score 3 - Spontaneous bleeding on placement

Table 7. Intraclass correlation statistics to assess for the reproducibility of measurements between 2 observers

Time	Variables	Group 1				Group 2			
		ICC	95% CI		P-Value	ICC	95% CI		P-Value
			Lower	Upper			Lower	Upper	
1 st day	Amount of separation	0.87	0.33	0.81	0.002*	0.89	0.68	0.96	<0.001*
	Gingival index	0.88	0.31	0.84	0.001*	0.88	0.59	0.89	0.001*
5 th day	Amount of separation	0.86	0.68	0.94	<0.001*	0.90	0.78	0.95	<0.001*
	Gingival index	0.82	0.73	0.95	0.001*	0.84	0.71	0.93	0.001*

*Statistically significant

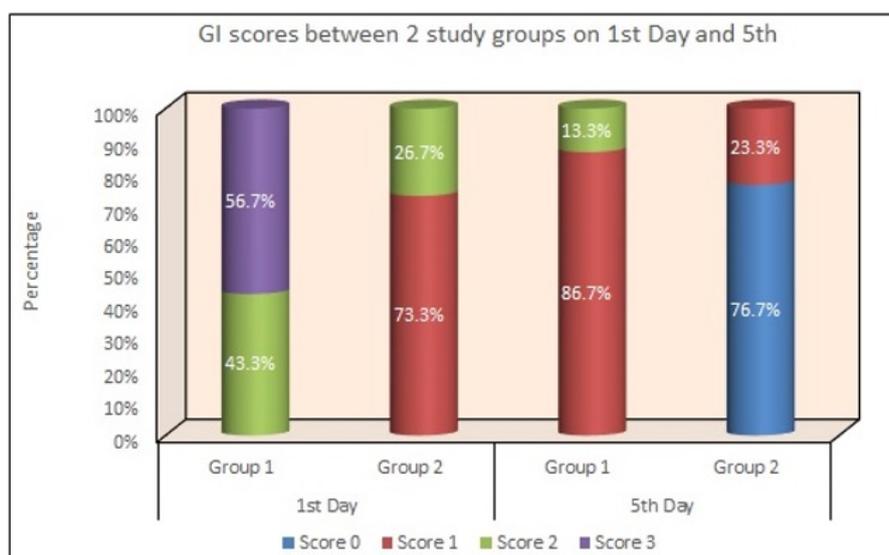
Note: ICC – Intra class Correlation Coefficient

ICC values <0.50 - Poor reliability

0.50 - 0.75 - Moderate reliability

0.75 - 0.90 - Good reliability

> 0.90 - Excellent reliability

**Figure 8.** Mean gingival scores between both groups.

4. Discussion

This single blind randomized split-mouth clinical trial was performed to assess the efficiency of Safe-T separators. The primary outcome of the study was to assess the amount of separation using two types of separators. Secondary outcomes were pain perception and gingival health of participants. Randomization was done in a 1:1 ratio with similar age groups; the mean age was 19.4 for Group 1 and 19.1 for Group 2. Furthermore, the gender distribution showed no statistical difference, indicating low bias in the study.

Safe-T separators tend to be more patient friendly in terms of pain perception and gingival health. Thus, study's null hypothesis has been rejected. This analysis included 60 patients with 240 sites that were assigned randomly to one of the 2 separators. Throughout the 5-day study, 6 patients reported with dislodged elastomeric separators.

Amount of separation

Incongruent separation of teeth may increase patient discomfort by the untoward manipulation of gingival tissues. An amount of 0.25 mm of separation is required between molars for proper placement of orthodontic bands (11).

In this study, greater amounts of separation were noted with the use of Safe-T separators (0.477 mm mesially and 0.508 mm distally) relative to elastomeric separators. The amount of separation with elastomeric separators in this study (mesial 0.352 mm, distal 0.379 mm) is greater than other previous studies reporting the efficiency of elastomeric separators over others (2,11,12,17). This suggests that the use of Safe-T separators is ideal for placing crowns used in fixed functional therapy and the correction of ectopic maxillary molars until further studies prove otherwise.

Pain assessment

Pain is considered to be a subjective response which relies on various variables including age, subjective pain tolerance, current emotional state or past history (18).

A qualitative and quantitative assessment was done to assess pain perception among patients as a secondary outcome. A greater intensity of pain was noticed in the first 24 hours of separator placement (6,19-20). The pain reduced significantly by the third day resulting in better patient compliance. The amount of pain experienced by patients on the elastomeric separator side was much greater on the day the separators were placed compared to Safe-T separator ($p < 0.05$). Also, the residual pain on the 5th day was greater with elastomeric separators, which is in line with the results of Bapna et al (21).

On objective evaluation, 36 patients reported with extreme pain on the elastomeric separator side and had to change their chewing side to the Safe-T separator site, which was statistically significant. 20 patients used medication to relieve their discomfort. These results are in line with Tripathi et al (11), and Alqhatani et al (22).

Pain is a subjective response and is often reported by patients with use of separators, aligning archwires, headgears, etc. in fixed orthodontic therapy and can influence the course of treatment (23).

Gingival health assessment

Brass wire separators were used initially for separation. Natural rubber was introduced as an elastomer due to its elasticity in 1927 (24). These separators were convenient and easy to use (25). It soon became the separator of choice amongst all clinicians. However, major drawbacks with these separators were the ability to dislodge from placement sites and also the amount of soft tissue injury caused (26-27). To overcome these drawbacks, Safe-T separators are ring shaped with an additional knob which prevents from displacing in the oral cavity and minimize the periodontal damage.

To assess the efficiency of these separators, a new parameter of gingival health assessment was also included in this study. Loe and Silness gingival index was recorded for each patient on the day of placement and removal of separators. Patients reported greater bleeding and soft tissue injury while placing elastomeric separators (Index-3 at $p < 0.05$). The additional knob of Safe-T separators helped in preventing such injuries, (Index-1 at $p < 0.05$). In addition, on

the 5th day of evaluation, gingival health was restored quickly with Safe-T separators and prevented their dislodgement into sub-gingival areas.

Our results demonstrated that Safe-T separators performed better than elastomeric separators with respect to patient comfort. These separators can be recommended for clinical use by orthodontists for optimum results.

The split-mouth study design was chosen as inter-subject reliability is removed and each patient would act as their own control, resulting in high study power. It also addresses the lack of uniformity between sites that may introduce selection bias with different baseline characteristics. This study design was apt because the amount of separation and Gingival Index depend on various in-vivo factors which could differ in each individual. The benefit of using a split-mouth study design was that the comparison of two separators can be made under similar intra oral environments in an individual (28).

Limitations and future directions

Double blinding was not possible in this study as the operator was aware about the type of separator being used. Generalization of pain on both sides is an inevitable limitation of the study.

Further studies can be done using Safe-T separators for separation and assessment of pain perception in different genders.

Conclusion

Safe-T separators performed better than elastomeric separators as no dislodgement was noted and patients experienced minimal discomfort with less gingival damage. Thus, this modification of regular elastomeric separators proved to be more efficient and can be used by clinicians for favourable results especially in cases requiring the placement of bands and crowns.

References

1. Sharma SK, Barthunia N, Pandit A, Singh A. Perception of discomfort and amount of separation from two types of orthodontic separators: A Prospective Study. *Int J Oral Health Med Res* 2017;4(3):35-38. doi:10.4103/jpbs.JPBS_765_20.
2. Malagan M. Comparison between efficacy of four different types of orthodontic separators. *J Clin Diagn Res* 2014;8(8):41-44. doi: 10.7860/JCDR/2014/9963.4755.

3. Flores-Mir C. Bonded molar tubes associated with higher failure rate than molar bands. *Evid Based Dent* 2011;12:84. doi: 10.1038/sj.ebd.6400813.
4. Firestone AR, Scheurer PA, Burgin WB. Patients' anticipation of pain and pain-related side effects, and their perception of pain as a result of orthodontic treatment with fixed appliances. *Eur J Orthod* 1999;21:387-96. doi: 10.1093/ejo/21.4.387.
5. Ngan P, Kess B, Wilson S. Perception of discomfort by patients undergoing orthodontic treatment. *Am J Orthod Dentofacial Orthop* 1989;96:47-53. doi: 10.1016/0889-5406(89)90228-x.
6. Ngan P, Wilson S, Shanfeld J, Amini H. The effect of ibuprofen on the level of discomfort in patients undergoing orthodontic treatment. *Am J Orthod Dentofacial Orthop* 1994;106:88-95. doi: 10.1016/S0889-5406(94)70025-7.
7. Wilson S, Ngan P, Kess B. Time course of the discomfort in young patients undergoing orthodontic treatment. *Pediatr Dent* 1989;11:107-10. PMID: 2762180.
8. Wilcock A, Kansal S, Singh G, Raghav P, Kumar P, Kumar A. The Kansal Separator: In Search of "A Better Mouse Trap". *Arch Cran Oro Fac Sc* 2014;2(1):100-3. doi: 10.4103/2278-0203.127552.
9. Davidovitch M, Papanicolou S, Vardimon AD, Brosh T. Duration of elastomeric separation and effect on interproximal contact point characteristics. *Am J Orthod Dentofacial Orthop* 2008;133:414-22. doi: 10.1016/j.ajodo.2006.02.036
10. Singh G. Separators in Dentistry. *J Oral Hyg Health* 1: e103. doi: 10.4172/2332-0702.1000e103.
11. Tripathi T, Singh N, Rai P, Khanna N. Separation and pain perception of Elastomeric, Kesling and Kansal separators. *Dent Press J Orthod* 2019;24(2):42-48. doi: 10.1590/2177-6709.24.2.042-048.oar.
12. Dragiff DA. Table clinic - Separators. *J Clin Orthod* 1969;3(12):664-71.
13. Monini A, Guimaraes M, Gandini Junior L, Santos-Pinto L, Hebling J. Tooth separation: A risk-free procedure? *Am J Orthod Dentofacial Orthop* 2012;142(3):402-405. doi: 10.1016/j.ajodo.2011.06.048.
14. Caldwell CR, Worms FW, Gatto DJ. Orthodontic and surgical intervention to arrest tooth loss secondary to subgingival elastic. *Am J Orthod* 1980;78:273-8. doi: 10.1016/0002-9416(80)90272-9.
15. Tarvade Daokar S. Separators in Orthodontics: A Review. *Orthod J Nepal*. 2016;6(1):37-40
16. Woodforde JM, Merskey H. Some relationships between subjective measure of pain. *J Psychosom Res* 1972;16:173-8. doi: 10.1016/0022-3999(72)90041-4. PMID: 1939630.
17. Mcgann DA. Nickle titanium separating spring. *J Clin Orthod* 1993;25(5):315-18. PMID: 1939630.
18. Aldrees AM. Intensity of pain due to separators in adolescent orthodontic patients. *J Orthod Sci* 2015;4:118-22. doi: 10.4103/2278-0203.173423.
19. Bondemark L, Fredriksson K, Ilros S. Separation effect and perception of pain and discomfort from two types of orthodontic separators. *World J Orthod* 2004;5:172-6. PMID: 15615136.
20. Scheurer PA, Firestone AR, Burgin WB. Perception of pain as a result of orthodontic treatment with fixed appliances. *Eur J Orthod* 1996;18:349-57. doi: 10.1093/ejo/18.4.349.
21. Kumar Bapna PA, Mane PN, Ganiger CR, Pawar RL, Phaphe SA, Ahammed YA. A survey of perception of pain and discomfort with elastomeric separators in patients undergoing orthodontic treatment in Western Maharashtra region. *J Oral Res Rev* 2017;9:56-61. doi: 10.4103/jorr.jorr_42_16.
22. Al Qahtani N, Al Wakeel A, Al Zamil A, Al Turki S, Al Dawsari G, Al Jabaa A et al. Comparison of two analgesics used for pain relief after placement of orthodontic separators. *Saudi Pharm J* .2017;25(8):1169-1174. doi: 10.1016/j.jsps.2017.07.010.
23. Banerjee S, Banerjee R, Shenoy U, Agarkar S, Bhattacharya S. Effect of orthodontic pain on quality of life of patients undergoing orthodontic treatment. *Indian J Dent Res* 2018;29:4-9. doi: 10.4103/ijdr.IJDR_113_16.
24. Mendes D, Nascimento J, Facholli A, Casa M, Carvalho L, Sato K. Evaluation of plasticity and radiopacity of elastic separators by means of traction tests and radiography. *Dent Press J Orthod*. 2012;17(6):1-10. doi: 10.1590/S2176-94512012000600008.
25. Baty DL, Storie DJ, ConFrauhonfer JA. Synthetic elastomeric chains: A literature review. *Am J Orthod Dentofacial Orthop* 1994;105(6):536-42. doi: 10.1016/S0889-5406(94)70137-7.
26. Thakur VK, Kannan S, Sharma M, Kumar P, Pradhan I. Innovative use of Kesling spring separators: A clinical pearl. *Int J Orthod Rehabil* 2018;9:90-1. doi: 10.4103/ijor.ijor_1_18.
27. Kumar A, Kansal S, Thareja V, Singh G, Kumar P. The biomechanics of Kansal Separator: A '2 in 1' self-secured orthodontic spring separator. *J Orthod Sci* 2014;3:12-6. doi: 10.4103/2278-0203.127552.
28. Pandis N, Walsh T, Polychronopoulou A, Katsaros C, Eliades T. Split-mouth designs in orthodontics: an overview with applications to orthodontic clinical trials. *Eur J Orthod*. 2013 ;35(6):783-9. doi: 10.1093/ejo/cjs108.