Comparative Evaluation of Molar-Premolar Separation, Stability, and Patient Pain Perception Using Four Orthodontic Separators: An In Vivo Study

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Orthodontic separators, separation effect, stability, pain perception, in vivo study.

ABSTRACT
Orthodontic separators play a crucial role in fixed orthodontic treatment by creating space between adjacent teeth for band placement. This in vivo study comparatively evaluates four types of orthodontic separators elastomeric, dumbbell, Kesling, and brass wire based on three key parameters: separation effect, intraoral stability, and patient pain perception. A total of 60 adult volunteers participated, with each separator type placed in different quadrants of the oral cavity. The separation effect was measured using a JAIBROS Feeler Gauge, stability was assessed by recording dislodged separators, and pain perception was evaluated using the Visual Analog Scale (VAS). Statistical analysis, including ANOVA and Bonferroni tests, revealed that dumbbell separators achieved the highest mean separation (0.26 ± 0.12 mm), while brass wire separators produced the least (0.2007 ± 0.06 mm). Stability analysis indicated that Kesling separators had the highest loss rate (11.7%), whereas dumbbell separators were the most stable (1.6% loss). Pain perception was highest with Kesling separators (VAS score: 5.03 ± 0.956) and lowest with dumbbell separators (VAS score: 1.30 ± 0.462). The findings suggest that dumbbell separators are the most effective in achieving optimal separation while minimizing patient discomfort, making them a preferred choice in clinical orthodontic practice.

Introduction

Orthodontic treatment plays a crucial role in correcting malocclusions and achieving optimal dental alignment, thereby enhancing both functional and aesthetic outcomes for patients[1]. One of the fundamental steps in fixed orthodontic therapy is the placement of orthodontic bands on posterior teeth, typically molars and premolars[2]. However, due to the close interproximal contact between these teeth, separation is necessary to create adequate space for the placement of orthodontic bands[3]. Various orthodontic separators have been developed to achieve this purpose, each differing in their mode of action, material composition, and effectiveness in generating space within the interproximal region[4]. Orthodontic separators are small devices placed between adjacent teeth to create sufficient space before band placement. The most commonly used separators include elastomeric separators, dumbbell separators, Kesling separators, and brass wire separators[5]. Each type of separator functions uniquely, exerting different amounts of force over varying time intervals. While separators are indispensable in orthodontic practice, their effectiveness and associated patient discomfort remain significant concerns. The ability of a separator to create adequate space within a specific duration while minimizing patient discomfort is a critical consideration in clinical orthodontics[6]. Among the different types of orthodontic separators, elastomeric separators are widely used due to their ease of placement and efficiency in creating space[7]. These separators are made from medicalgrade elastomers that exert a gentle yet continuous force on adjacent teeth, leading to separation over time. Dumbbell separators, on the other hand, have a unique design that enhances their retention in the interdental space. Kesling separators, which are made from resilient materials, function similarly to elastomeric separators but offer greater flexibility and durability[8]. Brass wire separators are another option that provides continuous force and can be adjusted for varying levels of separation. Assessing the effectiveness of these separators in generating space at the molar-premolar interphase is essential for optimizing treatment outcomes[9]. The amount of separation gained by each type of separator at different time intervals needs to be studied to determine the most effective option. Additionally, the stability of these separators intraorally is crucial, as premature dislodgement may compromise the space-gaining process and prolong treatment duration[10,3]. Patients' pain perception is another key aspect to consider since discomfort associated with separator placement can affect compliance and overall patient experience. Stability is another critical parameter in evaluating orthodontic separators[11]. A separator that remains in place throughout the intended duration ensures consistent force application and predictable separation. Premature loss of separators may necessitate repeated placement, causing inconvenience to both the patient and the clinician[12]. Studies suggest that separators with a firmer grip, such as brass wire separators, tend to remain more stable compared to elastomeric and Kesling separators[13]. However, their increased rigidity may contribute to heightened patient discomfort. Pain perception is a subjective yet important factor that influences patient compliance with orthodontic treatment[14]. The discomfort associated with separator placement results from the force applied to adjacent teeth, leading to pressure and temporary inflammation of the periodontal ligament[15]. The level of pain experienced by patients varies based on the type of separator used, individual pain threshold, and duration of separator placement. Elastomeric separators, which exert continuous force, are often associated with higher pain levels in the initial hours post-placement[16]. Conversely, dumbbell and Kesling separators may offer a more tolerable experience due to their design and material composition. Brass wire separators, while effective, may cause irritation if improperly positioned[17]. Patient-reported pain experiences can be assessed using standardized pain scales, such as the Visual Analog Scale (VAS) or the Numeric Rating Scale (NRS)[18]. These tools provide a quantitative measure of pain intensity, allowing for objective comparisons among different separators. Additionally, assessing pain at various time intervals post-placement can offer insights into the progression and duration of discomfort, guiding clinicians in selecting separators that balance efficacy with patient comfort. The present study aims to comprehensively evaluate four types of orthodontic separators—elastomeric, dumbbell, Kesling, and brass wire separators—based on three key parameters: the amount of separation achieved at the molar-premolar interphase over time, intraoral stability, and patient pain perception[19]. By systematically assessing these factors, this study seeks to identify the most effective and patient-friendly orthodontic separator for clinical use[20]. The findings will provide valuable insights for orthodontists, enabling them to make informed decisions regarding separator selection and improving overall patient experiences in orthodontic treatment. This research is particularly relevant in the context of evidence-based orthodontics, where treatment strategies are continuously refined to enhance efficiency and patient satisfaction[21]. While several studies have examined individual aspects of separator performance, a comprehensive comparison encompassing space gained, stability, and pain perception is needed[22-24]. The results of this study will contribute to the existing body of knowledge by providing a holistic evaluation of orthodontic separators, ultimately guiding clinical practice and improving treatment outcomes.

Material and method

The study utilized four orthodontic separators elastomeric, dumbbell, Kesling, and brass wire placed using separator pliers and assessed with a digital caliper and intraoral camera. Patient pain perception was measured using the Visual Analog Scale (VAS). Data analysis was conducted using SPSS and GraphPad software in a clinical setup with sterilized instruments.

Methods

Measuring the Stability and Separating Effect

The separating effect of four different types of separators was assessed on the fifth day, and the space created between the molars and premolars was recorded separately. The number and type of dislodged separators were also noted[25]. Elastomeric and Dumbbell separators were carefully removed using a curved probe, while Brass wire and Kesling separators were removed using light wire pliers. After air drying the molar and premolar areas, the separation between the molars and the second premolar in each quadrant was measured using a **JAIBROS Feeler Gauge** with a measurement range of 0.03–1.0 mm. The measurements were recorded intraorally on the fifth day. Volunteers were instructed to avoid hard food consumption for the five-day study period.

Measuring the Pain Perception Effect

The patients' pain perception was assessed using the Visual Analogue Scale (VAS), with a structured feedback form provided to all participants. This form allowed them to document their pain experiences for further investigation, review, and detailed analysis. To ensure accuracy, a cross-examination of patients was conducted to validate the results[26]. The study focused on two key parameters: dislodgement, which referred to the frequency and type of separators that became loose or fell out, and pain, which measured the intensity of discomfort experienced by patients. Prior to the study, a session was conducted to educate participants on how to complete the pain perception chart and maintain proper oral hygiene. They were instructed to practice bilateral chewing, avoid the intake of hard food, and follow necessary precautions, including the appropriate use of painkillers and antibiotics when required[27,28].

FOUR DIFFERENT TYPES OF ORTHODONTIC SEPARATORS USED IN THE STUDY

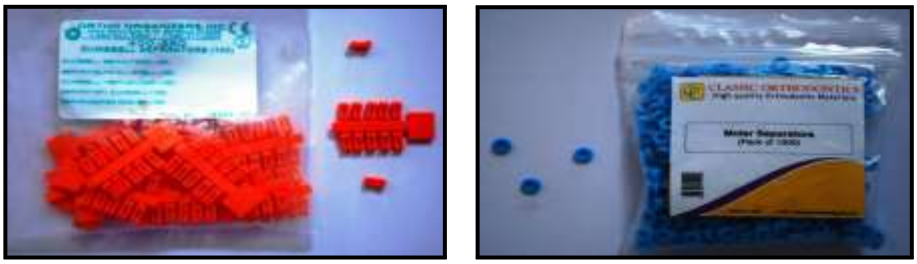

Fig. 1 Dumbbell and Elastomeric separators

Fig. 2 Brass wire and Kesling separators

Fig. 3 Pliers used for separator placement

SEPARATORS IN THE INTERDENTAL CONTACT POINT

Fig. 4 Dumbbell and Elastomeric separators in maxillary arch

Fig. 5 Brass wire and Kesling separators in mandibular arch

RESULTS

A total of 60 adult volunteers from Rajasthan Dental College and Hospital participated in the study. Four different types of orthodontic separators—Elastomeric, Dumbbell, Kesling, and

Brass wire—were placed in the four quadrants of each participant's oral cavity, with one type of separator randomly assigned to each quadrant.

STATISTICAL ANALYSIS

The data were coded and entered into a Microsoft Excel spreadsheet and analyzed using IBM SPSS Statistics Version 25 for Windows (SPSS Inc., IBM Corporation, NY, USA). Descriptive statistics, including percentages, means, and standard deviations, were computed. The normality of the data was assessed using the **Kolmogorov-Smirnov test** before statistical analysis. The **ANOVA test** with multiple comparisons using the **Bonferroni test** was applied for quantitative data to compare two or more observations. The level of significance was set at **$P \leq 0.05$**.

Table 1: ANOVA test to evaluate separation effect of four different types of orthodontic separators

	Mean	**Std. Deviation**	**P value**
Kesling	.25	.11	0.001 (S)
brass wire	.2007	.06	
dumbbell	.26	.12	
Elastomeric	.25	.08	

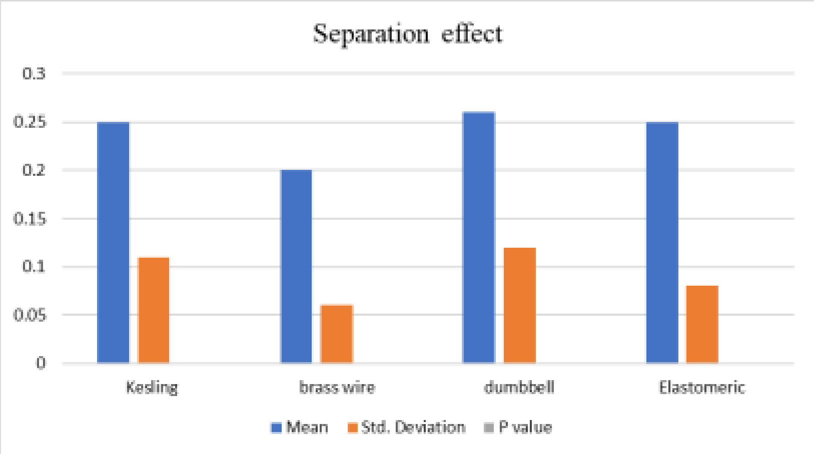

Fig. 6 Separation effect of four different types of orthodontic separators

Among the subjects, the mean separation effect varied among different types of orthodontic separators. Dumbbell separators produced the highest mean separation of 0.26 ± 0.12 mm, followed closely by Kesling separators and Elastomeric separators, both of which resulted in a mean separation of 0.25 mm, with standard deviations of 0.11 mm and 0.08 mm, respectively. Brass wire separators exhibited the lowest mean separation, measuring 0.2007 ± 0.06 mm. These findings, as presented in Table 1 and Graph 1, indicate that Dumbbell separators were the most effective in creating interdental space, whereas Brass wire separators produced the least amount of separation.

Table 2: Multiple Comparisons of separation effect of four different kind of seperators with Bonferroni test

		Mean Difference	P value
Kesling	**Brass Wire**	.04967*	.007
	Dumbbell	.04417*	.023
	Elastomeric	-.00017	1.000
Brass Wire	**Kesling**	-.04967*	.007
	Dumbbell	-.00550	1.000
	Elastomeric	-.04983*	.007
Dumbbell	**Kesling**	-.04417*	.023
	Brass Wire	.00550	1.000
	Elastomeric	-.04433*	.022
Elastomeric	**Kesling**	.00017	1.000
	Brass Wire	.04983*	.007
	Dumbbell	.04433*	.022

The separation effect of different orthodontic separators showed significant variations. The mean difference between the Kesling separator and the Brass wire separator was **0.04967 (p<0.007)**, indicating a very highly significant difference. Similarly, the Kesling separator demonstrated a significant difference when compared to the Dumbbell separator (**0.04417, p<0.023**), while its difference with the Elastomeric separator (**-0.00017, p=1**) was not significant. The Brass wire separator also showed a highly significant difference when compared to the Kesling separator (**-0.04967, p<0.007**) and the Elastomeric separator (**-0.04983, p<0.007**), but its comparison with the Dumbbell separator (**-0.00550, p=1**) was not significant. Furthermore, the Dumbbell separator exhibited a significant difference in separation effect compared to the Kesling separator (**-0.04417, p<0.023**) and the Elastomeric separator (**-0.04433, p<0.022**), whereas its difference with the Brass wire separator (**0.00550, p=1**) was not significant. The Elastomeric separator showed no significant difference in separation effect when compared to the Kesling separator (**0.00017, p=1**), but its differences with the Brass wire separator (**0.04983, p<0.007**) and the Dumbbell separator (**0.04433, p<0.022**) were very highly significant. These findings, as presented in **Table 2**, indicate that Kesling, Brass wire, and Dumbbell separators exhibit significant variations in their separation effects, with the Brass wire separator demonstrating the highest differences in comparison to other separators.

Table 3: ANOVA test for illustration of number of samples used and stability of four different types of orthodontic separators

SEPERATORS	TOTAL	N	% OF LOST SEPERATOR
Kesling	60	53	11.7
Brass wire	60	58	3.3
Dumbbell	60	59	1.6
Elastomeric	60	56	6.7

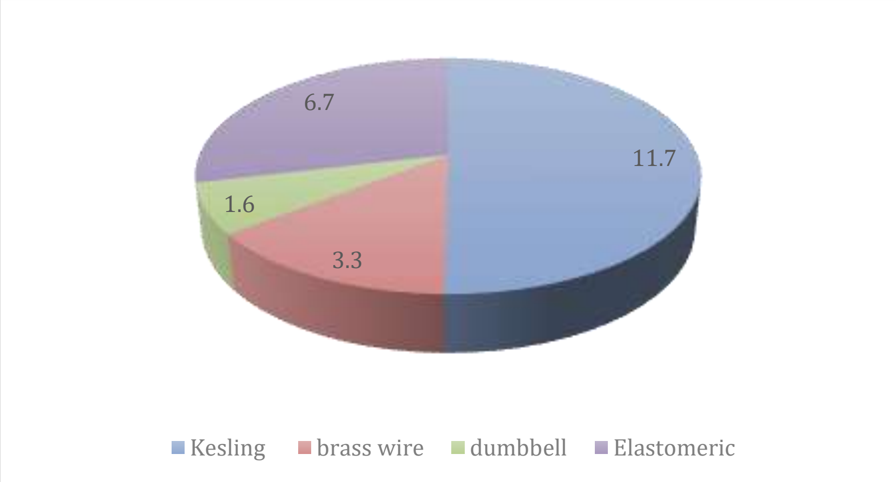

Fig. 7 Pie-chart to compare percentage (%) of stability among four different types of orthodontic seperators

Among the subjects, the percentage of separator loss varied across different types. **Kesling separators** had the highest loss rate at **11.7%**, followed by **Elastomeric separators** at **6.7%**. **Brass wire separators** showed a lower loss rate of **3.3%**, while **Dumbbell separators** had the least loss at **1.6%**. These findings, as presented in **Table 3 and Graph 2**, suggest that Kesling separators were the least stable, whereas Dumbbell separators exhibited the highest retention intraorally.

Table 4: ANOVA test to evaluate pain perception among four different types of orthodontic separators

	Mean	Std. Deviation	P value
Kesling	5.03	.956	0.001 (S)
Brass wire	3.82	.792	
Dumbbell	1.30	.462	
Elastomeric	2.87	.892	

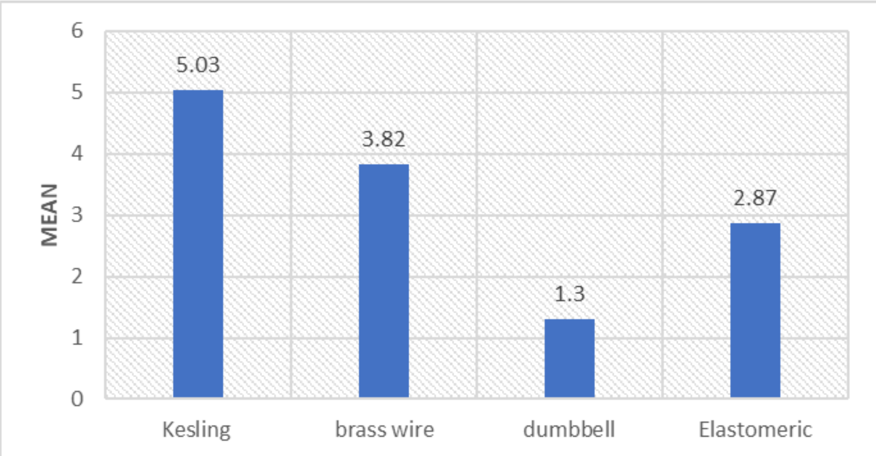

Fig. 8 To compare pain perception among four different types of orthodontic seperators

Among the subjects, pain perception varied across different types of orthodontic separators. The **Kesling separators** resulted in the highest pain perception, measuring **5.03 ± 0.956 mm**, followed by **Brass wire separators** at **3.82 ± 0.792 mm**. **Elastomeric separators** produced a moderate pain response of **2.87 ± 0.892 mm**, while **Dumbbell separators** caused the least pain, with a measurement of **1.30 ± 0.462 mm**. These findings, as presented in **Table 4 and Graph 3**, indicate that Kesling separators induced the most discomfort, whereas Dumbbell separators were associated with the lowest pain perception among the study participants.

Table 5: Multiple Comparisons of pain perception among four different type of seperators with Bonferroni test

		Mean Difference	P value
Kesling	Brass Wire	1.217*	.000
	Dumbbell	3.733*	.000
	Elastomeric	2.167*	.000
Brass wire	Kesling	-1.217*	.000
	Dumbbell	2.517*	.000
	Elastomeric	.950*	.000
Dumbbell	Kesling	-3.733*	.000
	Brass Wire	-2.517*	.000
	Elastomeric	-1.567*	.000
Elastomeric	Kesling	-2.167*	.000
	Brass Wire	-.950*	.000
	Dumbbell	1.567*	.000

The mean difference in pain perception between the Kesling separator and the Brass wire separator was **1.217 (p=0.000)**, indicating a very highly significant difference. Similarly, the Kesling separator showed a significant difference in pain perception when compared to the Dumbbell separator (**3.733, p=0.000**) and the Elastomeric separator (**2.16, p=0.000**). The Brass wire separator also demonstrated a significant difference in pain perception compared to the Kesling separator (**-1.217, p=0.000**), the Dumbbell separator (**2.517, p=0.000**), and the Elastomeric separator (**0.950, p=0.000**). Furthermore, the Dumbbell separator exhibited a significant mean difference when compared to the Kesling separator (**-3.733, p=0.000**), the Brass wire separator (**-2.517, p=0.000**), and the Elastomeric separator (**-1.567, p=0.000**). The Elastomeric separator also showed a highly significant difference in pain perception when compared to the Kesling separator (**-2.167, p=0.000**), the Brass wire separator (**-0.950, p=0.000**), and the Dumbbell separator (**1.567, p=0.000**). These findings, as presented in **Table 5**, indicate that pain perception varied significantly among the different types of orthodontic separators, with Kesling and Dumbbell separators showing the most pronounced differences.

Conclusion

The present study demonstrated that all four orthodontic separators Kesling, Brass wire, Dumbbell, and Elastomeric produced a significant amount of separation between the molars and premolars by the fifth day. Among them, Dumbbell separators consistently achieved the greatest mean separation of 0.26 ± 0.12 mm on the fifth day. A statistically significant difference was observed in the separation effect of all four separators. Regarding stability, the Kesling separator exhibited the highest loss percentage at 11.7%, while the Dumbbell separator had the lowest loss rate at 1.6% over five days. In terms of pain perception, patients experienced the highest discomfort with Kesling separators (5.03 ± 0.956 mm), whereas Dumbbell separators caused the least pain (1.30 ± 0.462 mm). The superior separation effect of the Dumbbell separator compared to other separators may be attributed to its larger size, which facilitates greater space creation. Additionally, its design made it easier to place in patients with tight interproximal contacts. Furthermore, the Dumbbell separator was associated with the least pain and discomfort, making it a more favorable choice for clinical use.

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