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Original Research Article

Comparative Evaluation of the Separation Efficacy of Four Radiological Separator Types

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Abstract:

Background: Achieving adequate interproximal space between teeth is a fundamental prerequisite for band placement during fixed orthodontic therapy. Dental separators serve this purpose by temporarily displacing adjacent teeth without causing irreversible damage or significant patient discomfort. With advancements in material science, various radiologically visible separators have been developed to improve placement accuracy and clinical monitoring. However, a comparative evaluation of their separation efficacy remains underexplored, particularly within the Indian dental population.

Aim: To evaluate and compare the separation efficacy of four different radiologically detectable dental separator types using standardized interproximal space measurement techniques.

Materials and Methods: This randomized controlled clinical trial was conducted in the Department of Dentistry, Narayan Medical College, and Hospital, Sasaram, Bihar, India from May 2018 to April 2019. A total of 80 patients requiring orthodontic band placement were divided into four equal groups (n=20) based on the type of separator used: Elastomeric separators, Dumbbell separators, Radiopaque coil spring separators, and Radiopaque separating modules. The separators were placed interdentally between the maxillary first molar and second premolar. Standardized bitewing radiographs were taken pre-placement and at 24, 48, and 72 hours to evaluate the separation achieved. Measurements were recorded in millimeters using digital calipers on radiographic images.

Results: At 72 hours, all four separator types achieved clinically acceptable separation; however, the Dumbbell separator group showed the highest mean separation (0.42 mm ± 0.05), followed by Radiopaque coil spring (0.39 mm ± 0.06), Radiopaque separating module (0.36 mm ± 0.04), and Elastomeric separator (0.33 mm ± 0.03). Statistically significant differences were observed between groups at each time point ($p<0.05$).

Conclusion: Dumbbell separators demonstrated superior separation efficacy among the four evaluated types, followed closely by radiopaque coil springs. The findings suggest that material design and radiopacity significantly influence clinical performance. Careful selection of separator type can improve treatment efficiency and patient outcomes in orthodontic practice.

Keywords: Orthodontic separators, Dumbbell separator, Radiopaque separator, Interproximal separation, Bitewing radiography, Dental materials.

Introduction

Orthodontic treatment often requires precise mechanical control over tooth positioning, and the first clinical step in many fixed appliance therapies involves the placement of bands on molars. Adequate interproximal space is essential to ensure that these bands can be seated properly without causing undue trauma to the periodontal tissues or compromising the retention of the appliance [1]. To achieve this space, dental separators are used as temporary devices that gently push adjacent teeth apart. Their effectiveness, however, can vary significantly depending on their material composition, design, and application technique [2].

Over the decades, a variety of dental separator types have been introduced, including elastomeric separators, brass wire separators, spring separators, and more recently, radiologically visible separators. Traditional elastomeric separators, though widely used due to their ease of placement and cost-effectiveness, are limited by their relatively low visibility in radiographs and inconsistent performance in achieving uniform separation [3]. Newer separator types, particularly those incorporating radiopaque materials or modified design features such as the dumbbell shape or coil spring configuration, offer potential advantages in both clinical monitoring and mechanical efficiency [4,5].

The introduction of radiopaque separators has been particularly beneficial in avoiding misplacement or inadvertent embedding of separators in the gingival sulcus—an issue that, though preventable, can lead to complications such as localized gingival inflammation, pain, or even tooth mobility. Radiological verification allows clinicians to monitor separator positioning post-insertion, especially in patients with tight contacts or malaligned teeth, where visual confirmation may be challenging [6,7].

Despite these advancements, there remains a lack of comparative clinical data evaluating the separation efficacy of these different types, particularly within the Indian population where dietary habits, enamel thickness, and tooth morphology may influence separation outcomes. Furthermore, patient-specific factors such as age, occlusion type, and individual pain threshold may also affect the clinical success of a separator [8,9].

Given the central role of separators in initiating fixed orthodontic treatment, it is critical to identify those that provide maximum efficiency, minimal discomfort, and reliable radiographic traceability. This study was thus designed to evaluate and compare four commonly available radiologically visible separator types: Elastomeric, Dumbbell, Radiopaque Coil Spring, and Radiopaque Separating Module based on their ability to create measurable interproximal separation over time.

By conducting this investigation in a clinical setting at the Department of Dentistry, Narayan Medical College and Hospital, Sasaram, Bihar, the study aims to provide evidence-based recommendations on the most effective separator design for routine orthodontic practice in the regional population.

Aims and Objectives: The present study was designed to address the clinical need for efficient and safe interproximal separation in orthodontics, especially in cases where radiological confirmation is crucial. With multiple radiopaque separator designs now available in the market, identifying the most effective type can significantly impact treatment outcomes and chairside time.

Primary Aim

- To compare the separation efficacy of four different radiologically visible orthodontic separators Elastomeric, Dumbbell, Radiopaque Coil Spring, and Radiopaque Separating Module using standardized radiographic assessment.

Primary Objective

- To measure and compare the mean interproximal space created by each separator type at 24, 48, and 72 hours after placement using bitewing radiographs.

Secondary Objectives

- To evaluate the radiographic visibility and positional stability of each separator type during the observation period.
- To assess the ease of placement and removal for each separator from the clinician's perspective.
- To monitor for any immediate adverse events such as displacement, gingival irritation, or patient-reported discomfort following separator insertion.

Materials and Methods

Study Design and Setting: This was a prospective, randomized controlled clinical trial conducted in the Department of Dentistry, Narayan Medical College and Hospital, Sasaram, Bihar, India from May 2018 to April 2019. The study was approved by the Institutional Ethics Committee, and written informed consent was obtained from all participating patients prior to enrolment.

Sample Size and Population: A total of 80 patients (aged 15–30 years) who required orthodontic treatment involving molar band placement were recruited. Patients were selected from the outpatient department using simple random sampling. They were divided into four groups (n=20 each) based on the type of separator used.

Inclusion Criteria

- Patients aged between 15 to 30 years requiring molar band placement
- Good oral hygiene with no active periodontal disease
- Fully erupted maxillary first molars and second premolars
- Willingness to return for follow-up radiographs at 24, 48, and 72 hours

Exclusion Criteria

- Presence of caries, restorations, or mobility in teeth adjacent to separator site
- Pre-existing interproximal spacing between molars and premolars
- Allergies to any component of the separator materials
- History of systemic diseases affecting periodontal tissues

Intervention Groups

Participants were randomly assigned into the following groups using computer-generated random numbers:

- **Group A**: Elastomeric separators
- **Group B**: Dumbbell-shaped separators
- **Group C**: Radiopaque coil spring separators
- **Group D**: Radiopaque separating modules

All separators were placed interdentally between the maxillary first molar and second premolar on one side. A single trained clinician placed all separators to maintain uniformity.

Radiographic Evaluation

Standardized bitewing radiographs were taken at:

- **T0** (baseline before separator placement)
- **T1** (24 hours post-placement)
- **T2** (48 hours post-placement)
- **T3** (72 hours post-placement)

Digital images were obtained using a paralleling technique with fixed angulation. Radiographs were analyzed using digital calipers to measure the interproximal space at the contact point, and the degree of separation was calculated as the difference from baseline.

Clinical Assessment

- **Ease of Placement and Removal** was graded by the operator using a visual analogue scale (VAS: 0–10).
- Any **adverse events** such as separator loss, impaction, gingival irritation, or discomfort were documented.

Statistical Analysis: All data were compiled in Microsoft Excel and analyzed using SPSS version 25.0. The mean separation achieved by each group was expressed as mean ± SD. Inter-group comparisons were made using ANOVA with post hoc Tukey test. A p-value of <0.05 was considered statistically significant.

Results

A total of 80 patients were evaluated in this study, with equal distribution across four separator groups: Elastomeric (Group A), Dumbbell (Group B), Radiopaque Coil Spring (Group C), and Radiopaque Separating Module (Group D). The study focused on analyzing interproximal separation achieved at 24, 48, and 72 hours, along with additional parameters such as radiographic visibility, clinical handling, and adverse effects. The results demonstrated measurable separation in all groups, with significant differences observed between separator types. Dumbbell separators consistently outperformed others in terms of separation achieved and radiographic detectability. A detailed summary of the findings is provided through the following tables.

Table 1: Age Distribution of Participants

Age Group (Years)	Frequency	Percentage
15–20	29	36.3%
21–25	27	33.8%
26–30	24	30.0%

Table 2: Gender-wise Distribution Across Groups

Group	Male	Female	Total
A	7	13	20
B	8	12	20
C	9	11	20
D	6	14	20
Total	**30**	**50**	**80**

Table 3: Mean Interproximal Separation at 24 Hours

Group	Mean Separation (mm) ± SD
A	0.18 ± 0.03
B	0.24 ± 0.04
C	0.22 ± 0.03
D	0.20 ± 0.02

Table 4: Mean Interproximal Separation at 48 Hours

Group	Mean Separation (mm) ± SD
A	0.26 ± 0.04
B	0.35 ± 0.05
C	0.31 ± 0.04
D	0.28 ± 0.03

Table 5: Mean Interproximal Separation at 72 Hours

Group	Mean Separation (mm) ± SD
A	0.33 ± 0.03
B	0.42 ± 0.05
C	0.39 ± 0.06
D	0.36 ± 0.04

Table 6: Comparison of Separation Between Groups at 72 Hours (ANOVA)

Source	F-value	p-value
Between Groups	9.72	<0.001
Within Groups	-	-

Table 7: Radiographic Visibility Rating

Group	Visibility (VAS 0–10) ± SD
A	4.2 ± 0.7
B	8.1 ± 0.6
C	8.5 ± 0.5
D	6.7 ± 0.8

Table 8: Ease of Placement Score (Clinician Feedback)

Group	Placement Ease (VAS 0–10) ± SD
A	9.0 ± 0.5
B	7.4 ± 0.6
C	6.9 ± 0.7
D	7.1 ± 0.6

Table 9: Ease of Removal Score (Clinician Feedback)

Group	Removal Ease (VAS 0–10) ± SD
A	8.8 ± 0.4
B	8.2 ± 0.5
C	7.0 ± 0.6
D	7.3 ± 0.7

Table 10: Incidence of Adverse Events

Group	Separator Loss	Gingival Irritation	Total Events
A	1	2	3
B	0	1	1
C	2	2	4
D	1	1	2

Table 1 shows a predominant age distribution in the 15–20 range, reflecting the typical orthodontic age group. Table 2 highlights a higher proportion of female participants, which is common in aesthetic-driven orthodontic cases. Table 3, Table 4, and Table 5 collectively show a progressive increase in interproximal separation over 72 hours, with Group B (Dumbbell separators) consistently achieving the highest mean separation values. Table 6 confirms statistically significant intergroup differences at 72 hours. Table 7 establishes that radiopaque coil springs and dumbbell separators had the best radiographic visibility, an important factor in clinical assessment. Table 8 and Table 9 show that while elastomeric separators were easiest to place and remove, dumbbell separators still offered reasonable handling comfort. Table 10 concludes that adverse events were minimal across all groups, confirming safety and clinical acceptability of all four separator types.

Discussion

Interproximal tooth separation is a critical preliminary step in fixed orthodontic appliance therapy, particularly for accurate band placement. The efficacy of this procedure hinges on both the amount of space created and the ability to monitor separator position to prevent clinical complications such as soft tissue impingement or loss. In this study, we performed a comprehensive comparison of four different radiologically detectable separators to evaluate their effectiveness in interproximal separation, radiographic visibility, clinical handling, and safety [10,11].

The results clearly demonstrated that dumbbell-shaped separators produced the highest mean separation (0.42 mm at 72 hours) among all evaluated types, followed by radiopaque coil springs (0.39 mm), radiopaque separating modules (0.36 mm), and elastomeric separators (0.33 mm) [12]. These findings are in alignment with earlier reports by Proffit et al. and other contemporary orthodontic studies, which suggest that spring-type and anatomically contoured separators provide superior and sustained separation compared to simple elastomeric rings due to better force distribution and mechanical resilience [13].

Radiographic visibility is a vital clinical feature to monitor separator placement, especially in posterior regions with poor access or crowding. In our study, coil spring and dumbbell separators scored the highest in radiographic detectability, allowing clinicians to verify position during follow-up appointments [14]. This is particularly useful in pediatric or anxious patients where missing a displaced separator could lead to gingival embedding or infection. Elastomeric separators, though easy to apply and remove, scored lowest in radiographic visibility and showed less separation efficiency, reinforcing their limitations in complex orthodontic cases [15].

From a clinical handling perspective, elastomeric separators were rated highest in ease of placement and removal, making them ideal for short-duration or simple cases. However, dumbbell separators, despite requiring slightly more technique-sensitive placement, offered a good balance between separation performance and clinician usability. The feedback from operators suggests that while radiopaque coil springs are effective, their stiffness may pose challenges during insertion in patients with tight contacts or rotated teeth [16,17]. The adverse event rate was minimal in all four groups, supporting the safety of the separator types used. There was only occasional separator loss and transient gingival irritation, both of which resolved without intervention. These findings further validate the clinical acceptability of all four separator options in routine orthodontic practice [18,19].

The major strength of this study is its controlled, comparative design with uniform placement by a single operator and radiographic evaluation at consistent intervals. Additionally, this is one of the few studies to incorporate quantitative digital radiographic analysis, providing more objective separation measurements [20].

However, some limitations must be acknowledged. The study was restricted to interproximal sites between the maxillary first molar and second premolar, which may not reflect performance in tighter or more posterior contacts. The sample size, although adequate for comparative analysis, may limit generalizability across broader populations. Furthermore, patient discomfort and pain perception were not assessed, which are also relevant considerations in separator selection.

Overall, the study findings suggest that dumbbell-shaped and radiopaque coil spring separators offer superior performance in terms of separation efficacy and radiographic monitoring. Clinicians may opt for these types in cases demanding greater space or where radiographic verification is essential. In contrast, elastomeric separators, with their ease of use, remain suitable for simpler banding procedures or when minimal separation is sufficient.

Conclusion

The comparative evaluation of four radiologically visible orthodontic separators in this study demonstrated that dumbbell-shaped separators provided the greatest interproximal separation over a 72-hour period, followed closely by radiopaque coil spring separators. Both types also offered superior radiographic visibility, which is crucial for clinical safety and monitoring. Although elastomeric separators were easiest to place and remove, they showed the least separation efficacy and limited visibility. All four separators were well-tolerated, with minimal adverse events. Based on the findings, dumbbell and coil spring separators are recommended for cases requiring efficient separation and radiological verification, while elastomeric options may be reserved for simpler clinical situations.

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