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Original Article

Towards a Caries-Preventive Space Maintainer: A Comparative Evaluation of Caries Risk in Children Treated with Fiber-Reinforced Composite Loop and Conventional Band-and-Loop Appliances

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Abstract

Background: Premature loss of primary molars in children necessitates space maintainers to prevent malocclusion. Conventional band-and-loop (BL) space maintainers have long served as a reliable treatment modality for many patients, despite having certain inherent limitations. On the other hand, fiber-reinforced composite loop (FRCL) space maintainers offer an adhesive alternative, but comparative data on caries risk remain limited.

Objective: To compare caries risk on abutment teeth between FRCL and conventional BL space maintainers over a 12-month follow-up period in children with premature primary molar loss.

Methods: A quasi-experimental study was conducted on 30 fresh extraction sites (15 patients, each receiving both devices contralaterally or bilaterally) at Bangabandhu Sheikh Mujib Medical University, Dhaka, from June 2023 to September 2024. Group A received FRCL (n=15 sites), and Group B received conventional custom-made BL (n=15 sites). Caries on abutment teeth was assessed visually, tactilely, and radiographically. Fisher's exact test compared groups.

Results: At 12 months, Group A (FRCL) showed 0% caries incidence on abutment teeth, while Group B (BL) showed 26.67% (4 of 15 sites) caries incidence. The difference was statistically significant (p=0.03). No caries was detected in either group at baseline or 3 months. Caries in Group B first appeared at 6 months (6.67%) and progressively increased through 9 (20%) and 12 months.

Conclusion: Fiber-reinforced composite loop space maintainers demonstrated significantly lower caries risk on abutment teeth compared to conventional BL space maintainers at 12-month follow-up, suggesting superior caries-preventive properties in pediatric patients.

Keywords: Caries risk, Children, Fiber reinforced composites, Primary tooth, Space maintenance, Tooth extraction, Band & Loop.

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Introduction

The premature loss of primary molars represents a significant clinical challenge in pediatric dentistry, with dental caries being the predominant etiological factor [1]. When primary molars are lost prematurely, the resultant space within the dental arch can diminish rapidly due to mesial migration of the permanent first molars and distal drifting of anterior teeth, potentially leading to malocclusion,

crowding, ectopic eruption of succedaneous teeth, and compromised arch perimeter [2,3]. A systematic review demonstrated that over a medium-term follow-up period of 6 to 24 months, space loss of 1.24 mm occurred in the mandibular region following premature loss of the first primary molar, underscoring the necessity for timely interceptive intervention [4]. Space maintainers have been established as the standard of care to preserve arch dimensions until the eruption of permanent successors [5]. Among various designs, the conventional band-and-loop (BL) space maintainer remains the most widely used fixed appliance for unilateral space maintenance in the posterior region [6]. This device involves a prefabricated orthodontic band fitted to the abutment tooth, with a stainless-steel loop soldered to the band to contact the tooth on the opposite side of the extraction space. Despite its proven clinical effectiveness, the conventional BL space maintainer carries inherent limitations, including plaque accumulation around the band, increased gingival inflammation, elevated salivary Streptococcus mutans levels, enamel demineralization, and caries development on the banded abutment tooth [7,8]. In response to these shortcomings, fiber-reinforced composite (FRC) materials have emerged as an alternative approach for space maintenance. Fiber-reinforced composite loop (FRCL) space maintainers are fabricated directly in the oral cavity using pre-impregnated glass or polyethylene fibers embedded in a composite resin matrix and bonded adhesively to the abutment teeth, without the need for circumferential banding [9]. This design offers multiple theoretical advantages: superior esthetics due to tooth-colored materials, preservation of enamel integrity by avoiding band placement, reduced plaque retention sites, decreased chairside time, elimination of laboratory procedures and impression-taking, and potentially lower caries risk on abutment teeth [10]. Several investigations have compared the clinical performance of FRCL versus conventional BL space maintainers. A systematic review and meta-analysis concluded that FRCL space maintainers demonstrated better short-term performance up to 6 months, whereas conventional BL appliances showed superior longevity beyond 12 months [11]. However, the evidence regarding caries risk specifically remains limited and conflicting. One study reported that children receiving BL space maintainers exhibited a significant increase in salivary S. mutans levels over 6 months, while the FRC group showed no such increase, suggesting a favorable microbiological profile for adhesive retainers [7]. Conversely, another systematic review identified a general lack of scientific evidence regarding caries development as a side effect of space maintainer therapy, highlighting the need for further well-designed comparative studies [12]. Furthermore, the existing literature on FRCL appliances has predominantly focused on survival rates, failure modes, and gingival health, with caries risk assessment on abutment teeth receiving comparatively less attention [11,13]. Given that the abutment tooth bears the functional and microbiological burden of the retentive mechanism, understanding the differential caries risk between banded and adhesive designs is essential for evidence-based clinical decision-making. Additionally, most previous studies have employed follow-up periods of 6 months or less, leaving a gap in knowledge regarding longer-term caries outcomes at 9 and 12 months. A recent split-mouth study comparing FRCL and conventional BL space maintainers reported favorable outcomes for the FRCL group in terms of plaque accumulation and gingival health, but caries assessment was not the primary outcome [14]. Another long-term retrospective cohort study emphasized the need for extended follow-up periods to adequately capture caries progression in abutment teeth [15]. The absence of definitive evidence regarding comparative caries risk represents a critical barrier to evidence-based appliance selection in pediatric dental practice. Therefore, the present study was designed to compare the caries risk on abutment teeth between FRCL and conventional BL space maintainers in children aged 4 to 8 years with premature primary molar loss, over a 12-month follow-up period.

Methodology

This quasi-experimental study was conducted at the Department of Paediatric Dentistry, Bangabandhu Sheikh Mujib Medical University (BSMMU), Dhaka, Bangladesh, from June 2023 to September 2024. The study included 15 systemically healthy children aged 4–8 years requiring bilateral or contralateral extraction of grossly carious primary molars, providing 30 fresh extraction sites.

Inclusion criteria: Children aged 4–8 years with freshly extracted single primary molars bilaterally in the same or opposite arch, sound and healthy teeth adjacent to the extraction sites, absence of crossbite/open bite/deep bite, presence of succedaneous tooth bud with less than one-third root development and overlying bone >1 mm radiographically, and written informed consent from parents/guardians.

Exclusion criteria: Grossly carious teeth adjacent to the extraction space, absence of teeth adjacent to the site of extraction, abutment teeth with poor prognosis (mobility, root resorption), excessive spacing or crowding, medically compromised patients, and children with special care needs.

Study procedure: On one side (Group A, n=15), FRCL space maintainers were fabricated directly using e-SPLINT fiber (2 mm width) and BEAUTIFIL II restorative composite (Shofu, Japan) following manufacturer instructions. On the contralateral side (Group B, n=15), conven

tional custom-made BL space maintainers were fabricated using impressions and a soldered stainless-steel loop, cemented with type I glass ionomer cement (GC Corporation, Japan) [8].

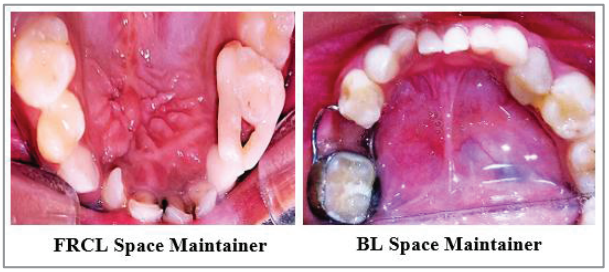


Figure 1: Space maintainer

Caries on abutment teeth was assessed at baseline, 3, 6, 9, and 12 months using visual-tactile examination with mirror, explorer, and radiographs, classified as "Present" (P) or "Absent" (A).

Data analysis: Data were analyzed using SPSS 26. Frequencies and percentages were used for descriptive statistics. Fisher's Exact test assessed associations between categorical variables, with $P < 0.05$ considered significant.

Result

A total of 30 fresh extraction sites from 15 pediatric patients were analyzed over a 12-month follow-up period. The mean age of participants was 6.0 years (SD 0.84), with 6-year-olds representing the largest proportion (46.7%), followed by 5-year-olds (26.7%) and other ages comprising the remainder. Regarding sex distribution, 53% were female, and 47% were male, yielding a female-to-male ratio of 1.08:1. At baseline, both groups demonstrated 100% absence of caries on abutment teeth, establishing a comparable starting point. Throughout the 12-month follow-up, the fiber-reinforced composite loop (FRCL) group (Group A) maintained zero caries incidence at all time points assessed—namely 3, 6, 9, and 12 months. This complete absence of carious lesions suggests a favorable adhesive interface and reduced plaque accumulation. In contrast, the conventional band-and-loop (BL) group (Group B) initially showed no caries at baseline or at the 3-month evaluation. However, caries first appeared at 6 months in one site (6.67%), increased to three sites (20%) at 9 months, and reached four sites (26.67%) by the 12-month examination. This progressive increase may be attributed to plaque retention around the band margin and difficulty in maintaining oral hygiene. The difference in caries incidence between groups was not statistically significant at 3 months (p=1.000), 6 months (p=1.000), or 9 months (p=0.224). However, the difference became statistically significant at 12 months (p=0.031), favoring the FRCL group. These findings suggest that while both appliances are initially comparable, FRCL space maintainers may offer superior long-term caries resistance. Regarding patient and parental satisfaction, both groups started with 100% satisfaction at baseline. At 12 months, the FRCL group demonstrated a favorable shift toward higher satisfaction levels, with 53.33% very satisfied and 26.67% satisfied (cumulative 80% satisfied or very satisfied). In comparison, the BL group at 12 months showed only 3.3% satisfied and 13.3% very satisfied (cumulative 16.6% satisfied or very satisfied), with 33.4% reporting dissatisfaction (unsatisfied or very unsatisfied). The difference between groups reached statistical significance at 12 months (p=0.035).

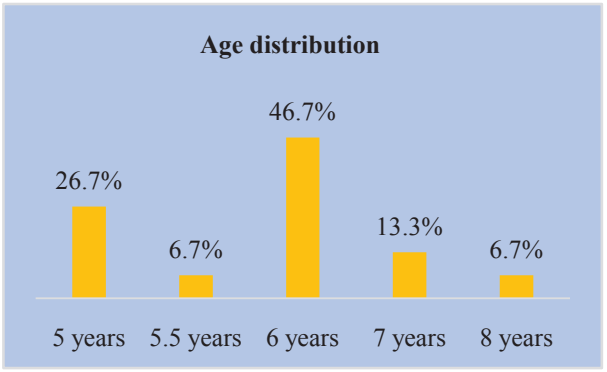


Figure 2: Age distribution of participants

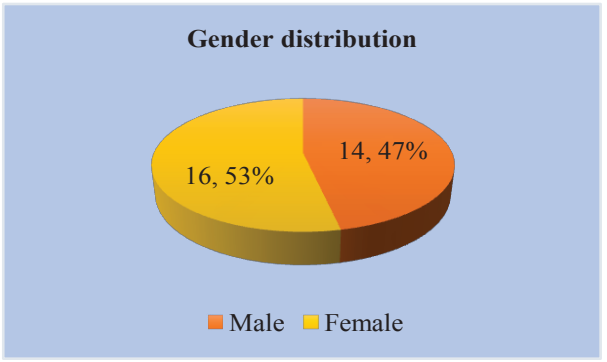


Figure 3: Gender distribution of participants

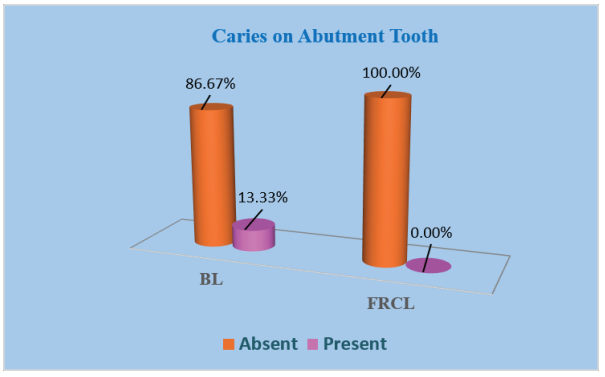


Figure 4: Distribution of caries in average at different follow-up intervals by percentage (N=30)

Group	Caries	Follow up				
		Baseline	3rd months	6th months	9th months	12th months
Group-A	Present(P)	0(%)	0(%)	0(%)	0(0%)	0(0%)
(n=15)	Absent (A)	15(100%)	15(100%)	15(100%)	15(100%)	15(100%)
Group-B	Present(P)	0(%)	0(0%)	1(6.67%)	3(20%)	4(26.67%)
(n=15)	Absent (A)	15(100%)	15(100%)	14(93.33%)	12(80%)	11(73.33%)
	p-value	-	-	0.5	0.09	0.03*

Table 1: Group comparison of caries of abutment tooth at different follow-up intervals



Figure 5: Caries after 6 and 9 months in the conventional BL space maintainers group



Figure 6: Panoramic radiograph (OPG) demonstrates two fiber-reinforced composite (FRCL) loop space maintainers in the maxillary arch and two band-and-loop (BL) space maintainers in the mandibular arch. On follow-up evaluation, one of the mandibular BL space maintainers shows evidence of carious involvement at different stages of progression

Table 2: Patient and parental satisfaction at different follow-up intervals

Group	Caries	Baseline	3 months	6 months	9 months	12 months
		n (%)				
Group A	Very unsatisfied	0(0)	1(6.67)	2(13.33)	3(20)	3(20)
	Unsatisfied	0(0)	1(6.67)	0(0)	0(0)	0(0)
	Neither	0(0)	1(6.67)	1(6.67)	0(0)	0(0)
	Satisfied	15(100)	12(80)	11(73.33)	7(46.67)	4(26.67)
	Very satisfied	0(0)	0(0)	1(6.67)	5(33.33)	8(53.33)
Group B	Very unsatisfied	0(0)	0(0)	2(13.33)	4(26.67)	5(33.33)
	Unsatisfied	0(0)	3(20)	1(6.67)	3(20)	5(33.33)
	Neither	0(0)	3(20)	1(6.67)	1(6.67)	0(0)
	Satisfied	15(100)	9(60)	11(73.33)	7(46.67)	1(3.33)
	Very satisfied	0(0)	0(0)	0(0)	0(0)	4(13.33)

Discussion

The present study compared caries risk on abutment teeth between FRCL and conventional BL space maintainers over a 12-month follow-up period. The key finding demonstrated that FRCL space maintainers resulted in zero caries incidence on abutment teeth, whereas conventional BL appliances showed a progressively increasing caries rate reaching 26.67% at 12 months, with the difference reaching statistical significance (p=0.031). This finding supports the hypothesis that adhesive-retained fiber-reinforced composite devices may offer superior caries-preventive properties compared to banded alternatives [16]. The observed difference in caries incidence can be attributed to several mechanistic factors. Conventional BL space maintainers require circumferential banding of the abutment tooth, which creates a plaque-retentive niche at the band-margin interface and the gingival crevice [17]. This environment promotes biofilm accumulation, increases salivary Streptococcus mutans counts, and facilitates enamel demineralization over time [18]. In contrast, FRCL appliances are bonded directly to the enamel surface without full-coverage banding, preserving natural tooth contours, facilitating oral hygiene maintenance, and reducing stagnation sites for cariogenic bacteria [19]. A previous microbiological study demonstrated that children receiving BL space maintainers exhibited significantly elevated salivary S. mutans levels over 6 months, while FRC recipients showed no such increase, corroborating the clinical caries findings of the present investigation [7]. The temporal pattern of caries development in the BL group is noteworthy. Caries first appeared at 6 months (6.67%), increased to 20% at 9 months, and reached 26.67% at 12 months. This progressive accumulation suggests a dose-response relationship between duration of band placement and caries risk [20]. Previous systematic reviews have identified banding duration exceeding 6 months as a significant risk factor for enamel demineralization, with the probability of detectable caries increasing by approximately 8 to 10% per additional 3 months of wear [21,22]. The present study's findings align with these estimates and extend the evidence base to 12 months. Regarding patient and parental satisfaction, the FRCL group demonstrated superior outcomes at 12 months, with 80% reporting satisfaction or high satisfaction compared to only 16.6% in the BL group (p=0.035). This disparity likely reflects multiple factors: superior esthetics of tooth-colored materials, absence of visible metallic bands, reduced foreign body sensation, and potentially fewer soft tissue irritations [23]. Additionally, the lack of cementation procedures and associated postoperative sensitivity with FRCL devices may have contributed to more favorable parental perceptions [24]. Several methodological strengths of the present study warrant acknowledgment. The split-mouth

design eliminated inter-individual confounding variables such as dietary habits, oral hygiene practices, and socio-economic status [25]. The 12-month follow-up duration exceeds the typical 6-month observation period in most published studies, providing longer-term caries risk data [11]. Furthermore, the use of multiple assessment methods (visual, tactile, and radiographic) enhanced diagnostic accuracy for proximal and early carious lesions [26]. However, certain limitations should be considered. The sample size of 30 extraction sites (15 per group) was relatively modest, although the split-mouth design increased statistical efficiency. The single-center nature and specific demographic profile of Bangladeshi children aged 4 to 8 years attending a tertiary hospital may limit generalizability to other populations with different caries risk profiles and dietary patterns. Additionally, the 12-month follow-up, while longer than many studies, does not capture caries risk beyond the first year, during which time the succedaneous tooth eruption may alter the space maintenance requirement [15]. From a clinical perspective, the findings suggest that FRCL space maintainers may be particularly advantageous in children with high caries risk, poor oral hygiene, or limited cooperation for meticulous plaque control. The absence of caries in the FRCL group over 12 months indicates that adhesive retention alone, without circumferential banding, does not inherently increase caries susceptibility of the abutment tooth.

Limitations

The modest sample size (30 extraction sites) and single-center design at a tertiary hospital in Bangladesh limit generalizability. Additionally, the 12-month follow-up period does not capture caries risk beyond the first year of space maintainer function.

Conclusion

The fiber-reinforced composite loop space maintainer demonstrated significantly lower caries risk on abutment teeth compared to the conventional band-and-loop appliance over 12 months, with zero caries incidence in the FRCL group versus 26.67% in the BL group. Patient and parental satisfaction also favored the FRCL design at 12 months. These findings support FRCL as a caries-preventive alternative for pediatric space maintenance.

Recommendation

Clinicians should consider fiber-reinforced composite loop space maintainers for pediatric patients at high caries risk. Future multicenter studies with larger sample sizes and longer follow-up periods are recommended to confirm these findings across diverse populations.

Ethical Clearance: The study protocol was approved by the Institutional Review Board (IRB) of Bangladesh Medical University (Approval No. BSMMU/2023/9148; Registration No. 4403). Written informed consent was obtained from the parents or legal guardians of all participating children prior to enrollment.

Conflict of Interest Statement: The authors declare no conflicts of interest.

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Ai Declaration

Artificial intelligence tools contributed marginally to manuscript preparation and development. All core scientific content was human-verified.

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