



## Fiber Technology in Space Maintainer: A Clinical Follow-up Study

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### ABSTRACT

Various space maintainers are used in pediatric dentistry. However, their construction requires time consuming laboratory procedures. Recently fiber-reinforced composite resin (FRCR) has been introduced for various application in dentistry. Polyethylene fibers appear to have the best properties in elasticity, translucency, adaptability, tenaciousness, resistance to traction and to impact. The purpose of this study was to clinically evaluate the long-term effect of FRCR space maintainer made with Ribbond® bondable reinforcement ribbon in children over a period of 18 months. A total of thirty FRCR space maintainers were applied to 30 children between the age group of 6 to 9 years old, follow-up visits were done at 1, 6, 12 and 18 months. The data obtained was subjected to statistical analysis. Maxillary appliances survived more than mandibular appliances. Mean survival time of space maintainer were found to be 12 months (minimum 1 and maximum 18 months). The present study suggested that FRCR space maintainers (Ribbond®), which was observed for up to 18 months, can be accepted as a successful alternative to conventional band-loop space maintainer only for short periods.

**Keywords:** Fiber-reinforced composite resin, Space maintainer, Polyethylene fibers, Bondable reinforcement ribbon.

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### INTRODUCTION

As a pediatric dentist, space management therapy is one of the most invaluable service that we can provide to our young patients. Early loss of primary teeth may result in drifting of both adjacent primary and permanent teeth and loss of space that can compromise the eruption of the succedaneous teeth and harm the normal occlusal development. Effective use of space maintainer can prevent or minimize the incidence of malocclusion by preserving the space.<sup>1</sup>

When a primary molar is missing prematurely a conventional fixed space maintainer is often used to preserve the space. Although these appliance are effective, they all have disadvantages such as multiple visits, time consuming laboratory procedures, disintegration of cements, caries formation, being embedded in gingival tissues, tipping or rotation of the adjacent teeth, breakage of solder joints and require cytotoxic solders.<sup>2,3</sup> These disadvantages reveal the need for designing new types of space maintainer. The technological advances that have occurred in the past few decades in dental materials for use in children necessitate constant re-evaluation of our treatment philosophies and techniques.

The use of fibers to improve the mechanical properties has been used in aerospace technology, automobiles and ships. The truth is, in lab tests and clinical use, fiber offers greater flexural strength than stainless steel, titanium or zirconia. Fiber is so strong; it is used in formula one race cars and the B-2 stealth bomber. With the popularization of dental composites, it is natural for fiber reinforcements to become a useful material in dentistry.<sup>4</sup> Different types of fibers are used in dentistry such as carbon fiber (unesthetic), glass fibers, polypropylene and polyethylene fibers. Glass fibers can pose health risk when inhaled resulting in silicosis-type problems.<sup>5</sup>

Polyethylene fibers can be used in pediatric dentistry to splint traumatized teeth, restore fractured teeth, as a space keeper, or in the postendodontic fixed retainers.<sup>6</sup> Previous studies done by Kargul et al<sup>7,8</sup> and Kirzioglu et al<sup>3</sup> used preimpregnated glass fiber to construct FRCR fixed space maintainers. Therefore, in the present study an attempt is made to evaluate the clinically performance of FRCR fixed space maintainer, made with Ribbond® non-preimpregnated polyethylene fibers in children over a period of 18 months.

## Subjects and Methods

Clinical cases done in this study was performed in the department of Pediatric Dentistry, College of Dental Sciences, Davangere, karnataka. After intraoral and radiographic examination (IOPA), children who had lost their first or second primary molar teeth early due to various reasons, with the need for space maintainers were selected.<sup>19</sup> Thirty children (12 boys, 18 girls) of age group 6 to 9 years old (mean  $\pm$  SD,  $7.9 \pm 1.1$  years) were included in this study (Table 1).

Patient selection criteria were:

1. Absence of pathology.
2. Presence of succedaneous teeth.
3. Presence of teeth on mesial and distal side of the space to be maintained.
4. Absence of the root resorption of the abutment teeth.
5. Presence of bony crypt over the succedaneous tooth germ.
6. Presence of class I occlusion and normal primary molar relations.<sup>2,3</sup>

Parents and children were informed about the clinical trial and new material being used. Informed parental consent

**Table 1:** Distribution of FRCR space maintainers according to age and gender

Age	Boys	Girls
6 Years	1	3
7 Years	3	5
8 Years	2	2
9 Years	6	8
Total	12	18

was obtained before commencing the study. The research protocol of the study was reviewed and approved by the ethical committee of the institution.

## Materials Used (Fig. 1)

Ribbon®-THM (Thinner Higher Modulus) - Ribbon, Inc, USA.

Ultra-etch® gel (Ultradent Products, Inc, USA).

PQ1® - (Ultradent Products, Inc, USA).

Permaflo® - (Ultradent Products, Inc, USA).

Teeth adjacent to the space were evaluated (Fig. 2). Any caries or old restorations were removed and drilled grooves or roughened the surfaces where needed.<sup>7,8</sup> Space to be maintained was measured intraorally, two strips of



**Fig. 1:** Materials used



**Fig. 3:** Post-treatment



**Fig. 2:** Pretreatment



**Fig. 4:** Review after 12 months

nonimpregnated Ribbond®-THM bondable reinforcement ribbon was cut using manufactures scissors or BP blade no 12 to proper length. Cut Ribbond®-ribbons should not be touched with bare fingers or gloves until it is wetted with bonding agent according to the manufactures guide.

The prepared teeth surfaces were cleaned with pumice, etched using Ultra-etch® 35% phosphoric acid gel, rinsed dried lightly and wetted with PQ1® bonding agent twice, dried lightly and light-cured. A thin layer of Permaflo® flowable composite was applied on the buccal surfaces of adjacent teeth. Wetted Ribbond®-ribbon strip was positioned properly, with a rounded instrument to create close contact during curing process. Same was repeated on the lingual side. Flowable composite was further added to cover the exposed Ribbond®-ribbons and finally cured for 40 seconds.<sup>15,16</sup> Final finishing and polishing were done. Occlusion was checked and excess composite were removed (Fig. 3).

Oral hygiene instructions and motivations were given to the children. The children and parents were instructed to indicate if an appliance was loosened or dislodged. The children were recalled and examined at 1, 6, 12 and 18 months (Figs 4 to 6).

Following criteria's were used to assess the clinical performance of FRCR space maintainer in the recall visits:

1. Present in good condition.
2. Debonding between tooth and FRCR space maintainer.
3. Debonding between Ribbond® ribbons.
4. Fracture of FRCR space maintainer.
5. Lost or missing.
6. Inflammation of adjacent tissues.

Appliances removed during study period due to eruption of succedaneous permanent tooth or due to failures were recorded. Complete data collected in following recall visits were processed using SPSS (statistical program for social science) version 11.0 soft ware for Windows. Statistical analysis was performed using Fishers exact Test and Kaplan Meiner survival analysis (Graph 1).

### RESULTS

A total of 30 space maintainers, at the end of 6 months, 5 (16%) appliances were failed, 4 (13%) were due to debonding between tooth and appliance and 1 (3%) was lost. At the end of 12 months 14 (47%) were in position out of which 6 (20%) were removed due to eruption of succedaneous permanent tooth. Out of 16 (53%) failures, 11 (37%) were due to debonding between tooth and appliance, 4 (13%) were debonding between Ribbond® ribbons and 1(3%) was lost.

At the end of 18 months, out of 30 FRCR space maintainers:

1. Success and functioning — 4 (13%).
2. Success and removed — 6 (20%).
3. Failure due to debonding between tooth and appliance 15 (50%).
4. Failure due to debonding between Ribbond® ribbons 4 (13%).
5. Lost – 1 (4%).

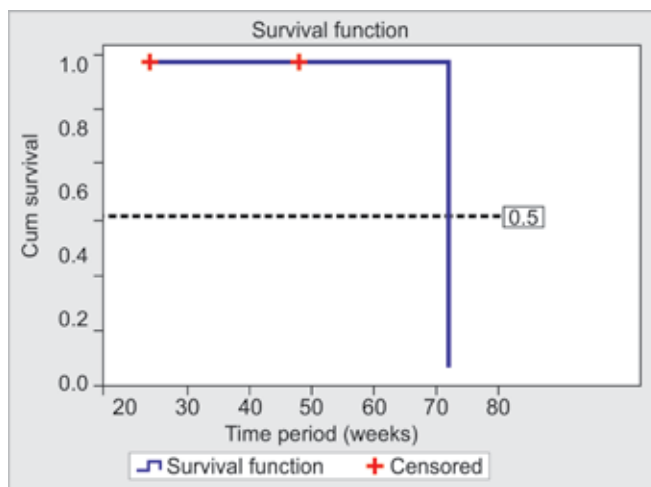
Maxillary FRCR space maintainers survived more than the mandibular space maintainers. There was a significant statistical difference between maxilla and mandibular appliance ( $p < 0.05$ ). Mean survival time of space maintainer



Fig. 5: Review IOPA after 12 months



Fig. 6: After removal of FRCR space maintainer



Graph 1: Survival curves of FRCR space maintainers

were found to be 12 months (minimum 1 and maximum 18 months). There was a tendency; however, for plaque accumulation at the gingival areas on the abutment teeth more easily than when space maintainers were not placed (Table 2).

## DISCUSSION

Ribbon® (Ribbon Inc, Seattle, USA) is a cross-linked leno stitch weave made of ultrahigh molecular weight polyethylene fiber that has an ultrahigh modulus. Ribbon® bondable reinforcement ribbon is a spectrum of 215 fibers with a very high molecular weight. These fibers have a very high coefficient of elasticity (117GPa) this means an excellent resistance to stretch and distortion.<sup>18</sup> They also have a very high resistance to traction (3GPa), a result of their 'closed stitch' configuration and a good adaptability. Ribbon fibers are also characterized by impact strength five times higher than that of iron. They are translucent and assume the color of the resin to which they are added. Ribbon fibers easily absorb water because of the 'gas-plasma' treatment to which they are exposed. This treatment reduces the fibers superficial tension, ensuring a good chemical bond to composite materials.

In this clinical study we used single syringe (PQ1®), 5th generation bonding agent and Perma flo® flowable composite. As per manufacture both are fluoride releasing materials and it may act as an intraoral fluoride releasing device. It was stated that the flow composite, because of their thixotropic qualities, could better adapt to the difficult places to access and that lower air bubbles could emerge during the application.<sup>2</sup> Previous studies Kargul et al<sup>8</sup> observed 43% success of 23 FRCR space maintainers at the end of

12 months. Kirzioglu et al<sup>3</sup> showed 27% success of 40 splint-it appliances at 6 months and 13% at 12 months. Swaine and Wright<sup>9</sup> reported 30% failure of stainless steel wire bonded space maintainers at the end of 6 months. Simsek et al<sup>2</sup> evaluated the clinical performance of simple fixed space maintainers bonded by using a flowable composite resin for 12 to 18 months and they concluded 95% success rate. In this clinical study, at the end of 6 months 83% were success, 47% success at 12 months and 33% success at 18 months. There was a significant statistical difference between success and failure ( $p < 0.05$ ). The difference in success rate in our study from above studies may be due to use of Ribbon® bondable reinforcement ribbon, nonpreimpregnated polyethylene fibers.<sup>17</sup>

Maxillary appliances survived for longer duration than mandibular appliances. The possible explanation for high rates of failure in mandible may be due to difficulty in salivary isolation, not completely obtained in children.<sup>7-9</sup> Fifty percent of failure in this study was due to debonding between tooth and the FRCR space maintainer. Zachrisson<sup>11</sup> reported the main reason for this type of failure as improper surface preparation, moisture contamination, and/or disturbance during the setting process of the adhesive.<sup>10</sup> Thirteen percent failure was due to debonding between the Ribbon® fiber strips. The main reason for this type of failure is the addition of insufficient composite to cover the appliances, at the bonding site. Another possible reason is salivary isolation cannot be completely obtained in children.<sup>9</sup> Although the children's were strictly instructed not to bite on hard objects at the site of appliance, 1 out of 30 appliances were lost at the end of 18 months. Fracture of fiber frame was not observed in any cases.

**Table 2:** Summary of criteria's used to assess the clinical performance of FRCR space maintainers at different time intervals\*

Criteria's		1 month		6 months		12 months		18 months		p-value
		N	%	N	%	N	%	N	%	
Present in good condition	Yes	30	100	25	84	14	47	4	13	<0.05 (S) <sup>†</sup>
	No	-	-	5	16	16	53	26	87	
Debonding between tooth and FRCRSM <sup>‡</sup>	Yes	-	-	4	13	11	37	15	50	<0.05 (S) <sup>†</sup>
	No	30	100	26	87	19	63	15	50	
Debonding between Ribbon ribbons	Yes	-	-	-	-	4	13	4	13	<0.05 (S) <sup>†</sup>
	No	30	100	30	100	26	87	26	87	
Fracture of FRCRSM	Yes	-	-	-	-	-	-	-	-	1.00 (NS)
	No	30	100	30	100	30	100	30	100	
Lost	Yes	-	-	1	3	1	3	1	3	<0.49 (NS)
	No	30	100	29	97	29	97	29	97	
Inflammation	Yes	-	-	3	10	5	16	5	16	<0.05 (S) <sup>†</sup>
	No	30	100	27	90	25	84	25	84	
Removed during study due to Permanent tooth eruption	Yes	-	-	-	-	6	20	6	20	<0.05 (S) <sup>†</sup>
	No	30	100	30	100	24	80	24	80	
Removed due to failure	Yes	-	-	5	16	16	53	20	67	<0.01 (S) <sup>†</sup>
	No	30	100	25	84	14	47	10	33	

\* Fisher's exact test; <sup>†</sup>S = Significant, NS = Not significant; <sup>‡</sup>FRCRSM: Fiber reinforced composite resin space maintainer

Qudeimat and Fayle<sup>13</sup> investigated the longevity of 301 space maintainers fitted in 141 patients aged 3.4 to 22.1 years. Failure occurred in 190 space maintainers (63%), of which 36% was due to cement loss, 24% due to breakage, 10% due to design problems and 9% were lost. Using the life table method, the median survival time for space maintainers was found to be 7 months. Kargul et al<sup>8</sup> evaluated 23 FRCR space maintainer over a period of 12 months and found the mean survival time of failed space maintainers to be 5 months. Kirzioglu et al<sup>3</sup> evaluated 40 splint-it space maintainers over a period of 24 months and found mean survival time to be 5.7 months. In this clinical study, the mean survival time of FRCR space maintainers was found to be 12 months (minimum 1 and maximum 18 months).

Although the patients were given oral hygiene training during the follow-up evaluation periods of the space maintainers placed, it was observed that there was an accumulation of plaque in the abutment teeth, but there was no decalcified area or cavity.<sup>2,3,12</sup> Prush<sup>13</sup> expressed that decalcification of the enamel and occurrences of caries are common problems in the abutment tooth where the orthodontic band of the band-loop space maintainers is present. McDonald and Avery<sup>14</sup> suggested that band and loops should be removed once a year to clean, and apply fluoride to the tooth. FRCR space maintainers eliminate these annual steps and offer several benefits, as reported by Kargul et al<sup>7,8</sup> are esthetics, easy acceptance of patients, less time consuming (single visit), good bonding property, adaptable to tooth contour, strength to Weight ratio is superior than most alloys, no tarnish and corrosion, can be used in metal allergy, biocompatible, natural feel and ease of repair.

## CONCLUSION

Ribbon<sup>®</sup> bondable reinforcement ribbon space maintainer can be accepted as a successful space maintainer only for short periods. Finally, it was observed that success rate depends on operator experience, isolation and the choosing of favorable patient groups.

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