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A CLINICAL EVALUATION OF COMPOSITE RESIN SPACE MAINTAINERS REINFORCED WITH GLASS FIBRES

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ABSTRACT

Background: The primary dentition performs a variety of vital roles in children's ongoing development and well-being. Speech, mastication, aesthetics, avoiding bad dental habits, and directing the erupting permanent teeth are all significantly impacted by an undamaged primary arch[1]. Early loss of the primary teeth is a very common dental problem. The premature loss of primary molars, notably, may lead to numerous types of malocclusions[2]. To avoid malocclusion due to premature loss of the primary teeth, clinicians may advise various types of space maintainers (removable or fixed appliances), depending on the child's stage of dental development, the dental arch involved, and the location of the missing primary teeth.

Objectives: This study evaluates the use of glass fiber–reinforced composite resin (GFRCR) as a space maintainer and compares it with the traditional band-and-loop space maintainer**.**

Materials and Methods: Twenty children (12 boys and 8 girls) aged 5-8 years with missing primary molars were selected. A band-and-loop space maintainer was cemented in one quadrant, and a GFRCR space maintainer was applied in the other. Patients were recalled at regular intervals over nine months, and the caries, soft tissue response, retention, and space maintenance of both types of space maintainers were assessed.

Results: The study's findings demonstrated that GFRCR space maintainers outperformed band-and-loop space maintainers in terms of soft tissue response and caries resistance during a mid-term evaluation. Both types of space maintainers were effective in preserving space.

Conclusion: GFRCR space maintainers are suitable as effective appliances for brief periods

Keywords**:** Band-and-loop, glass fiber-reinforced composite resin, space maintainer

INTRODUCTION

The primary dentition performs a variety of vital roles in children's ongoing development and well-being. Speech, mastication, aesthetics, avoiding bad dental habits, and directing the erupting permanent teeth are all significantly impacted by an undamaged primary arch[1].

Early loss of the primary teeth is a very common dental problem. The p remature loss of primary molars, notably, may lead to numerous types of malocclusions [2]., To avoid malocclusion due to premature loss of the primary teeth, clinicians may advise various types of space maintainers (removable or fixed appliances), depending on the child's stage of dental development, the dental arch involved, and the location of the missing primary teeth. Although removable space maintainers have certain advantages, such as being easier to clean and allowing better maintenance of oral hygiene, they may be removed and worn at the whim of the patient and may be broken or lost easily and, if they are not used properly, they will not be effective [3]

On the other hand, because they are worn constantly for a longer amount of time, fixed appliances, if properly developed, are less harmful to the oral tissues and less annoying to both the patient and the dentist[3]. According to reports, both patients and dentists prefer a well-designed fixed space maintainer over a removable appliance[4]. The most popular fixed space maintainers for posterior tooth loss are pedodontic crowns or wires soldered to bands. Despite being long-lasting and well-tolerated, these fixed equipment do not return to normal operation[5]. In order to examine, clean, and apply fluoride to the teeth, it has also been proposed that the band-and-loop space maintainer be taken out once a year[6].

The ability to evaluate novel materials for use as space maintainers is made possible by modern technologies. New to the paediatric dentistry market, glass-fiber reinforced composite resins (GFRCRs) offer an alternative for maintaining space. GFRCRs have drawn more attention in the field of dentistry. In recent years, they have been created for use in dentistry.[7]

A translucent-colored, semi-manufactured product, Splint-it® (Jeneric/Pentron, Walford, Conn) is composed of unidirectional fibres that enhance the finished product's strength and stiffness perpendicular to the fibres' direction[7]. Therefore, the current study's objective was to assess GFRCR's performance as a

space maintainer and contrast it with the traditional band-and-loop space maintainer.

MATERIALS AND METHODS

A total of 20 children, comprising 12 boys and 8 girls, aged 5 to 8 years, were selected for the study from the patients attending the Paediatric Dentistry Department clinic, Faculty of Dentistry, Najran University. The selected children had bilateral primary molars that were indicated for extraction or that have been recently extracted. A total of about 40 space maintainers were placed in 20 children, they were assigned to two groups. In **Group I (test group):** 20 GFRC space maintainers were placed on one side. While in **Group II (control group):** 20 band and loop space maintainers were placed on the contra lateral side.

For each participant in the study, a concise medical history was documented, followed by a thorough clinical examination. Intraoral periapical radiographs were obtained in the regions of tooth loss. Impressions were taken, study models were created, and the space span was measured in accordance with the methodology established by Lin YT and Chang LC[8]. The inclusion criteria for the study are detailed in [Table 1].

Table 1. Criteria for patient selection

A. *Clinical criteria*:[9, 10]

- Bilateral primary molars that are indicated for extraction or that have been recently extracted with no space loss.
- Presence of teeth on mesial and distal side of the edentulous area.
- Buccal surfaces of abutment teeth free from caries.
- Presence of Class I occlusion or normal primary molar relations.
- Absence of any pathological lesions.
- Absence of malocclusion or abnormal oral musculature.
- Absence of any systemic diseases.

B. *Radiographic criteria:* [9, 10]

- Presence of succedaneous teeth with no more than 1/2 of their roots formed.
- Root resorption of the abutment teeth should be less than1/3 of their root length.
- Presence of the bony crypt over the succedaneous tooth germ.

The treatment plan was communicated to the parents, and their written consent was secured prior to the commencement of the study. For each selected child, oral prophylaxis and additional restorative treatments were performed before the placement of space maintainers. In one quadrant, a GFRCR space maintainer was applied, while in the opposite quadrant, a band-and-loop space maintainer was cemented.

Technique

The required length of the Splint-it®(Jeneric/Pentron,Wallingford,Conn) strip was measured on study cast or inside the patient's mouth using a dental floss. After administration of adequate anesthesia, rubber dam was used to isolate along with suction. Both buccal abutment tooth surfaces underwent cleaning with non-fluoridated pumice paste, followed by acid etching with 37% phosphoric acid for a duration of 30 seconds (15 seconds for the permanent teeth). The teeth underwent rinsing, followed by air drying, and were subsequently treated with an adhesive (Adper

Single Bond-2® 3M), which was light-cured for a duration of 20 seconds. A thin layer of flowable composite (Filtek Z350® 3M) was applied to the buccal surfaces of the abutment tooth without undergoing light-curing. The fiber strip was gently pressed into the layer of flowable composite using a plastic filling instrument and light cured for 30-40 seconds. A layer of flowable composite was subsequently applied over the cured Splint-it® fibre. The space maintainer underwent an evaluation for gingival clearance and occlusal interference. The finishing process was accomplished utilising composite finishing burs.

In the opposite quadrant, a traditional band-and-loop space maintainer was utilised, following the technique

outlined by Graber[9] and Finn.[10]

Guidelines on the oral hygiene along with the appliance maintenance were provided to both children and their parents. They were directed to return immediately if any appliance became loose, dislodged, or damaged.

All patients were recalled after one week to assess any complaints, followed by additional recall visits scheduled at three, six, and nine months for the evaluation of both types of space maintainers. The evaluation of the available space was conducted utilising a boley gauge, as outlined by Lin YT and Chang LC [8]. Retention was assessed based on the criteria established by Kirzioglu and Erturk[2] and Qudeimat and Fayle[11][Table 2].

Table 2. Retention criteria for space maintainers

Retention criteria for GFRCR [2]. Failure was considered if debonding occurred at the following areas: • Fiber-composite interface. • Enamel composite interface. • Fracture of the fiber frame. **Retention band and loop [13].** Failure was considered if the following occurred: • Loss of the space maintainer • Solder failure • Breakage of the space maintainer

The inflammatory condition of the soft tissue was evaluated using the gingival index, following the methodology of Loe and Silness [12]. Additionally, dental caries were examined in accordance with the International Caries Detection and Assessment System (ICDAS)[13].

In the course of evaluation, space maintainers were removed in instances of failure and subsequently either repaired or replaced; such cases were excluded from further evaluation in the study.

Statistical analysis

The data obtained was tabulated using the McNemar test and Log rank test was used for comparison of mean survival times of appliances. Significance was set at the 5% level. Analysis was done using SPSS software version 13. (SPSS Inc., Chicago Ill, USA).

RESULTS

The present study included 20 children (12 boys and 8 girls), aged 5-8 years with a mean age of 6.7 ± 1.0 years. The selected children had two similar bilateral missing primary molars; each received two types of space maintainers. GFRC space maintainers were placed on one side and band and loop space maintainers were placed on the contra lateral side [Figure 1]. All cases were available to follow up at 3, 6 and 9 months so the only excluded cases were those that failed.

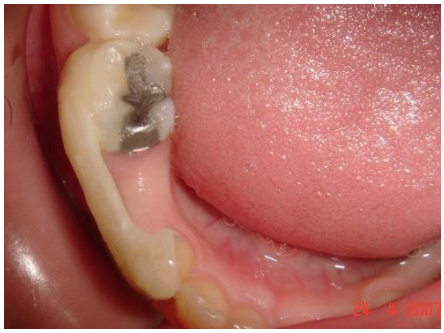

Figure 1. GFRCR

Figure 2. GFRCR Failure

After 3 months, 16 (80%) of GFRC appliances (Group I) remained retentive and 4 appliances failed. Of these failed appliances, one (5%) showed failure between fiber-composite interface and three (15%) showed failure between enamel-composite interface [Figure 2]. After 6 months, 10 (50%) appliances remained retentive and 6 (37.5%) failed between enamel-composite interface. After 9 months, these 10 (50%) appliances continued to remain retentive [Table 3].

Figure 3. Band and **loop**

Figure 4. Band broken Failure

Figure 5. Solder Failure

Regarding band and loop space maintainers [Figure 3], (Group II), After 3 months, 17 (85%) appliances remained retentive, while 3 failed. Of the failed space maintainers, 2 (10%) were lost and 1 (5%) had its band broken. [Figure 4] After 6 months, 14 (70%) remained retentive, while 3 failed. Of these failed, 2 (11.8%) were lost and 1 (5.9%) showed solder failure [Figure 5].

Table 3. Retention in GFRCR appliance (Group I) at different follow up period.

	BASELINE N (%)	AFTER 3 MONTHS N (%)	AFTER 6 MONTHS N (%)	AFTER 9 MONTHS N (%)
Retentive	20 (100)	16 (80)	10 (50)	10 (50)
Failure at fiber composite interface	-	1 (5)	-	-
Failure at enamel composite interface	-	3 (15)	6 (37.5)	-
Fracture of the fiber frame	-	-	-	-

After 9 months, 12 (60%) remained retentive and 2 failed, one showed solder failure and the other had its band broken (7.1% each) [Table 4].The difference between the two groups was not statistically significant (P=1.00) Table 5.

Table 4. Retention in band and loop appliance (Group II) at different follow up period.

	BASELINE N (%)	AFTER 3 MONTHS N (%)	AFTER 6 MONTHS N (%)	AFTER 9 MONTHS N (%)
Retentive	20 (100)	17 (85)	14 (70)	12 (60)
Loss of space maintainer	-	2 (10)	2 (11.8)	-
Solder failure	-	-	1 (5.9)	1 (7.1)
Breakage of the space maintainer	-	1 (5)	-	1 (7.1)

Table 5. Comparison between GFRCR and band and loop as regards retention at different follow up period

	GFRCR N (%)	band and loop N (%)	P of McNemar test
Baseline	20 (100)	20 (100)	-
After 3 months	16 (80)	17 (85)	1.00 NS
After 6 months	10 (50)	14 (70)	0.38 NS
After 9 months	10 (50)	12 (60)	1.00 NS
P value of McNemar test*	1.00 NS	0.50 NS	

NS: Not statistically significant

*P value of McNemar test : difference between baseline and 9 months

Regarding soft tissue response and resistance to caries, no caries was observed in group I with only one case presented with mild gingival inflammation. While in group II, 5 cases showed signs of caries on their abutment teeth and 4 cases demonstrated gingival inflammation,with no statistically significant difference between two groups regarding soft tissue response and resistance to caries.

Both types of appliances had equal efficiency in maintaining the space, with no statistically significant difference between two groups.

The average survival time for retentive GFRC space maintainers was determined to be 6.8 months. The duration for band and loop space maintainers was 7.2 months, with no significant difference observed between the two groups.

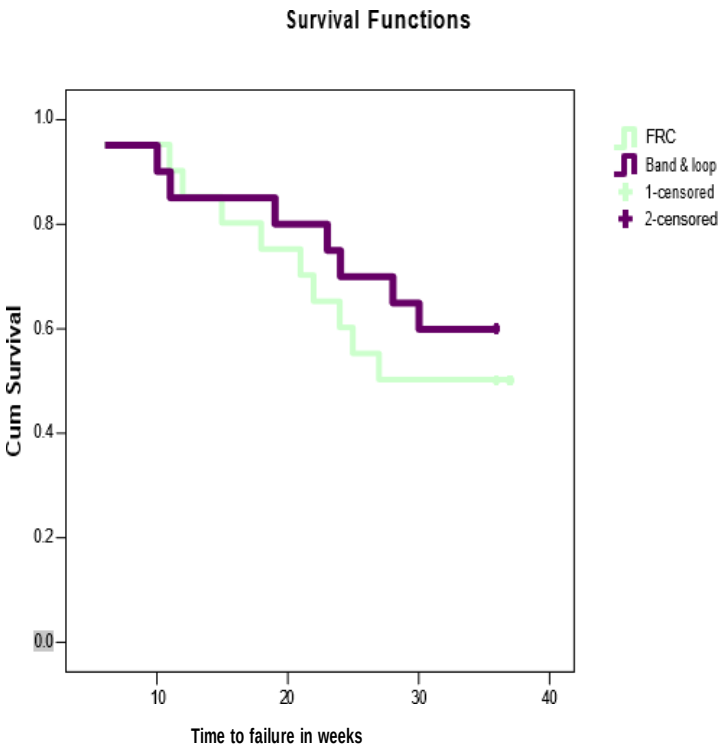

Figure 6. Comparison of mean survival time in weeks between GFRCR and band and loop

DISCUSSION

Directly bonded GFRCR space maintainers were recently introduced as a an alternative to conventional fixed space maintainers, they were chosen for their biocompatibility, esthetics, ease of manipulation and they generally require one visit procedure without requiring laboratory services[2].

On the other hand, band and loop space maintainers represent the most reliable and the most widely used space maintainer to maintain space for a single missing tooth. These appliances can be easily adjusted to accommodate changes in dentition. However, there are drawbacks, including the potential for cement disintegration, challenges in preventing the rotation and tipping of abutment teeth, a propensity for embedding in gingival tissues or promoting caries formation, the requirement for a cast or model, the necessity of a second visit, and the risk of metal allergy.[2,3] These limitations of the conventional type of space maintainers indicate the need for newer materials and designs of the appliances.

This study was carried out to evaluate and compare the clinical performance of Glass Fiber Reinforced Composite Resin (GFRCR) as a fixed space maintainer and the traditional band and loop space maintainer, regarding their efficiency in preventing space loss, retention and soft tissue response. The selected cases in this study had bilateral missing primary molars, so as to unify the systemic factors affecting the space maintainer under comparison.

Regarding the retention of GFRCR space maintainers in this study, 10 space maintainers were dislodged at the end of follow up period with 50% success rate. In comparison with other studies done on the same material, Kirzioglu and Erturk (2004)[2] reported a success rate of 27%. While Kargul et al (2005) [7] obtained a success rate of 43% using the same space maintainer. The higher success rate in the current study is due to the use of rubber dam leading to an effective isolation.

In the present study, the GFRCR space maintainers that are placed on primary teeth showed a higher failure rate than those placed on permanent teeth. A result which is supportive by the findings of Swaine and Wright (1976) [14], Artun and Marstrander (1983)[15], Santos et al (1993)[16], Kirzioglu and Erturk (2004)[2] and Simsek et al (2004)[17].

I The low success rate in primary teeth can be attributed to the presence of prismless enamel areas, which may adversely affect resin retention. On the other hand, studies have shown that newly eruptive permanent teeth are conductive to efficient acid etching [14, 15].

Regarding the retention for band and loop space maintainers showed 60% success rate. A comparable result was reported by Hill et al (1975) [18], where they got a success rate of 68%. On the contrary, higher success rates were observed by other researchers [11, 19, 20].

Comparing both groups regarding their retention there was no statistical significant difference at different follow up periods. However, a statistical significant difference in retention was seen between baseline and 6 months for GFRC space maintainers, because most of the failed appliances occurred at 6 months. Thus GFRC appliances worked efficiently until the end of 6 months which was consistent with the findings of Kirzioglu and Erturk (2004) [2] and Kargul et al (2005) [7]. The conclusion drawn is that the GFRC space maintainer may be regarded as an effective appliance, albeit only for limited durations.

However, when considering the failures that occurred for GFRCR space maintainers in the present study, most of the cases showed failure between the enamel and the composite. The same findings were observed by Artun and Marstrander (1983) [15], Kirzioglu and Erturk (2004) [2] and Kargul et al (2005) [7].

Zachrisson (1997) [21] reported that the reasons for these failures was improper surface preparation, moisture contamination and /or disturbance during the setting process of the adhesive. It was found that to obtain a strong bond, it is important that the setting process of the material was not disturbed by moving the appliance. If the setting process was disturbed, fracture lines would spring up in the material and the appliance might become loose shortly afterwards [15].

Another possible reason for this type of failure, was that the placement of the rubber dam clamp on abutment teeth yielded a diminished working area vertically (occluso gingivally) which led to placement of some appliances closer to the occlusal surface. Possibly greater occlusal forces were exerted on the appliance in those cases[14].

Although the patients were strictly instructed not to bite on hard food, two appliances failed while chewing hard food and one following facial trauma.

Failure between fibre and composite was observed in a single instance. The likely cause of this failure is attributed to premature contact, specifically an occlusal interference. This finding aligns with the observations made by Artun and Marstrander (1983)[15] and Santos et al. (1993)[16]. It has been proposed that occlusal trauma could present a significant issue, particularly concerning the first permanent molars shortly after their eruption, as the bonding area is frequently constrained by the rubber damclamp[15,16].

The fibre frame fracture was not detected in any instance. The observed phenomenon can be attributed to GFRCR's superior transverse strength and rigidity, along with its exceptional mechanical properties, achieving strength levels up to seven times that of conventional composites [22,23]. The flexural strengths of 1mm thick samples can reach up to 1000 MPa [22.]

Regarding the failures for band and loop space maintainers in the present study, the main problem encountered was the loss of the space maintainer; they were removed by the children or parents at home. This accounted for 21% of the cases studied. Similar results were obtained by Hill et al (1975) [18], Baroni et al (1994) [19] and Qudeimat and Fayle (1998) [11] .The main reason for lost space maintainers in this study was caused by the excessive manipulation of the space maintainers by the patient with his tongue, fingers and other means. Moreover, loss of cement

may be attributed to this failure as concluded by Baroni et al (1994) [19] and Qudeimat and Fayle (1998) [11]. Cement loss represented 33% and 36% respectively of failed space maintainers.

The breakage of space maintainers and solder failures are ranked as the second most common type of failure. Previous studies have determined that the majority of mechanical failures, including solder failure and breakage of space maintainers, can be attributed to subpar construction quality. Factors contributing to these failures include incomplete solder joints, overheating of the wire during the soldering process, wire thinning due to polishing, residual flux on the wire, and inadequate encasement of the wire in the solder.[18,19,24].

Regarding the efficiency of GFRCR space maintainers in maintaining space, the appliance was efficient. This was in accordance with the results found by Kirzioglu and Erturk (2004) [2] and Kargul et al (2005) [7]. The same result was also obtained by Swaine and Wright (1976) [14], Santos et al (1993) and [16] Simsek et al (2004) [17] using the direct bonded wire space maintainer.

As regards caries on the abutment teeth and soft tissue response, it was seen that GFRC space maintainers were superior to band and loop space maintainers, although there was no statistical significant difference between the two groups. The possible reason for this finding was that GFRCR space maintainers cover less space in the oral cavity, making them feel natural and easy to clean and this might be explained by that GFRCR space maintainers do not make any contact with adjacent periodontal tissues, thereby eliminating periodontal problems affiliated with conventional fixed space maintainers as stated by Kargul et al (2005) [7].

When comparing the two groups clinically regarding their over all survival time, the mean survival time for GFRCR in the present study was lower than that of band and loop space maintainer; however, there was no statistical significant difference between them.

The current study indicated that GFRCR space maintainers exhibited a mean survival time of 6.8 months over a follow-up period of 9 months. In contrast to the findings of Kirzioglu and Erturk (2004) [2] and Kargul et al (2005) [7], the reported mean survival times were 5.7 months and 5 months, respectively. The increased survival time observed in the current study can be attributed to the implementation of a rubber dam, which facilitated effective isolation. It was noted that the majority of adhesion failures were attributed to moisture contamination[14,15,16.]

The mean survival time for band and loop space maintainers was 7.2 months. This finding is consistent with the work of Baroni et al. (1994)[19] and Qudeimat and Fayle (1998) [11]. Comparable results were also achieved by Rajab (2002) [20] and Tulungolu et al. (2005)[25], who assessed the median survival time of fixed and removable space maintainers.

Although the statistical results of the present study are in favor of band and loop space maintainer, however, the single visit procedure without requiring laboratory services, in addition to its esthetics, render GFRCR more favorable to use.

CONCLUSIONS

From the results obtained in this study, the following could be concluded:

1. GFRCR space maintainers can be accepted as successful appliances only for short periods.
2. There was no statistically significant difference between the mean survival time of GFRCR and band and loop space maintainers.
3. Both types of space maintainers proved to be effective in maintaining space.
4. Band and loop appliances showed more signs of caries and gingival inflammation than GFRCR appliances, but with no statistically significant difference.

What this paper adds

- GFRCR space maintainer seems to be a suitable alternative to the conventional fixed space maintainer
- GFRCR space maintainers are easy to apply, require only one visit, no need for making impressions and laboratory procedures are eliminated.
- Patients are satisfied because these space maintainers are esthetic, occupy less space in the oral cavity, and feel natural

Why this paper is important for paediatric dentists

- Enable the pediatric dentist to follow a simple method for space maintainer application.
- Making the appliance more comfortable and esthetically pleasing for young patients.
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DECLARATIONS

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Competing Interests
The authors have no competing interests to declare.

Ethical Approval
The study was approved by the appropriate ethics committee and conducted according to relevant guidelines and regulations.

Informed Consent
Not applicable.

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