Success of Reinforced Fiber Material Space Maintainers

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ABSTRACT

Purpose: Various space maintainers are used in pediatric dentistry. However, their construction requires time-consuming laboratory procedures. Recently, fiber-reinforced composites (FRC) have been introduced and used in different branches of dentistry. The objective of this study was to assess long-term results for a newly developed space maintainer as an alternative procedure for practitioners.

Methods: This study used Splint-it (Jeneric/Pentron, Wallingford, Conn), a FRC, to prepare a newly developed space maintainer chairside in 1 appointment. A total of 40 space maintainers were applied to 29 children (14 girls, 15 boys) between 7 to 14 years old (mean±SD=10 years, 1 month±1 year, 11 months) to protect the space of their early extracted first and second primary molar teeth. For 4 children, space maintainers were prepared with artificial teeth to restore the anterior teeth loss, which occurred due to trauma. To protect the space until the fixed partial dentures were constructed, 5 space maintainers were applied to 3 children who had 2 permanent first molar teeth extracted. Appliances were observed for up to 2 years.

Results: Twenty-nine (73%) space maintainers were dislodged at the end of the sixth month. The space maintainers placed on primary teeth (1 or both abutments) showed the highest failure rate (94%).

Conclusions: This study suggested that Splint-it space maintainers can be accepted as successful appliances only for short periods. Prolonged use of this material for space maintenance in children must be further evaluated. (*J Dent Child*. 2004;71:158-162)

KEYWORDS: SPACE MAINTAINER, FIBER-REINFORCED COMPOSITE

Early loss of primary teeth is a common dental problem. Early loss of primary molar teeth especially may lead to different types of malocclusions.

The safest way to prevent future malocclusions from tooth loss is to place a space maintainer that is effective and durable. Factors that influence the selection of fixed or removable space maintainer types are: (1) dentitional development stage; (2) the number of lost teeth; (3) dental arch and occlusion; and (4) the patient's age, psychological condition, and cooperative ability.[1]

Many different space maintainer types are available today. Among the most commonly used are:

1. several kinds of bands and crowns with welded tube and loop;
2. fixed wire composite resin space maintainers;
3. distal shoe retainers;
4. mandibular lingual arch;
5. Nance appliance and transpalatal bar;
6. several kinds of removable appliances.

They have disadvantages such as:

1. disintegration of the cement;
2. failure to prevent rotation and tipping movement of abutment teeth;
3. being embedded in gingival tissues;
4. caries formation;
5. needing preparation of the abutment teeth.[1-4]

These disadvantages reveal the need for designing new types of space maintainers. Few articles, however, describe space maintainer designs, clinical effects, and success.

Recently, fiber-reinforced composites (FRC) have been introduced and used in[5-11]:

1. immobilization of periodontally involved teeth;
2. creation of a fixed partial denture with a composite resin pontic or a natural tooth pontic;
3. stabilization of traumatized teeth;
4. orthodontic fixed space maintainers;
5. reinforcement of temporary crowns and bridgework;
6. denture repairs.

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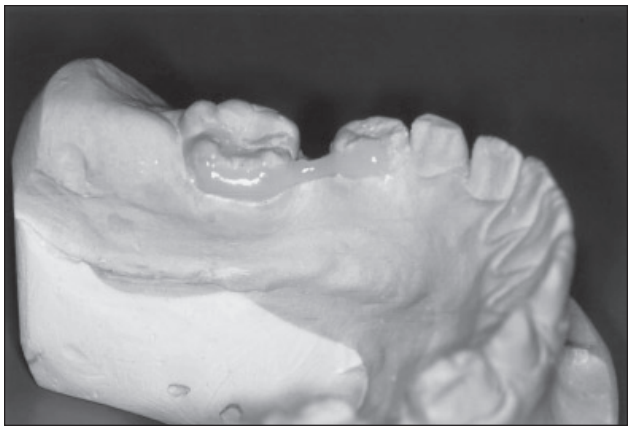

Figure 1. Appearance of a Splint-it space maintainer prepared for posterior teeth on the model.

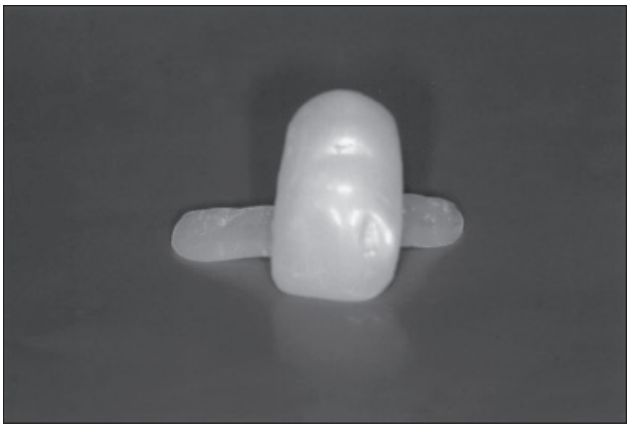

Figure 2. Splint-it space maintainers constructed with artifcial teeth for the patients with anterior tooth trauma histories.

The aim of this study was to assess long-term results for a newly developed space maintainer as an alternative procedure for practitioners.

METHODS

Parental consent was obtained for 29 children (14 girls, 15 boys between 7-14 years old; mean±SD=10 years, 1 month±1 year, 11 months). Space maintainers were planned on the models. The same dentist examined the children clinically and radiographically. Patient selection criteria were:

1. noncarious lingual surfaces of abutment teeth;
2. absence of pathology;
3. presence of succedaneous teeth;
4. presence of teeth on mesial and distal side of the edentulous area;
5. absence of the root resorption of the abutment teeth;
6. presence of the bone crypt over the succedaneous tooth germ;
7. presence of Class I occlusion and normal primary molar relations[12];
8. absence of abnormal dental conditions such as crossbite, open bite, deep bite, etc.

The same dentist measured space spans for each patient, and the patients with similar measurements were included in the study (mean±SD; 10.02 mm±0.81 mm).

Splint-it (Jeneric/Pentron, Wallingford, Conn), a FRC composed of unidirectional and woven preimpregnated S-glass fibers, was used. The required length of fiber was cut with a special scissors supplied by the manufacturer to prevent unraveling. Splint-it space maintainers were prepared for the maxillary teeth palatal surfaces and the mandibular teeth lingual surfaces by strictly following the manufacturer's instructions (Figure 1). Palatal or lingual abutment teeth surfaces were:

1. cleaned with a nonfluoridated pumice paste;
2. acid etched with 37% orthophosphoric acid for 30 seconds (15 seconds for the permanent teeth);
3. washed thoroughly for 20 seconds;
4. dried without desiccating.

Bonding agent Bond-1 and flowable composite Flow-it (both Jeneric/Pentron, Wallingford, Conn) were applied to the enamel surfaces, and space maintainers were placed. Slight pressure was applied with a rounded instrument to create close contact during the curing process. The embrasures were shaped to facilitate good oral hygiene, and composite was polished. A rubber dam could not be used because of its difficulties in pediatric patients. Space maintainers were prepared with artificial teeth for the 4 patients with trauma histories (Figure 2).

The occlusion of all patients was controlled and premature contacts were removed with composite finishing burs. Oral hygiene instruction and motivation were given to the children. The children were instructed to indicate if an appliance was loosened or dislodged. The subjects were recalled and examined over 3 month intervals for 2 years. Failure protocol used in this study was:

1. debonding of fiber-composite interface;
2. debonding of enamel composite interface;
3. fracture of the fiber frame;
4. decay of the abutment tooth.

Time of application and failure was recorded.

The data were subsequently processed and analyzed using SPSS statistical software version 10.0 (Statistical Package for the Social Sciences, SPSS, Chicago, Ill). Kaplan-Meier survival analysis was employed to compare qualitative data and determine statistical significance.

RESULTS

A total of 40 space maintainers were applied to all 29 children to protect the space of their early extracted first and second primary molar teeth. For 4 children, space maintainers were prepared with artificial teeth to restore the anterior teeth loss, which occurred due to trauma. To protect the space until the fixed partial dentures were constructed, 5 space maintainers were applied to 3 children who had 2 permanent first molar teeth extracted.

The distribution of space maintainers according to age and gender is shown in Table 1. Table 2 summarizes the number of inserted and failed space maintainers and average period of dislodged space maintainers in the mouth. At the end of the first year, 6 of 9 space maintainers placed between the permanent

Table 1. Space Maintainer Distribution According to Age and Sex.

	Lost teeth							
	Primary first molar		Primary second molar		Permanent central incisor		Permanent first molar	
Age	Girl	Boy	Girl	Boy	Girl	Boy	Girl	Boy
7	1							
8	2		2	3				
9	4	2	2	3				
10	3	2	1	1				
11	2		1			1		
12				2			2	
13						1		1
14					1	1		2
Total	12	4	6	9	1	3	2	3

teeth, 14 of 15 space maintainers placed between the permanent and primary teeth, and 15 of 16 space maintainers placed between the primary teeth were dislodged and recorded as failures. Failure rates were higher for the space maintainers placed between primary teeth (94%) and between primary and permanent teeth (94%) than for those placed between permanent teeth (67%).

There was no statistical difference between abutment teeth type and the number of failed space maintainers (P=.148). The failed space maintainer percentage was higher on the right side (94%) than the left side of the arches (84%). There was no statistical significance, however, between sides for failed arch rates (P=.741) and failed jaw rates (P=.995; Figures 3, 4).

After 24 months, 5 space maintainers placed on at least 1 permanent abutment tooth were determined to be sound and accepted as successful. Two space maintainers were removed to allow succedaneous tooth eruption. The mean survival time the space maintainers remained intact was 5.7 months (±7.4 months; maximum=24 months; minimum=1 month).

The reason the majority of space maintainers failed was debonding of the enamel composite interface (83%). Fracture of the fiber frame was not observed in any cases.

No patients complained about their space maintainers, and the space maintainers with artificial teeth were reported as "aesthetically perfect" by the patients. No caries lesions were observed in teeth contacting the space maintainer. 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.

DISCUSSION

Removable space maintainer disadvantages, such as requiring cooperation and the possibility of being lost or fractured by the patient, has led to a preference for fixed space maintainers.

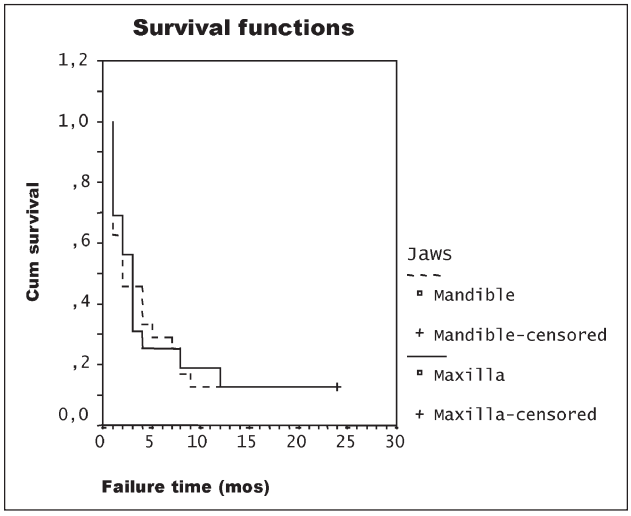

Figure 3. Survival curves for Splint-it space maintainers due to jaws.

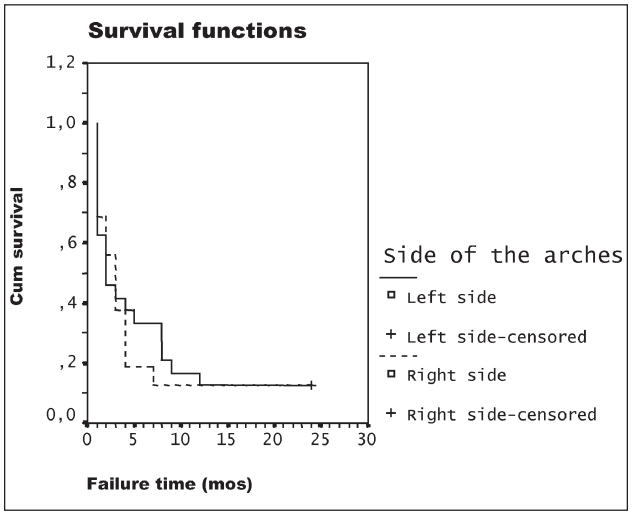

Figure 4. Survival curves for Splint-it space maintainers based on arch side.

Table 2. Number of Space Maintainers Inserted and Dislodged, and Average Period of Dislodged Space Maintainers to Last in the Mouth

Abutment teeth	Gender	Inserted					Failures																			
							0-3 months					3-6 months					6-9 months					9-12 months				
		Maxilla		Mandible		Total (N,%)	Maxilla		Mandible		Total (N,%)	Maxilla		Mandible		Total (N,%)	Maxilla		Mandible		Total (N,%)	Maxilla		Mandible		Total (N,%)
		Right	Left	Right	Left		Right	Left	Right	Left		Right	Left	Right	Left		Right	Left	Right	Left		Right	Left	Right	Left	
Permanent teeth	Female	1*				1 (3)						1*				1 (14)										
	Male	1*	1+2*	1	3	8 (20)	1*	1*		2	4 (18)												1*			1 (50)
	Total	2	3	1	3	9 (23)	1	1		2	4 (18)	1				1 (14)							1			1 (50)
Permanent and Primary teeth	Female	1	3	3	1	8 (20)		3	3	1	7 (32)	1				1 (14)										
	Male			2	5	7 (18)			2	2	4 (18)									1	1 (25)				1	1 (50)
	Total	1	3	5	6	15 (38)		3	5	3	11 (50)	1				1 (14)				1	1 (25)				1	1 (50)
Primary teeth	Female	3	3	3	3	12 (30)	1	2	1		4 (18)	1		2	2	5 (72)		1		1	2 (50)					
	Male		1	1	2	4 (10)		1		2	3 (14)								1		1 (25)					
	Total	3	4	4	5	16 (40)	1	3	1	2	7 (32)	1		2	2	5 (72)		1	1	1	3 (75)					

*Space maintainers with artificial tooth.

Hill[13] observed a 43% failure rate of 226 space maintainers in 196 children between 6 and 10 years old, during follow-ups over 4 years. Foster[14] reported that a well-designed fixed space maintainer could be more preferable than a removable appliance.

The advantage of the directly bonded splint is that it is a biocompatible, aesthetic, easily manipulated, single-visit procedure without requiring laboratory services. Splint-it space maintainers have many advantages, as reported by Artun,[15] including:

1. simplicity of design;
2. fast insertion;
3. laboratory costs and cooperation aren't required;
4. total reversibility;
5. no risk of causing damage to abutment teeth;
6. effective performance;
7. prevent tipping of the abutment teeth;
8. don't prevent tooth eruption;
9. high durability rate;
10. easy-to-clean design.

Twenty-nine (73%) of the 40 space maintainers were dislodged at the end of the sixth month. Mostly, failure between the enamel and the composite was observed at the posterior abutment tooth. Zachrisson[16] reported the main reasons for this type of failure as improper surface preparation, moisture contamination, and/or disturbance during the setting process of the adhesive. The space maintainers were placed on the abutments' lingual surfaces to minimize the occlusal forces acting upon them. This may tend to change the available occlusogingival dimension. Other possible reasons for this type of failure are the difficulty in using a rubber dam in pediatric patients and the insufficiency of suctions for some children.

Few studies report the effectiveness of FRC materials in construction of space maintainers.[8-10] Meiers and Freilich[8] reported that 1 of 20 FRC/particulate resin composite, chairside-fixed, partial dentures with artificial teeth had been in place for over 42 months in adult patients with 1 missing tooth.

Freilich et al[9] also stated that FRC materials could be used to make metal-free prostheses with excellent aesthetic qualities.

Karaman et al[10] used ultrahigh molecular weight polyethylene fiber in the construction of a fixed space maintainer in 1 patient and a space maintainer with an artificial tooth in another. They reported that the applications for composite reinforcement fibers seemed very promising.

Since the introduction of the acid-etch technique, its area of application has increased rapidly, and some types of direct bonded space maintainers have been tested clinically.[4,15,17-19] Kırzıoğlu and Yılmaz[17] found a 4% failure rate for the wire and composite space maintainers at the end of the sixth month, which had been observed for up to 30 months. However, Swaine and Wright[18] reported a 30% failure rate for the same space maintainer type at the end of the same period.

In the present study, the space maintainers placed on primary teeth (1 or both abutment teeth) showed the highest failure rate (94%). It is possible to explain this low success rate by the presence of prismless enamel areas, which may negatively

influence resin retention. Another possible reason is salivary isolation cannot be completely obtained in children.

Although the patients were strictly instructed not to bite with their anterior teeth, 4 space maintainers prepared with artificial anterior teeth were dislodged at the end of the 12th month, since the patients did not follow the instructions. Despite manufacturers' instructions, these space maintainers were applied without preparing grooves on the abutment teeth to prevent unnecessary loss of tooth structure. Furthermore, no study has investigated the effectiveness of Splint-it space maintainers in grooved teeth. It can be one of the reasons for the failure of this type of space maintainer. Another possible reason is the use of artificial teeth, which are known to have poor bonding to composite or FRC.

Although today's tendency is toward preparing the tooth directly from composite in the patient's mouth, the authors used denture teeth because of their advantages over composite pontics in child patients. Among their advantages, denture teeth:

1. are ready-to-use, and there is no need to form anatomic tooth contours in the mouth;
2. do not require long finishing and polishing procedures;
3. shorten working time in the mouth.

These properties are important to child patients and facilitate the procedure for the clinician.

The majority of space maintainers that dislodged were at the right side of the mandible (90%). Artun[15] stated that occlusal trauma might be more of a problem in the mandible, especially for the first permanent molars just after their eruption, where the area available for bonding often was limited. Baroni et al[20] reported a 31% failure rate within 88 space maintainers and that cement disintegration was the main reason recorded for the failure. Santos et al[4] however, reported higher failure rates on the left side of the maxilla.

CONCLUSIONS

The present study indicated that Splint-it space maintainers, which were observed for up to 2 years, can be accepted as successful appliances only for short periods. However, different application types and the prolonged use of this material for space maintenance in children with early loss of primary teeth must be evaluated further.

REFERENCES

1. Ghafari J. Early treatment of dental arch problems. I. Space maintenance, space gaining. *Quintessence Int*. 1986;17:423-432.
2. Qudemiat MA, Fayle SA. The longevity of space maintainers: A retrospective study. *Pediatr Dent.* 1998;20:267-272.
3. Caroll TP. Prevention of gingival submergence of fixed unilateral space maintainers. *J Dent Child.* 1982; 49: 48-51.
4. Santos VLC, Ameida MA, Mello HS, et al. Direct bonded space maintainers. *J Clin Pediatr Dent.* 1993;17:221-225.
5. Strassler HE, Haeri A, Gultz JP. New-generation bonded reinforcing materials for anterior periodontal tooth stabilization and splinting. *Dent Clin North Am*. 1999;43:105-126.
6. Ahlstrand WM, Finger WJ. Direct and indirect fiber-reinforced fixed partial dentures: Case reports. *Quintessence Int.* 2002;33:359-366.
7. Goldberg AJ, Freilich MA. An innovative pre-impregnated glass fiber for reinforcing composites. *Dent Clin North Am*. 1999;43:127-133.
8. Meiers JC, Freilich MA Chairside prefabricated fiber-reinforced resin composite fixed partial dentures. *Quintessence Int*. 2001;32:99-104.
9. Freilich MA, Karmaker AC, Burstone CJ, et al. Development and clinical applications of a light-polimerized fiber-reinforced composite. *J Proshet Dent*. 1998; 80:311-318.
10. Karaman AI, Kir N, Belli S. Four applications of reinforced polyethylene fiber material in ortodontic practice. *Am J Orthod Dentofacial Orthop*. 2002; 121:650-654.
11. Eskitaşçıoğlu G, Belli S. Use of a bondable reinforcement fiber for post-and-core buildup in an endodontically treated tooth: A case report. *Quintessence Int*. 2001; 33:549-551.
12. Baume LJ. Physiologic tooth migration and its significance for the developement of occlusion. I. The biogenetic course of the decidious dentition. *J Dent. Res*. 1950;29:123-132.
13. Hill CJ, Sorenson HW, Mink JR. Space maintenance in a child dental care program. *J Am Dent Assoc*. 1975;90:811-815.
14. Foster TD. Dental factors affecting occlusal development. *A Textbook of Orthodontics*. London: Blackwell; 1990:129-146.
15. Artun J, Marstrander PB. Clinical efficiency of two different types of direct bonded space maintainers. *J Dent Child*. 1983;50:197-204.
16. Zachrisson BU. Clinical experience with direct bonding in orthodontics. *Am J Orthod*. 1977;71:173-189.
17. Kırzıoğlu Z, Yılmaz Y. Long-term evaluation of simple space maintainers bonded with composite resin. *J Atatürk Univ Fac Dent.* 1999;9:47-54.
18. Swaine TJ, Wright GZ. Direct bonding applied to space maintenance. *J Dent Child*. 1976;43:401-405.
19. Palmer ME. Bonded space maintainers. *J Clin Orthod*. 1979;13:176-178.
20. Baroni C, Franchini A, Rimondini L. Survival of different types of space maintainers. *J Pediatr Dent*. 1994; 16:360-361.