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Fixed Space Maintainers Combined with Open-Face Stainless Steel Crowns

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Abstract

Objective: This study investigates the clinical performance of fixed space maintainers placed on seriously damaged abutment teeth.

Methods: Crowns were placed on damaged abutment primary teeth. Fixed space maintainers were prepared by using rectangular wire between the window in the facial surface of the crowns and other abutment teeth and were subsequently bonded with a flowable resin composite. This procedure was introduced clinically, and the cases were observed over a period of twelve months.

Results: Twenty-seven fixed space maintainers (25 on lower jaw, two on upper jaw) were included in this study. No clinical failure was recorded in any of the cases in the observation time, and the rate of clinical performance was 100%.

Conclusion: The study shows the effectiveness of fixed space maintainers combined with stainless steel crowns ("open-face fixed space maintainers") which were placed on primary molar teeth used as abutments in cases with extensive caries and loss of occlusogingival dimension.

Keywords: open-face fixed space maintainers, fixed space maintainers, direct bonded space maintainers

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Introduction

While there has been some decrease in the rate of premature tooth loss due to the advances in the field of preventive dentistry, this issue still remains a problem and requires further research. In a recent study the findings showed that of all study subjects with space maintainers, 69% had lost their primary teeth due to pulpal pathology or alveolar bone abscess.[1] Premature primary teeth loss may lead to extraction and subsequent malocclusion. Various space maintainers have been used to cope with these problems and to protect the mesiodistal relationships of the teeth on the dental arch.[2-8]

There has not been a major change in the basic matrix structure of resin composites since their introduction, but their physical properties have undergone some radical changes. In the mid-1980s major advances were made in resin bonding agent systems. Bonding agents have been used widely since that time to strongly bond composite resin materials to the teeth.

Parallel to the improvements in resin composite materials and adhesive systems, there have also been innovations in the techniques used to place space maintainers in the mouth.[9-11], In 1976 Swaine and Wright[11] prepared a fixed space maintainer by using UV light polymerizing resin composite and claimed the rate of failure in their studies was 30%. In 1999 Kirzioglu and Yilmaz[12] used a different bonding system in order to place fixed space maintainers by means of a hybrid resin composite polymerized by visible light cure. They claimed the rate of success in the use of these fixed space maintainers over a period of 2.5 years was 85.72%. However, in some cases the existence of caries in a primary tooth used as an abutment tooth or the loss of occlusogingival dimension influenced the survival rate of space maintainers. To overcome such problems, crown-loop or band-loop space maintainers were recommended. Such space maintainers require some laboratory steps and there is risk of solder joint failure. In addition Mockers et al.[13] called attention to the cytotoxic characteristics of solder alloys.

In this study stainless steel crowns were used to restore the teeth of children in which a space maintainer was needed and there was a severe loss of tooth structure or loss of occlusogingival dimension in their abutment teeth. At the same time, a space maintainer was attached between a window on the vestibule surface of these stainless steel crowns and the other abutment tooth with a flowable resin composite. The primary aim of this study was to evaluate this clinical strategy and report the results of a 12-month clinical observation.

Methods and Materials

Subjects

A total of 23 children (9 girls and 14 boys) were included in this study with their parents' consent. The children, whose ages ranged from 6 to 8 years, presented to the Pedodontics Clinic of the Faculty of Dentistry at Ataturk University with the complaint of premature loss of a primary first or second molar tooth. During clinical examinations, the extent of the loss of tooth structure and the mesial distal space between the damaged tooth and the other abutment tooth were evaluated. Using radiographic observation, a number of criteria were considered such as the degree of root resorption if the abutment tooth was a primary tooth; the degree of apex formation if the abutment was a permanent tooth; the existence of a tooth bud under the extracted tooth; the extent of the tooth crypt around the tooth bud; and if a pathological condition existed to influence the tooth bud.

Space Maintainer Design

Stainless steel crowns were placed on the primary molar teeth to be used as abutment teeth of those children who had the above criteria (Figure 1).

Figure 1. Tooth #75 exhibits extensive caries on the mesio-occlusal surfaces.

The teeth were prepared for stainless steel crowns. The appropriate crown sizes were selected and the cervical margins adapted tightly to the gingival margins of the preparations. The crowns were then cemented using glass-ionomer cement (Aqua Meron, Voco, Cuxhaven, Germany Art. No. 1172) in accordance with the recommendations of the manufacturer. After the cement set, remnants were removed and a window was created on the vestibular surface of the stainless steel crown. The borders of the window were determined to be 1-1.5 mm from the mesial and distal contact surfaces and 1 mm from the gingiva and gingival to the occlusal surface. The window was created with a #801/014 round bur (Aqua Meron, Voco, Cuxhaven, Germany Art. No. 1172) (Figure 2).

Figure 2. Tooth #75 was restored with a stainless steel crown and a window was created on the buccal surface of the crown.

After the impression of the related jaw, a plaster model was prepared for fabrication of the space maintainer. The window was filled with a temporary zinc eugenol restorative material until the next appointment. On the prepared plaster model, a 0.53 mm x 0.64 mm long-space maintainer made of orthodontic rectangular wire was prepared in such a way to touch the vestibule surface of the abutment tooth (Figure 3).

Figure 3. A space maintainer fixed on the abutment teeth on a plaster model.

During the second visit, the temporary filling material in the window was removed and the remnants were removed with fluoride-free prophylaxis paste. The next step was to attach the space maintainer to the vestibule surface of each abutment tooth. The attachment area of the abutment teeth were etched with phosphoric acid (Art. No. 1063, Voco, Cuxhaven, Germany) for 60 seconds and the acid was removed from the surface with an air-water spray. The etched tooth surfaces were dried with polyurethane foam pellets polymerized with visible light for 10 seconds according to the manufacturer's recommendation for Single Bond (3M Dental Products, St. Paul, MN 55144, USA) bonding agents.

Figure 4. Intraoral view immediately after insertion of the space maintainer bonded on the buccal surfaces of teeth #73 and #75.

The space maintainer made of rectangular wire was placed first on the mesial abutment tooth and then on the distal abutment using Tetric Flow (ReOrder #556546, Vivadent-Ets., FL-9494 Schaan/Lichtenstein). This is a flowable material polymerized with a curing light (visible light). After the polymerization process, a polymerization control was applied and the tooth surface was finished using Sof-Lex polishing discs (3M ESPE Dental Products D-82229 Seefeld, Germany) (Figure 4).

The appliances were evaluated every three months for one year following placement. During these periodic examinations it was determined whether the space maintainer still existed in

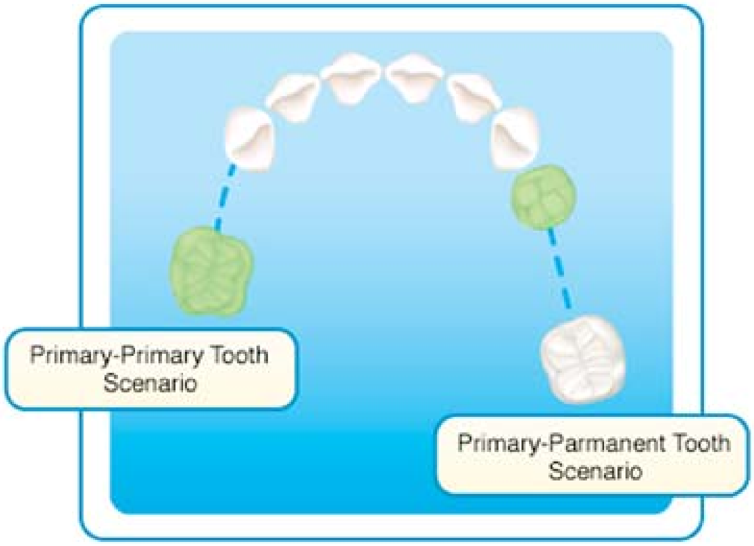


Figure 5. Measurement of the linear change between primary-to-primary tooth scenario and primary-to-permanent tooth scenario.

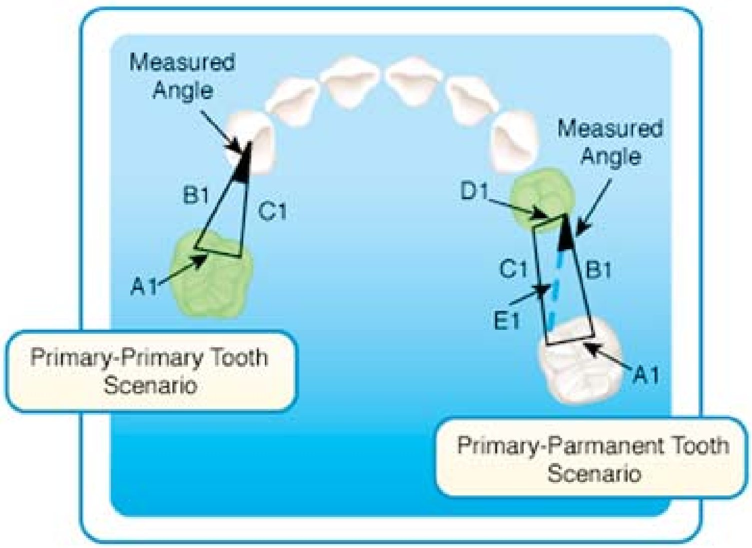


Figure 6. Measurement of the angular change between primary-to-primary tooth and primary-to-permanent tooth. **A.** The primary-to-primary tooth scenario. **B.** The primary-to-permanent tooth scenario.

the mouth and if there was any decrease in the amount of resin composite used to attach the space maintainer. Radiographs were taken to determine if any pathological change had occurred in the abutment tooth as well as the level of root resorption.

Measurements

The ability of the space maintainer to maintain the space during the study was determined by evaluating the linear and spatial relationships between the two abutment teeth. One scenario was a missing primary first molar with a stainless steel crown placed on the primary second molar to restore it and to which the space maintainer was attached (primary-to-primary tooth). Another scenario was a missing primary second molar with a stainless steel crown placed on the primary first molar to restore it and to which the space maintainer was attached (primary-to-permanent tooth) (Figure 5).

These measurements were taken on the initial study models and then on the final control models of the dental arches. The spatial measurements to determine whether there was any loss between the initial and the final models were obtained by modifying the methods of Swaine and Wright[11] and calculated by entering these data into a formula created with Excel for Windows® software.

Measurements were obtained as shown in Figure 6.

Primary-to-Primary Tooth Scenario: In the absence of a primary first molar tooth; a line connecting the mesiobuccal and mesiolingual cusp tips of the stainless steel crown placed on the primary second molar tooth formed the base of the triangle (A1) was measured and recorded. Another line connecting the tip of the mesiolingual cusp of the crown on the primary second molar tooth and the tip of the canine tooth formed one side of a triangle (C1) was measured and recorded. A third line connecting the tip of the mesiobuccal cusp of the crown on the primary second molar tooth and the tip of the canine tooth forming the other side of the triangle (B1) was measured and recorded. The measurements of all sides of this triangle were entered into a spreadsheet, and the median of the triangle was obtained using the following formula:

SQUARE ROOT((B1*B1+C1*C1-A1*A1/2)/2)

To determine if rotation occurred in the abutment teeth, the apex angle of the triangle was taken into consideration. This angle was calculated using a second Excel® formula as follows:

DEGREE ((ACOS ((B1*B1+C1*C1-A1*A1)/ (2*B1*C1)))

Primary-to-Permanent Tooth Scenario: In the absence of a primary second molar tooth and the first primary molar restored with a stainless steel crown the following measurements were obtained. A line connecting the mesiobuccal and mesiolingual cusp tips of the first permanent molar tooth formed one end of a rectangle (A1) was measured and recorded. A second line connecting the tips of the distobuccal and distolingual cusps of the stainless steel crown on the primary first molar tooth forming the other end of a rectangle (D1) was measured and recorded. To complete the rectangle, the line connecting the distolingual cusp tip of the stainless steel crown on the primary first molar tooth and the mesiolingual cusp tip of the permanent first molar tooth (C1) and the line connecting the mesiobuccal tip of the permanent first molar tooth and distobuccal cusp tip of the stainless steel crown on primary first molar tooth (B1) were measured and recorded.

Once the rectangle was established, the length of the line which connects the mid-points of the lines connecting the cusp tips of each tooth was calculated through the use of the following Excel® formula:

SQUARE ROOT ((B1*B1+C1*C1- (A1-D1)*(A1-D1)/2)/2)

To determine if any angular change occurred in the space maintainers bonded to these teeth, the apex angle of the triangle formed by a line (E1) connecting the mesiolingual cusp tip of the permanent first molar tooth and distobuccal cusp tip of primary first molar tooth with the other lines was calculated by using the following Excel® formula:

DEGREE ((ACOS (B1*B1+E1*E1-A1*A1) (2*B1*E1)))
formula

The paired samples t-test was used to determine statistical significance between the initial and the final linear and angular values obtained from the calculation.

Results

The distribution of open-face space maintainers was used to either restore the abutment tooth or to protect the space of lost teeth if there were loss of occlusogingival dimension or extensive carious lesions in the primary teeth on which the fixed space maintainer would be placed and used as abutment tooth, according to gender and jaws as given in Table 1.

Table 2 presents the distribution of the space maintainers which were placed and still observed according to the abutment teeth to which they were bonded.

Throughout the observation period no clinical failure was found in any of the bonded 27 space maintainers resulting in a clinical success rate of 100% (Figures 7-9).

Table 1. The distribution of space maintainers according to the jaws and genders.

Gender	Jaws	
	Mandible	Maxilla
Female	12	2
Male	13	-

Table 2. The distribution of space maintainers according to the abutment teeth.

Abutment Teeth	Distribution
Primary Tooth-Primary Tooth	18
Primary Tooth- Permanent Tooth	9

Figure 7. Intraoral view six months after insertion of the space maintainer bonded to teeth #63 and #65.

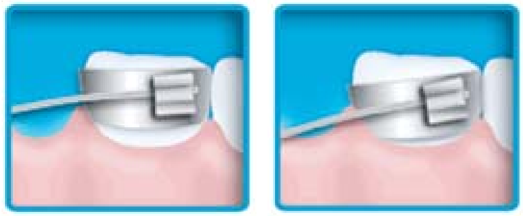
Figure 9. View nine months after insertion of the space maintainer bonded to teeth #83 and #85.

Figure 8. View of 12 months after insertion of the space maintainer bonded to teeth #83 and #85.

There was no significant difference between the initial and final distances between the abutment teeth or angular changes measured on the abutment teeth to which the space maintainers were bonded ($P>0.05$).

Discussion

The loss of primary teeth before normal physiological exfoliation occurs can result in the collapse of vertical and horizontal occlusal relationships in the primary and permanent dentitions. For this reason, it is important the spaces caused by the premature loss of primary teeth should be maintained. Nevertheless, the occlusogingival dimension or structure loss of the abutment tooth where fixed space-maintainers are to be placed makes the clinical application of space-maintainers somewhat less successful,



particularly in the lower jaw. Kirzioglu and Yilmaz[12] pointed out the rate of failure in the bonding of fixed space maintainers, which they bonded by using different dentin bonding systems and hybrid resin composites, is somewhat higher in the lower jaw than it is in the upper jaw. By applying dentin bonding systems and hybrid resin composite to different primary teeth, Yilmaz et al.[14] determined the bond strength of fixed space maintainers placed *in vitro* is lower in primary teeth of the lower jaw. Fixed space maintainers to be bonded to problematic abutment teeth, as described above, will cause premature occlusal contacts caused by the loss of the occlusogingival dimension of the abutment teeth, especially in the lower jaw. As a result, a debonded space maintainer and Temporo-Mandibular Joint (TMJ) problems caused by premature occlusal contacts are likely to occur. The survival rate of such space maintainers can be substantially affected because of their dependence on the attachment of resin composites to intact hard tissue which decreases in the presence of extensive caries in abutment teeth.

Previously, crown-loop or band-loop space maintainers were preferred in cases where the abutment teeth had the above mentioned problems. On the other hand, Qudeimat and Fayle[6] pointed out the most common reasons for failure in the space maintainers were the loss of cement and solder failure. It was noted these space maintainers have the potential to submerge into the gingivoalveolar tissues and tend to lead to tipping and rotating in the abutment teeth.[15]

In the present study stainless steel crowns were placed on problematic abutment primary teeth creating a window on the facial surface of the crown to make them more esthetic. A fixed space maintainer was then placed between the abutment teeth and bonded to them on the facial surface. Using this technique such problems as incomplete solder joint[16-22], the overheating of the wire during soldering[3,21,22], wire thinned by polishing[8], and the remnants of flux on the wire[8] in crown loops or band loops space maintainers were avoided.

In the present study, when compared with the original form of stainless steel crown, the resin composite did not grow in volume and, therefore, the subject to the excessive occlusal stress on this surface was prevented. Throughout the observation period no clinical failure was recorded in any space maintainer or in the resin composite on any abutment teeth. Qudeimat and Fayle[6] and Baroni et al.[16] recorded the failure rates of soldering in the fixed space maintainers as 7.6% and 11.3%, respectively.

Glass-ionomer can be used to cement stainless steel crowns if there is insufficient intact hard tissue in teeth to be used as abutments. If the stainless steel crowns are to be used with an open-face or window, the cement material can be allowed to remain on the exposed surface after removing the buccal aspect of the crown to create the window for it will contribute to the bonding of the resin composite.[23] However, the bond strength of modern bonding agents is even higher than that of glass-ionomer cements.[24] Therefore, in the present study we chose to remove the cement from the window area and use a flowable resin composite; Tetric Flow was used to better adapt to the prepared cavities during the application of space maintainers.[25]

For intact abutment teeth with natural tooth structure, no mechanical preparation procedure was used before bonding space maintainers to either primary or permanent teeth. The purpose of restorative dentistry is to provide a better surface by removing the prismless outer enamel layer mechanically before applying a bonding agent. However, this procedure is contrary to the nature of preventive dentistry practice. We believe the space maintainer must be designed in such a way as to be easily removed from the teeth with the least damage possible at the end of the treatment process. Therefore, no mechanical procedure was used on intact abutment teeth.

Conclusion

In our study the preliminary data about the use of open-face space maintainers proved to be promising in the cases with the loss of the occlusogingival dimensions or extensive caries.

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