Case Report

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Distal shoe space maintainer modifications: A stainless steel crown and stainless steel wire appliance

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These case studies of distal shoe space maintainer modified from stainless steel crown (SSC) and stainless steel wire were reported. The metal band made from SSC and custom bent stainless steel wire were used instead of a conventional orthodontic band and the attachments of the distal shoe. The purpose of these case studies was to discuss the simple modification of a distal shoe appliance, which a general practitioner can handle without purchasing the commercial distal shoe components. Regarding a case whereby the treatment of children with SSC restored tooth was required, these modified distal shoes were fixed onto the SSC abutment without removing the existing SSC, in order to fabricate a crown-loop distal shoe as a single unit. Equally important, a reduction in the cost and chair time for the patient was possible. The steps employed when making these modified distal shoe appliances were described. The follow-up period of over one year before lower lingual arch replacement showed that the treatment was productive, for the appliance successfully maintained the dental space and provided healthy gingival tissue.

Keywords: distal shoe, early loss of primary molars, preventive orthodontics, space maintainer

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Introduction

A distal shoe space maintainer is used to prevent the loss of space for the second premolar when there is an early loss of the second primary molar prior to the eruption of the first permanent molar [1]. The extraction of second primary molars is usually due to advanced caries, which made the tooth unrestorable and advanced root resorption. The contraindications for using distal shoe include patients with blood dyscrasias; uncontrolled diabetes; immunocompromise; congenital heart disease that require antibiotic prophylaxis prior to dental treatment; and patients who are allergic to any components of the appliance. The component of this appliance consists of a plain orthodontic band or a crown on an abutment, the first primary molar; a horizontal bar or female attachment that expands from a metal band; and a guide plane or a male attachment that penetrate the gingiva of the edentulous area [2]. This guide plane, a distal shoe, should be extended deep enough into the gingiva to touch the mesial marginal ridge of an erupting first permanent molar in order to prevent mesial drifting of the tooth [2]. Since the major cause of an early loss of second primary molars comes from pulp exposures or unrestorable crowns due to dental caries, children who experience this condition usually have unsuitable oral hygiene habits [3]. The distal shoe space maintainer also has an intra alveolar extension part in which bacteria from dental plaque can penetrate oral tissue and cause an infection or inflammation [4]. Oral hygiene care needs to be discussed between dentists, pediatric patients, and their caregivers before deciding to use this appliance. Since a distal shoe extension is into and under the gingival tissue,

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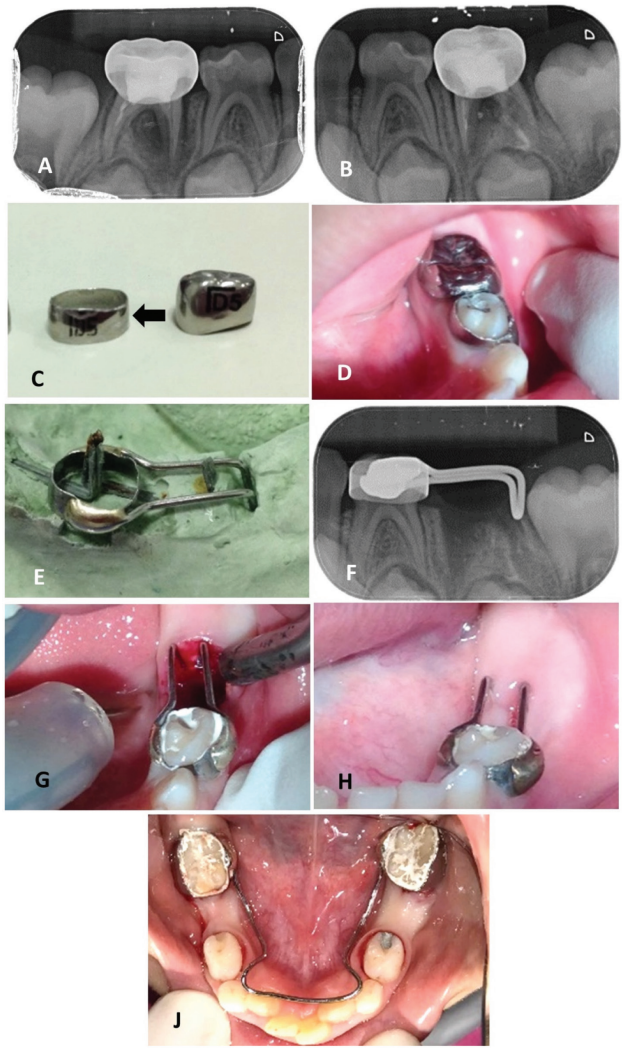
children required the adult assistant to maintain proper oral hygiene. Various types of distal shoe modification have been reported in other studies. For the most part, they were re-designed for premature loss of multiple primary molars or bilateral loss of primary molars. The lingual arch wire was used to connect the space maintainer between the abutments on the right and left sides which may be the primary canines or the first primary molars. The horizontal bars and gingival distal extension parts of the distal shoe featured different designs, such as a buccal-lingual wired long loop [5], a soldered buccal-lingual wired loop [6], and a connected wired loop with adjustable Gerber's distal shoe [7]. Chanchla and colleagues are the only group of researchers who developed a fixed functional distal shoe that was comprised of an acrylic teeth component [8]. Anegundi and colleagues revealed that the short-span distal shoe with a semi-adjustable broad wire loop was able to increase the flexibility and withstand the force of the eruption from the first permanent molar [9]. Most of the previous case studies used the commercial orthodontic bands for distal shoe construction. Patients who require a distal shoe space maintainer usually are referred to a dental specialist who is capable of performing the procedure and is equipped with the appliances which can only be found at a large dental clinic or hospital. This study proposes the use of a distal shoe space maintainer, which occupies a single tooth space loss, by using a stainless steel prefabricated metal crown and a stainless steel wire. These SSC are commonly found in most dental clinics and can be easily modified to create a distal shoe space maintainer.

Case reports

Case 1

A 6-year-old boy came to the pediatric dental clinic at the Naresuan University Dental Hospital with a fistula opening and 1st degree mobility of the mandibular left and right second primary molars; even though, the patient received pulpectomy treatment one year ago. The periapical film showed a large, rarefied area at the furcation and external root resorption of the mandibular right and left second primary molars (Figures 1A, 1B). An available medical history of the child indicated no significate issues. After retreatment attempts with medication, the presence of pus exudate was still observed at both teeth. The failure of pulpectomy treatment was recorded, so it was determined to extract these teeth. The dentist decided to maintain the space of the mandibular second primary molars for second premolars by distal shoe space maintainers. The advantages and disadvantages of this treatment plan were discussed with a parent prior to starting the space maintainer procedure, especially the oral hygiene condition. Although the current child's oral hygiene was good, the parents were asked to help the child maintain the best oral hygiene status. At that time, the dental clinic did not have any small metal bands that could be used for the mandibular first primary molar, so the dentist decided to modify the SSC (3M™, ESPE™) to be used as a first primary molar metal band. The occlusal part of the SSC was removed using a tapered shape green stone bur. The gingival margin was also trimmed to remove the cervical constriction part of the crown (Figure 1C). The modified metal band was then tried on to the mandibular left first primary molar (Figure 1D). Since the band was made from a stainless steel crown, the shape of the modified band perfectly conformed to the anatomy of first primary molar. Afterwards, a dental impression was performed using alginate impression material and the patient was then discharged. The gingival extension part of the appliance was measured on paralleling periapical films by a computer software. Once



results were achieved an appliance was made which extended 1-2 mm below the mesial marginal ridge of the mandibular first permanent molars. The distal areas of second primary molars on the dental cast were cut vertically according to the calculation. The second primary molars on the model were removed to create edentulous areas. The 0.09 mm diameter stainless steel hard wire was fabricated to extend gingivally into the cut part of the dental model. The gingival loop was in V-shape or U-shape and width should not be wider than the bucco-lingual dimension of the first permanent molar. Then, the wired component was bent from this cutting part approaching the metal band, parallel to the edentulous area. The wires which attached to the metal band were conformed to the contour of the buccal and lingual surfaces of the metal band. Afterward, those wires were soldered to the band with the orthodontic silver soldering wire (Figure 1E). Two weeks later, extraction of the mandibular left second primary molar was performed. The distal shoe space maintainer was tried on the mandibular left first primary molar and a periapical radiograph, using paralleled technique, was carried out to confirm the proper position of the gingival extension of the appliance (Figure 1F). The periapical radiograph

Figure 1. (A) A periapical radiograph shows the previously treated mandibular right second primary molar with a large, rarefied area underneath the furcation and around the mesial root. (B) A periapical radiograph shows a previously treated mandibular left second primary molar with a large, rarefied area underneath the furcation and the distal root resorption. (C) The occlusal surface of the SSC is modified to produce a metal band. (D) The modified metal band from an SSC is tried on to the mandibular left first primary molar. (E) A dental model was cut at the area of mesial marginal ridge of a mandibular first permanent molar and a wire was soldered to the modified metal band. (F) A periapical radiograph of the mandibular left molars area confirms [prior to cementation] the correct position of a vertical extension part of a distal shoe space maintainer. (G) A mandibular left second primary molar is extracted, and the modified metal band is cemented to the abutment. (H) Three months after the distal shoe placement, the extraction site heals well. The healthy soft tissue around the distal shoe space maintainer is observed. (J) After the mandibular first permanent molars eruption, the distal shoes are replaced with a lingual holding arch.

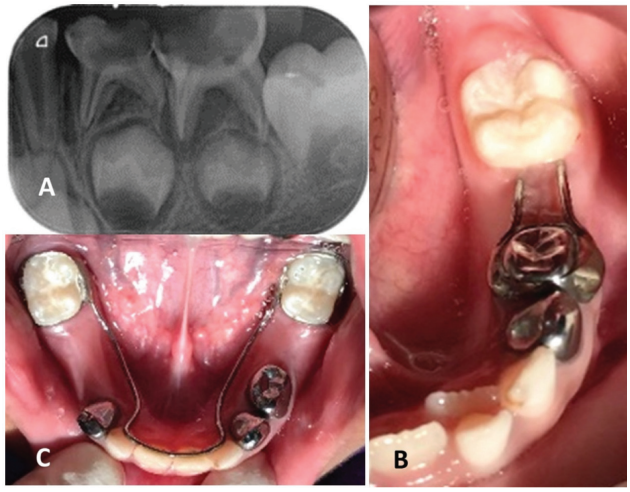
showed the proper position of the gingival extension wire loop was as expected. The position of the loop was confirmed to be extended approximately 2 mm below the mesial marginal ridge and contacted to the mesial surface of the mandibular left first permanent molar. Afterwards, the distal shoe was fixed onto the mandibular left first primary molars using glass ionomer cement (HY-Bond GlasIonomer CX-Smart, SHOFU) (Figure 1G). Post-operative care included informing the patient and his mother of some normal discomfort, and the need to avoid sticky or hard foods, in addition to cleansing the appliance at least twice a day.

Two weeks later, the other side of the mandibular second primary molar was extracted. Another distal shoe space maintainer was tried on the mandibular right first primary molars. After the periapical radiograph revealed the correct position of the gingival extension part, the distal shoe was cemented onto the mandibular right first primary molar. During the follow-up examination at 3 to 6 months intervals, the patient had no complaints of pain or discomfort. The bands were clean, and the gingiva around the appliance appeared normal (Figure 1H). No signs and symptoms of infection or inflammation were observed. A year and a half later, when the child was 7-year, 7-month-olds, the mandibular first permanent molars on both sides had fully erupted. The distal shoe appliances were removed and replaced with the lingual arch. During the procedure, a small amount of local anesthesia was injected at the area of gingival extension of distal shoe to prevent any discomfort that might occur. Band removal pliers were used to remove the band from the first primary molars, and a #325 wire bending pliers were used to pull the extending loop from the gingiva. A small amount of bleeding was stopped with gauze bite pressure; once bleeding ceased, the lingual arch appliance was fixed (Figure 1J).

Case 2

A 5-year, 6-month-old boy had severe tooth destruction at the mandibular left second primary molar. He experienced pain while eating and during the night; however, the patient was well oriented and there were no indications of any contributory medical treatments or illness. The periapical film revealed an unrestorable crown with large radiolucent area around mesial, and distal roots (Figure 2A). Extraction of the mandibular left second primary molar was the only reasonable solution to relieve the child's discomfort. The mandibular left first primary molar was diagnosed as dentin caries, and the treatment plan was to restore with an SSC. A space maintaining plan was discussed with a parent, and the child's oral hygiene status was evaluated. The patient's oral hygiene had improved considerably from the first dental visit. The condition of the oral hygiene showed an absence or small amounts of plaque along with healthy gingival tissue. A size 4 SSC (3M™, ESPE™) was fixed onto the mandibular left first primary molar during the subsequent treatment visit, and a size 6 SSC (3M™, ESPE™) was trimmed to make a metal band. The modified metal band was placed onto the first primary molar, and a dental impression was performed. This process assured that the first primary molar with dentin caries was promptly restored without prolonged laboratory process waiting if a conventional crown-distal shoe fabrication was chosen. Two weeks later, the mandibular left second primary molar was taken out, and a distal shoe appliance was tried on to the first primary molar. A paralleling technique of periapical radiograph image was taken to adjust the position of the extension part to 1-2 mm below the marginal ridge of the mandibular left first permanent molar. When the correct position of a distal shoe was achieved, then an appliance was cemented onto a mandibular left first primary molar. Afterwards, the treatments

were focused on the maxillary first and second primary molars, which had extensive dental caries. Pulp treatments, followed by stainless steel crown restorations and band and loop space maintainers, were carried out, the last restorative quadrant was on the right side of the lower arch. The mandibular right primary canine was restored with a stainless steel crown, while the mandibular right first and second primary molars were extracted due to extensive dental caries which were unrestorable. Furthermore, the mandibular right first permanent molar had partially erupted. The options for maintaining the space of the mandibular right first and second premolars were discussed with the parent. The mother chose to wait for the full eruption of the mandibular left and right first permanent molars, so the lower lingual arch space maintainer could be placed. The consequences that might occur from minor space loss in mandibular right posterior quadrant was shared and acknowledged. During routine scheduling, the child and his mother maintained good care of the child's oral hygiene, and the space maintainer was in good condition (Figure 2B). A year and two months later, the mandibular first permanent molars were fully erupted, the distal shoe appliance was removed, and the lingual arch space maintainer was replaced (Figure 2C).



Discussion

A Distal shoe appliance is a space maintainer that is used to keep a space for an unerupted second premolar when there is no abutment at the distal end of the arch. Premature loss of second primary molars without space maintainer results in mesial shifting of first permanent molar, severe space loss, crowding, and subsequently complicated orthodontic problems [10]. Distal shoe space maintainer can be used only when one tooth is lost on each quadrant and the patient's oral hygiene should be excellent. On the mandibular arch, the distal shoe space maintainers are placed on the dental arch up until the two lower first permanent molars and four lower incisors have been fully erupted. Afterwards, the distal shoe space maintainer should be removed, and the lingual holding arch can be used to preserve the space for lower premolars. On the maxillary arch, after the full eruption of the two upper first permanent molars, the distal shoe can be removed. There is no need to wait for the eruption of the upper incisors because the Nance holding arch only requires the abutment of two molars from each side. The acrylic button on the anterior palate will provide the resistance for the space maintainer.

Figure 2. (A) A periapical radiograph of mandibular left second primary molars reveals an extensive carious lesion with pulp exposure and large rarefied areas around mesial and distal roots. (B) During the routine check-up period, the distal shoe space maintainer and the surrounding gingival tissue are in good condition (C) After the mandibular first permanent molars eruption, the distal shoe space maintainer is replaced with a lingual holding arch.

The conventional distal shoe consists of a metal band, a horizontal bar, and a vertical bar or gingival part of the distal shoe space maintainer [2]. The vertical bar or intra alveolar extension should insert gingivally to touch the mesial marginal ridge of an unerupted first permanent molars. This gingival part functioned as a guide plane for the first permanent molar and prevented it from moving into the edentulous space [2]. A paralleling periapical radiograph should be taken before cementation of an appliance needed to assure proper positing of the extension part [1, 2]. Anegundi and colleagues proposed the horizontal U loops space maintainers with an extended vertical arm length which can be adjustable to resist the mesial tipping of the first permanent molar [9]. There are several studies that have reported various designs of modified appliances for premature loss of multiple primary molars with inadequate abutments [4-6, 8, 11]. In our case studies, we presented a simple method to modify an SSC to be a metal band for the first primary molar. Then a custom-made stainless steel wire was used for the horizontal and vertical parts of the distal shoe; moreover, SSCs have a perfect contour and shape easily adapts to the anatomy of first primary molars. Most dental clinics do not stock plain orthodontic bands. The preparation of a modified metal band made from an SSC is also not complicated. The gingival trimming of SSC was done with a tapered shaped green stone bur [12]. The modified SSC band and customized stainless steel wire can be fitted by general practitioners without a specialist's involvement, which is less costly and time-consuming.

When the abutment had to be restored with an SSC, the dentist needed to remove the old intact SSC before replacing with the new one which had the horizontal and vertical components of distal shoe soldered to the crown [13]. As shown in case 2, we did not have to remove the existing intact SSC because the modified band could easily be placed over the old SSC. Stainless steel wire 0.09 mm or 0.036 in is a common material in most dental clinics and dental laboratories. This wire is customized to replace the commercial distal shoe attachments which are rare and expensive. In this study, the materials used for making the customized distal shoe space maintainers cost 3-6 times lower than the commercial products. There are many advantages of using a modified metal band to cover existing SSC instead of making a crown-distal shoe, a fabricated distal shoe space maintainer with original SSC. Initially, as the first permanent molar begins to erupt, the distal shoe space maintainer can be removed without needing the replacement of the existing SSC abutment. The procedure requires using only a pair of band removal pliers for removing the metal band from an abutment. Secondly, the carious tooth abutment can be promptly restored before the extraction of the second primary molar or rendering the impression for a distal shoe space maintainer. Thirdly, during the maintenance period, if there is any damage or distortion of the distal shoe space maintainer, the repair or replacement of the appliance can be done without disturbing the SSC abutment. Our case studies also revealed: the healthy gingival tissue around distal shoe appliances and the abutments after more than a year, furthermore, the appliance did not interrupt the eruption of the first permanent molars. The routine and rigorous oral hygiene care regime is important to maintain healthy gingival conditions, especially of the fixed appliance for those with a gingival tissue penetration part. Patients that brush their teeth using fluoridated toothpaste will help with plaque removal and caries prevention. An interdental brush or end tuft brush will help to clean underneath the wires as well as the abutments. Parents were advised to provide assistance in oral cleaning,

especially for young children who are in their developmental stages where their fine motor skills are limited. Glass ionomer cement (HY-Bond GlasIonomer CX-Smart, SHOFU) was used for attachment of the metal band to the tooth abutment because of the remineralization effect, like the fluoride recharging properties, help in caries inhibition [14].

The distal shoe appliance is a standard space maintainer for the premature loss of the primary second molars before the full eruption of the permanent first molars. The advantage of this fixed space maintainer is that it is the easily accepted by the child and provides good stability of the appliance. In some cases, however, when a child patient's proper oral hygiene care is difficult to achieve, a distal shoe space maintainer is not recommended because a fixed space maintainer will create more plaque retention area. This space maintainer cannot be taken out to clean, unlike the removable space maintainer. Poor oral hygiene has a direct impact on dental caries on the abutment and surrounding teeth. For this reason, the corrective orthodontic treatment when the children enter adolescence or adulthood will be the only option for solving the mesial migration problem of the first permanent molars. There are few alternative options for maintaining the space for the second premolars when the second primary molar was early loss, before the eruption of first permanent molar. Gegenheimer proposed a bilateral acrylic-saddle fixed appliance instead of a conventional distal shoe. However, the appliance was not widely used because of the insufficient retention and lack of patient compliance with the requirements needed to achieve the expected results [15]. A removable appliance with an acrylic pressure ridge on the area of the unerupted first permanent molar was purposed by Kupietzky. The pressure ridges were made by making 2mm deep x 2mm wide grooves in the plaster model in the area of the unerupted first permanent molar. These removable acrylic appliances were claimed to be sufficed to guide the eruption of the first permanent molar [16]; however, this removable space maintainer is only recommended to be used when the unerupted first permanent molar is slightly close to the acrylic pressure ridge. If the tooth bud of the first permanent molar is too far from the distal extension of an acrylic ridge or too deep, the space loss may occur.

There are some limitations in this study. The distal shoes in our patients were placed only in a mandibular arch; therefore, the outcome of this modified distal shoe space maintainer in a maxillary arch was not provided. Our patients also accepted the distal shoe maintainer well. Non-compliance of some patients affected the outcome of the treatment that a particular patient receives, which results in unsatisfactory outcomes such as caries on tooth abutment, gingival inflammation, and dental arch space loss [17].

Ethical Permission

This study was carried out with the approval by the Institutional Review Board of Naresuan University, project number P10124/64.

Consent

Parental consents for dental treatment and publication were obtained.

Conflicts of interest

The author declares no conflicts of interest.

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