3D Printed Band and Loop Space Maintainer: A Digital Game Changer in Preventive Orthodontics

Premature loss of primary molars often leads to loss of arch circumference in the primary and mixed dentition. It can lead to malpositioning and even impaction of permanent tooth, if not prevented. Space maintainers in preventive orthodontics, are imperative in maintaining arch integrity. Band and loop space maintainers are indicated whenever there is premature loss of primary molar. The conventional band and loop space maintainer is most routinely fabricated, but poses certain limitations. Three-dimensional (3D) printing in digital dentistry is one of the major developments in dentistry. It replicates the dental cast in the most accurate forms. This allows for supreme precision and minimal human errors. Besides decreasing the laboratory procedures, it has the least chance of failure or breakage. The current case report discusses 3D printing technology for the fabrication of band and loop space maintainer, which can revolutionize preventive orthodontics for children.

***Keywords**: 3D printing, digital, band and loop, space maintainers, preventive orthodontics*

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INTRODUCTION

Dental caries is one of the major public health issues in the modern world.[1] It often leads to premature loss or extraction of decayed tooth. Baume in 1950, stated that primary dentition, is a key factor in determining the amount of space required for normal eruption of permanent successor.[2] Primary dentition plays an important role in growth and development of the jaw and also in terms of speech and chewing abilities. The dimension and spacing of the dental arches play a vital role in space closure after premature loss of the primary teeth.

Especially, in clinical scenarios with smaller jaw dimensions and deficient space, early loss of primary first or second molar or proximal lesions causes space closure resulting in crowding of the permanent dentition.[3] Some of the repercussions also include loss of arch circumference, drifting of adjacent tooth, impaction of succedaneous tooth, midline shift, and subsequent impairment of function. Space maintenance holds a very crucial role in preventive orthodontics. It is rightly mentioned that primary teeth serve as the best space maintainers. However, there are instances when premature extraction cannot be avoided due to extensive caries and space maintenance is essential. Band and loop space maintainer is the most commonly used space maintainer for unilateral loss of tooth. Also, they can be used in cases of bilateral loss of primitive molars only if the permanent incisors have not yet developed.[4,5] There are certain challenges associated with the fabrication and survival of conventional band and loop space maintainers. Inadequate band pinching and fracture of soldered loop often leads to repeated fabrication or repair of conventional band and loop space maintainer.

Various studies have suggested the use of fibre-reinforced composite resin based space maintainers, which include polyethylene fibers (Ribbond, Ribbond Inc, Seattle, WA, USA), pre-impregnated silanized E-glass fibers with Bis-GMA (Interlig, Angelus,

Londrina, Brazil) and pre-impregnated silanized E-glass fibers with Bis-GMA, PMMA (EverStick, Stick Tech Ltd, Turku, Finland) as a viable alternative to the conventional band and loop space maintainers.[6-11] However, they are extremely technique sensitive.[9]

Digitalization in dentistry is at its forefront with the introduction of latest technologies. One of which is three-dimensional (3D) printing also known as additive manufacturing or rapid prototyping.[12] It is a process of making 3D solid objects from a digital file. The digital 3D model is saved in 'Standard Tessellation Language' (STL) format and then sent to the 3D printer where the layer by layer design of an entire 3D object is formed.

This creation of the 3D-printed object is achieved using additive process. Each of these layers can be observed as a thin sliced horizontal crosssection of the eventual object.[13] The following case report discusses bilateral placement of band and loop space maintainers with the emphasis on the use of 3D printing technology for the fabrication of band and loop space maintainer in one of the quadrants.

Case Report

A 6-year old boy reported to the Department of Pediatric and Preventive Dentistry with a chief complaint of pain and mobility of teeth in the lower right region of his jaw for one week. Intraoral findings revealed deep occlusal caries with mandibular right first primary molar. Intraoral periapical radiographic examination with mandibular right first primary molar revealed coronal radiolucency involving enamel, dentin and pulp with furcal involvement. It also revealed resorption of root with loss of 2/3rd of the root length. (Figure 1A)

Similarly, intraoral findings showed deep proximal caries with mandibular left first primary molar. Intraoral periapical radiograph revealed proximal radiolucency involving enamel, dentin, pulp and furcal region. Root resorption was also evident with loss of more than 2/3rd of its root length. (Figure 1B)

Extraction of mandibular right and left first primary molars were planned under 2% lignocaine with 1:1,00,000 adrenaline followed by the placement of bilateral band and loop space maintainers. As the patient was uncooperative, banding procedure was only possible on one side of the arch. This led to the fabrication of conventional band and loop space maintainer one the right side. Since the patient was less cooperative, a less cumbersome procedure was requested by the parents on the opposite side that would require minimal chair side time.

It was then decided to fabricate a band and loop space maintainer using the most recent 3D printing technology. The parents were explained about the procedure and consent was obtained for the same. Single-step rubber base impression was made using addition silicon and poured to make a cast. The retrieved cast was sent to the 3D printing laboratory for scanning and printing a metal-based space maintainer by the following technique.

Design and fabrication procedure

The cast was scanned using a 3D digital dental scanner (Medit T500, Medit Corp., Seongbukgu, South Korea) followed by the designing of the band and loop, similar to the conventional space maintainer, on the DentalCAD 2.2 Valletta (Exocad GmbH, Darmstadt, Germany). The 3D designed space maintainer was printed using a titanium-based powdered metal material (Ti64 Gd23; LPW Technology Ltd., Cheshire, UK) by Micro Laser Sintering Technology which offers all benefits of an additive manufacturing process. (Figure 2)

The printed space maintainer was tried, the post- operative occlusion was checked and found satisfactory. Further, both conventional band and loop and the 3D printed space maintainers were cemented using glass ionomer cement. (Type 1, GC, Fuji, Tokyo, Japan) (Figure 3 and 4). The child was instructed not to drink or chew on hard food for 30 minutes after placement of band and loop space maintainers. There was a substantial improvement in the cooperation of the child since the first appointment. It was observed that Frankel's behavior rating scale after placement of 3D printed space maintainer changed from 3 to 4 suggesting enormous improvement.

At six months follow up visit, the 3D printed space maintainer appeared intact. (Figure 5) Furthermore, it was noticed that there was no plaque accumulation when compared to conventional band and loop space maintainer. However, the gingiva in relation to the conventional band and loop was mildly inflamed. Also, one of the key observations revealed depressions on the buccal aspect of the conventional band and loop space maintainer due to the occlusal forces being transferred at the solder joint. (Figure 5 and 6)

It was also evident that the solder joint displayed a crack on the buccal aspect. Radiographically, the conventional band and loop presented a fracture line on the mesial aspect. (Figure 5)

Figure 1: Pre-operative intraoral periapical radiographs of mandibular right first primary molar (A) and mandibular left first primary molar (B)

Figure 2: Designing of 3D printed band and loop space maintainer using 3D digital dental scanner

Figure 3: Post-operative intra oral clinical (A) and periapical radiograph (B) of 3D printed band and loop space maintainer cemented on mandibular left first primary molar.

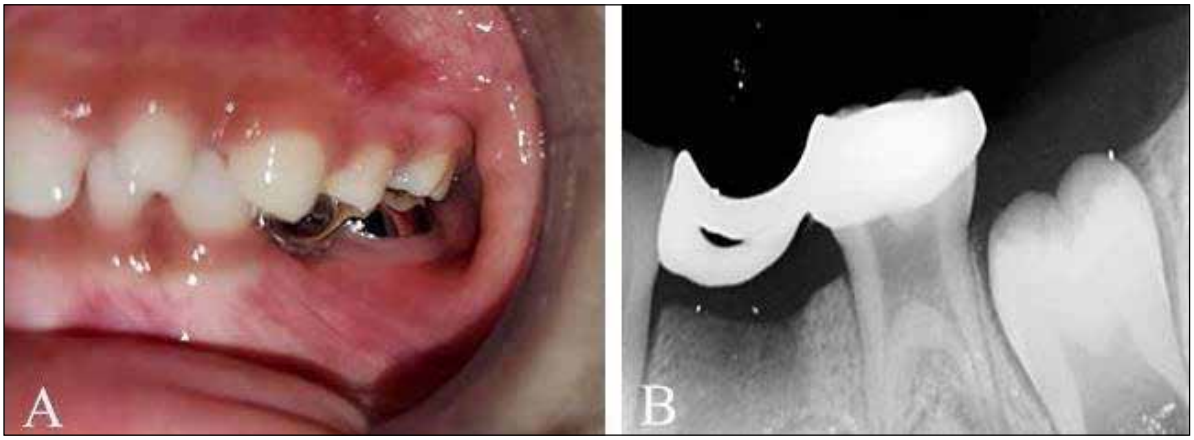
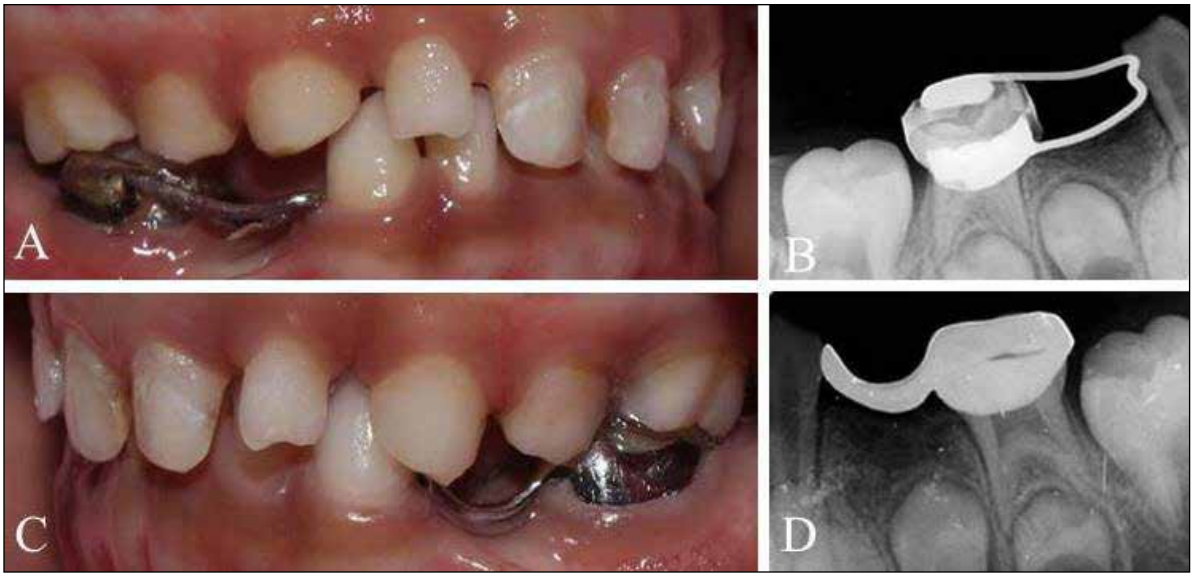


Figure 4: Post operative intra oral photograph

Figure 5: 6-month follow up photograph of bilaterally cemented conventional band and loop and the 3D printed space maintainers

Figure 6: 6 month follow up intra oral photographs and of conventional band and loop (A and B) and the 3D printed space maintainers (C and D)



DISCUSSION

According to Richardson, the most severe space problems occur when the primary teeth, in particular, the first primary molars are exfoliated before the eruption of the first permanent molar.[14] Arch length maintenance during primary, mixed and early permanent dentition is of prime importance for normal development of future occlusion.[15] A greater percentage of space loss occurs by mesial migration of posterior teeth than distal migration of anterior teeth, especially in the mandible.[16] Hence, it is important that the space created by premature loss of primary teeth be maintained until the eruption of permanent successors.

Space management is an important moiety for monitoring the developing dentition. The use of space maintainers may preclude the need for later extractions and/or complex orthodontic treatment.[17] Various appliances can be used for space maintenance depending on the child's age, development and occlusion of dental arches. However, little attention has been given by the researchers on the clinical efficacy of space maintainer and how variables in design and construction affect survival time.[18] In cases of premature loss of primary first molars, it is important to place a band and loop space maintainer on the primary second molar prior to the 'dynamic' eruption phase of the first permanent molar, because the force of eruption of the permanent molar will exert significant mesial force on the primary second molar.[17] Thus, it is important that the space created by premature loss of primary teeth be maintained until eruption of permanent successors.

There are certain challenges reported while constructing the conventional space maintainer which may lead to its failure. Baroni *et al*,[19] mentioned solder breakage as one of its important reasons. At times, it is difficult to control the flame while heating the arch wire. According to Hill[20], overheating of the arch wire during the soldering procedure caused breakage of the appliance. The present design of space maintainer offers several advantages over the conventional band and loop space maintainer. Band pinching and transferring the band on the impression is not only challenging in pediatric patients but also a cumbersome task which is eliminated in the present design. The 3D design of the appliance is made using CAD software that allows maximum precision with least possible flaws. One of the many advantages of 3D printing is that it allows the appliance to be printed in one single unit. This drastically reduces the chances of breakage of the appliance. The use of 3D printing technology minimizes human errors and lessens extensive laboratory procedures. In the present case, it was noted that the patient satisfaction improved remarkably. It was also observed that the band did not require any alteration while cementation. The time required for fabrication of 3D printed band and loop space maintainer also was less which reduced the number of appointments. In the present case, a successful follow – up of six months was carried out. On clinical examination, after six months, there were no signs of plaque accumulation and gingival inflammation.

Owing to the design and finish of the 3D printed band and loop space maintainer, the patient did not report any discomfort associated with it. However, at six month follow – up visit, the conventional band and loop space maintainer showed signs of breakage. As mentioned earlier, loss of cement or solder breakage are one of most common reasons for failure of the appliance.[18, 19] In the present case, occlusal forces acting on the solder joint could be cited as the underlying cause for the early deterioration of the conventional band and loop space maintainer. This was not seen in case of 3D printed space maintainer as the occlusal stresses were not transferred on the band since the design of 3D printed space maintainer allows for single unit fabrication, not requiring solder joint. This can also be attributed to the fine adaptation which does not hinder the occlusion even in cases of high occlusal forces. (Figure 4). The use of 3D printing technology minimizes human error and lessens extensive laboratory procedures.[21] This innovative technology of 3D printing has groundbreaking applications. In dentistry, this technology is already being used in creation of virtual model for implant positioning using intraoral scanners.[22] In orthodontics, one of the major applications is the invention of aligners using 3D printed models.[23] When prices drop this technique will be very useful to develop different appliances for the growing child.

CONCLUSION

In the present case, 3D printed band and loop space maintainer showed accurate details and exceptional fit. Nevertheless, it cannot be considered as the most cost effective option. But the idea behind 3D printing is to be more predictable, less invasive which definitely weighs out its cost. It also reduces chair side time and laboratory hours. In current scenario, where patient exposure should be least, the use of 3D printing technology should be encouraged immensely.

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