



Space maintenance in pediatric dentistry: Concepts and methods

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Abstract

Primary teeth play a key role in the nutrition and speech of the children as well as space maintenance in the permanent teeth. If dental caries and trauma lead to tooth loss, space maintainers should be used to preserve the space of the primary teeth. Space maintainers vary depending on the child's growth and development and the number and type of the lost teeth. In this study, the Google Scholar, Science Direct, PubMed, and Scopus databases were searched using the terms 'space management', 'space maintainer', space loss, and 'premature tooth loss' to completely review the space maintainers used in pediatric dentistry. There are numerous space maintainers for clinicians to choose from based on the developmental and dental conditions of the child, their preference, and patient's ease.

Keywords: space management, space maintainer, space loss, premature tooth loss

Introduction

Primary teeth play a pivotal role in the children's growth and development. They not only affect the speech, chewing, appearance, and prevention of bad oral habits, but also play a role in the guidance and eruption of the permanent teeth. Premature loss of primary teeth leads to lack of harmony and integrity between the primary and permanent teeth as well as loss of arch length and space due to abnormal distal and mesial movements of the primary and permanent teeth in the primary and mixed dentitions [1, 2].

Hence, since premature loss of primary teeth before their physiologic loss leads to the collapse of occlusal, vertical, and horizontal relations in the primary and permanent dentitions, most of which occurs in the first six months, numerous studies have suggested placement of space maintainer [3, 4]. Various appliances have been proposed for space maintenance of the lost teeth, whose selection depends on the patient's need and clinician's decision. Many studies have been done to find the easier and more effective types of these appliances [5].

Methods

The Google Scholar, Science Direct, PubMed, and Scopus databases were searched using the terms 'space management', 'space maintainer', space loss, and 'premature tooth loss' to extract the articles. A total of 65 articles were obtained, from which 35 articles were included in this study for analysis using the clinical viewpoints.

Premature Loss of Primary Teeth

Causes

Factors such as dental caries, infection, trauma, and crowding lead to premature loss of primary teeth, which along with congenital absence of permanent teeth, bad oral habits and possible presence of malocclusion increase the need for space management and orthodontic treatment [1].

Effects

Space loss following premature loss of the first molar was first described in 1887. Despite all attempts made to prevent space loss, this phenomenon has still remained a common problem in pediatric dentistry. The worst consequences reported for space loss include:

1. Dental arch crowding
2. Ectopic eruption
3. Impaction of permanent teeth
4. First permanent molar tipping and poor molar relationship
5. Cross bite formation
6. Midline discrepancies
7. Increased overbite
8. Asymmetric arch [4, 6, 7]

Loss of Anterior Teeth

Unlike the loss of posterior teeth, premature loss of anterior teeth, in the case of eruption of primary canines, is not followed by space loss and does not interfere with the child's chewing and eating. Of course, absence of these teeth may lead to defective speech if the child has not started speaking [8]. The most important reasons for replacement of anterior teeth in children are aesthetic aspects and regaining self-confidence, which is done by fixed or removable appliances [9, 10].

Loss of Posterior Teeth

Premature loss of primary second molars leads to more space loss compared to the primary first molars, which reduces from 70% in primary second molars to 51% in primary first molars [11, 12]. However, the prevalence of malocclusion following tooth loss has been reported to be higher in mandible than in maxilla [13].

Space Maintenance

Time Considerations

Space closure usually occurs in the first six months after tooth extraction or loss. Hence, use of space maintainer (SM) is necessary if the interval between the tooth loss and eruption of the substitute permanent tooth is more than six months [14]. Accordingly, the most important time for placement of the appliance is the first time available and the best method is preparation of the appliance before tooth extraction and replacement in the same session [6]. Various considerations are taken into account in this regard:

Patient's Dental Age

The patient's chronologic age is not as important as the developmental age. According to the findings of Gron, teeth usually erupt when three fourth of the root is developed. Therefore, radiographic findings are helpful for the diagnosis of root development during placement of space maintainer [14].

Amount of bone on the crown of impacted teeth

If the tooth covers the dental crown, it takes six months for 1 mm bone to erupt [14].

Eruption order of teeth

A dentist should analyze the eruptive and developmental relationship of the teeth adjacent to the lost teeth [15, 16].

Delayed eruption of permanent teeth

If a tooth is impacted, the primary tooth should be necessarily extracted and space maintainer should be placed to make it possible for the permanent tooth to erupt. Is the primary tooth is erupted in the jaw opposite to the impacted tooth, occlusal stop is required to prevent the supraeruption of the opposite teeth [3, 4].

Congenital absence of permanent teeth

In the case of the congenital absence of permanent teeth, the dentist should decide whether to keep the space for replacement of tooth with prosthesis for years or to let the space to close. If the space is supposed to close, the bodily movements of the teeth adjacent to the space rarely occur, and orthodontic treatments are needed to guide the teeth into a proper position [3, 4].

Informing the parents of all the problems

Proper time should be specified to explain the problems and conditions and to discuss the development of malocclusion in the future with parents. Sufficient explanation is required to inform the parents that space maintainer prevents the worsening of the patient's malocclusion conditions, reduces the need for complicated orthodontic treatment, and does not correct the malocclusion [17].

Space maintainer appliances

The selection of appliance for space maintenance depends on factors such as:

1. The child's developmental and growth stage
2. Involved jaw
3. Number of lost teeth
4. Presence of occlusion

However, the patient's age and ability to cooperate and tolerate the fixed or removable appliances are highly important in the selection of the type of space maintainer [2, 18].

Properties of a good space maintainer

1. Maintaining the mesiodistal space due to tooth loss
2. Maintaining the function as much as possible and preventing the overeruption of the opposite teeth
3. Easy manufacturing
4. Adequate strength for strong functional pressures
5. Lack of too much pressure on the base teeth
6. Possible observation of hygiene
7. Absence of limitation in the development and usual adjustments of occlusion during changes from primary to permanent dentition
8. Non-interference with different functions [8, 19].

Types of space maintainer

Space maintainers are made of various materials such as acryl and stainless steel, which can come in different forms, including fixed and removable, active and passive, functional and nonfunctional, with and without band, or a combination of the above cases [1, 20].

Components of removable appliances [1, 20]

1. acryl,
2. acrylic tooth,
3. arch wire,
4. auxiliaries

Components of fixed appliances [21, 22]

1. Band,
2. loop larch wire,
3. solder joint,
4. auxiliaries

Type of bands used [21, 22]

1. loop bands,
2. tailored bands,
3. performed seamless bands

The band is usually made of precious metals or chromium alloys.

1. Structural properties of band [21, 22]
2. Exact fit with tooth contours
3. Lack of extreme subgingival extension (at least 1 mm above the gingival tissue)
4. Resistance of band alloy against deformation under stress and strain
5. Resistance against tarnish
6. Inherent flexibility
7. Lack of occlusal interference
8. Proper buccolingual width for noninterference with eruption of substitute permanent dentition [21, 22]

Fixed space maintainers

Unilateral fixed space maintainers

Band and loop

The best choice for the treatment of primary first molar loss is placement of band and loop on the primary second molar. The problem of band and loop in primary second molar loss is that the primary first molars are lost before eruption of primary second premolars and band and loop will not have its proper anchorage. Hence, the lingual arch or palatal arch is preferred. Exceptions to this are when the mandibular permanent incisors are impacted and when placement of lingual arch interferes with their eruption [21, 22] (Fig. 1).

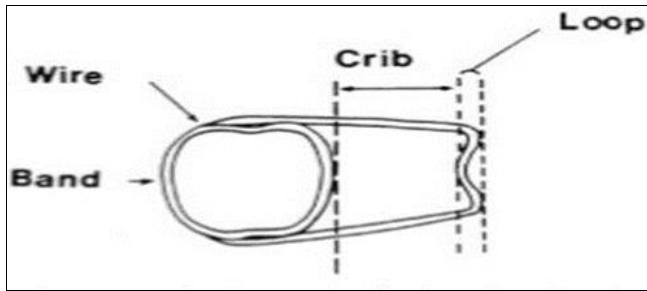


Fig 1: Band and loop components

Crown and loop

Crown and loop is similar to band and loop except that SSC is used instead of band on the base tooth. The characteristics of this space maintainer include maintaining the space of one tooth, inexpensiveness and easy manufacturing, failure to restore the occlusal function of the missing teeth

Indications

1. unilateral missing of the primary first molar before eruption of the permanent first molar
2. bilateral missing of primary molar before eruption of permanent incisors ^[21, 22] (Fig. 2)



Fig 2: Crown and loop

Tube and loop

Tube and loop is another type of band and loop that is manufactured in one stage and is followed by less waste of time. One of the most important reasons for failure of band and loop is fracture (37%) at the soldered region, which is compensated for in this way. Further, the band is cleaned easily and its activation and inactivation can be performed by uncoiling helix, coiling without removal of band ^[11, 12] (Fig. 3).



Fig 3: Mayn's appliance

Considerations for correct use of band and loop:

1. Periodic follow-up of the patient to examine the eruption process
2. Patient's return after three months to analyze the health status, gingival bleeding, and looseness (research has shown maximum bleeding and plaque in the first three months)
3. Radiographic examinations to diagnose the stability of space maintainer
4. Analysis of appliance, fluoride therapy, and recementing the band and loop ^[11, 21]

Disadvantage of band and loop

1. High laboratory skills
2. Supraeruption of the opposite teeth in the case of not using pontic
3. Interference with vertical eruption of abutment teeth due to presence of pontic
4. Possibility of washing the cement
5. Fracture of soldered area and caries along the marginal band due to long-term use and decalcification of the teeth under the band ^[11, 21]

To prevent tooth decalcification under the band, the following considerations should be taken into account:

1. Proper selection of band (appropriate size)
2. Complete prophylaxis before cementing
3. Keeping the tooth dry during cementing
4. Using GI cements owing to compatibility with the surface of the tooth and metal and fluoride release
5. Training the oral hygiene and use of fluoride mouthwash to children and parents ^[14]

Mayn's appliance

This appliance was first designed by Mayn and was rarely found in the studies. Its advantages are easy manufacturing and maintenance and limited adjustments in the patient's oral cavity. This appliance is a nonfunctional space maintainer and includes a bar with crib that follows the tissue contour and provides the possibility of partial adjustments in cases with indefinite tooth eruption, thereby not interfering with eruption of the permanent teeth ^[23, 24] (Fig. 3).

Direct bonded EZ space maintainer (New bonded space maintainer)

This appliance has many advantages compared to the removable and cemented types. It is composed of two 1-mm steel wire arms and segmental tubes (internal diameter of 1.2 mm). It has two bases at its end that are bonded to the buccal surface of the missing incisors ^[7, 25]. Plaque accumulation is much lower in this appliance than in other types. However, the first week after bonding is the most important time for patient adaptation and observation of oral hygiene ^[25] (Fig. 4).



Fig 4: Direct bonded space EZF

Glass fiber reinforced composite resin

This appliance was first introduced in 1935. Its aesthetic selection is appropriate, it is well tolerated by the patient and takes little time to manufacture. In a study done by Garg *et al*, the fracture level of FRCRS in relation to the

composite debonding on the primary teeth was investigated. The primary teeth undergo a high level of debonding fracture due to the presence of prismless enamel surfaces that have a negative effect on the resin gear. Similar results are seen in other studies [26, 27] (Fig. 5).

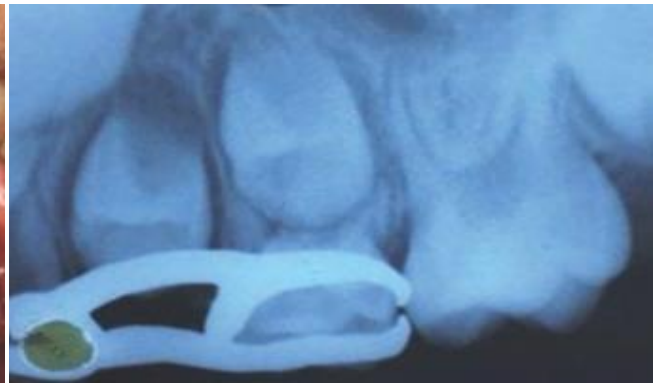


Fig 5: Glass fiber reinforced composite resin

Distal shoe

This appliance was first introduced by Willets in 1932 as a bar type gingival extension, which was modified by Roche in 1942 as a V-shaped gingival extension. It is used in the primary second molars before lost permanent first molars as well as in impacted permanent first molars. In these conditions, there is no abutment for the band and loop maintenance. In turn, a metal wire is inserted into the gingiva to maintain the space until eruption of the permanent tooth. Exact radiographic measurement and correct placement are required to ensure correct guidance of the permanent molar by a blade [10] (Fig. 6).

The acrylic distal shoe extension is another removable distal shoe that guides the eruption of the permanent first molar using an acrylic appendage [9, 28].

than one tooth in the quadrant or loss of primary second molars. The problems with manufacture of this type of SM are manufacturing stages and casting, high cost, and waste of time for patients [1, 29]. Three types of these SMs include:

1. Lingual arch
2. Nance appliance
3. Transpalatal arch

Lingual arch

Uses

1. Bilateral loss of mandibular primary molars after eruption of permanent incisors
2. Unilateral loss of more than one tooth in mandibular arch [1, 30]

This appliance consists of two bilateral bands on the molars connected passively by a thick wire on the cingulum of mandibular incisors. Its function is not only to control the posterior-anterior movements but also to prevent the arch reduction by controlling the lingual collapse. The omega loop in premolars passively makes the adjustment of the appliance possible by wire heating at the band connection point and rear part of cingulum [29, 31] (Fig. 7).

One reason for not using LLHA is lingual eruption of incisors, in which case the substitute appliance is reverse crown and loop [29].



Fig 6: Distal shoe

Disadvantages of distal shoe

1. High fracture due to cantilever form and bonding to a tooth crown
2. Absence of restored occlusal function due to lack of strength
3. Lack of complete epithelization of the gingival tissue at the site of inserted wire after replacement of this appliance based on histologic studies [8, 10].

Bilateral fixed space maintainers

Bilateral space maintainers are used during loss of more

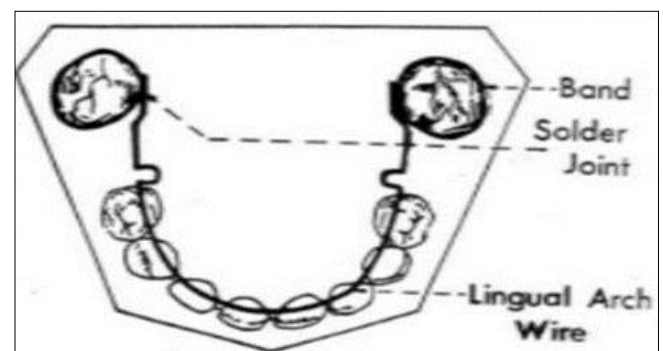


Fig 7: Lingual arch components

Nance appliance

This appliance is used in bilateral loss of maxillary primary molars or unilateral loss of more than one molar in the maxillary arch. The bilateral bands on the molars are

connected to a heavy wire along the palatal rugae connected to an acrylic button in the resting position and prevent the U-loop anterior movement. The acrylic button is placed in the most anterior and deepest part of the midpoint of the hard palate. The U-loop wire reaches the main bend at 1-2 mm from the soft tissue ^[32, 33] (Fig. 8).



Fig 8: Nance appliance

Trans Palatal Arch (TPA)

The indication is this appliance is similar to that of Nance appliance except that the bands on the molars are connected by a thick wire placed in the hard palate without contacting the soft tissue. This appliance prevents the migration and mesiolingual rotation of permanent molars around the palatal root ^[20, 32]. Although cleaning this appliance is easier than that of Nance appliance, the stability of this appliance is very low, especially when the primary second molars are lost bilaterally and dental shift is possible to occur ^[32].

Fixed functional space maintainers

Functional space maintainers come in two forms of fixed and removable. The fixed type replacing the anterior teeth is called pedo partial, which, along with replacing the incisors and regaining the function and statics until the eruption of permanent incisors, is used more due to lower inflammation in the oral tissues and lack of need for patient's and parent's cooperation.

Removable space maintainer

This appliance is used when severe and extensive caries of primary teeth along with extensive pulpal involvement lead to extraction of all primary teeth. The denture used needs modification after eruption of maxillary permanent first molars and mandibular incisors. Two major problems of this appliance are its retention and compliance ^[5, 12, 14] (Fig. 10).



Fig 9: Fixed functional space maintainer

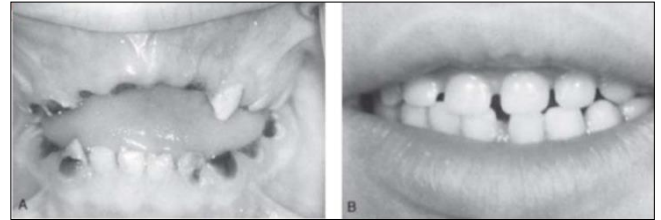


Fig 10: Removable space maintainer

Uses

1. Aesthetic significance
2. Weak dental abutments to support the fixed appliance
3. Patients with cleft palate requiring cleft palate closure
4. Cases with impaction of permanent teeth and lack of proper compatibility between bands
5. Loss of a number of primary teeth requiring the supply of function ^[5, 12].

Advantages

1. Easy cleaning and maintaining of oral hygiene
2. Maintaining or regaining the vertical height
3. Blood supply to the soft tissue owing to lack of full-time use
4. Embedding a space for unhindered eruption of permanent teeth
5. Preventing the progress of tongue thrust habit at the site of extracted tooth ^[5, 12].

Disadvantages

1. Possibility of losing and fracture by the patient
2. Lack of use in patients with low cooperation
3. Limited lateral growth of jaw in case of connection of clasps
4. Possible stimulation of soft tissue in patients allergic to acrylic materials
5. Lack of use in patients with epilepsy due to possible aspiration during epileptic attacks
6. Possibility of swallowing and aspiration by children in the unilateral type due to being small ^[5, 12]

Other space maintainers

Porous space maintainers

Mandibular defects can occur due to mandibular cut following trauma or tumor. A significant loss of underlying soft tissue occurs in cysts with severe accidents or blasts or in locally aggressive tumors ^[35]. Therefore, reconstruction is aimed to maintain the form and function of the lost bone and its underlying soft tissue, which is done by autologous bone grafting. In such cases, the purpose of space maintainer is to provide a space for bone graft by covering the soft tissue around the defect ^[35].

Maintenance and follow-up of space maintainer

As for the removable appliances, periodic check is performed to evaluate the patient's use of appliance, probable fracture or distortion, and soft tissue inflammation ^[6, 14]. In fixed appliances, the following cases need to be investigated: fracture at the soldered area or band and looseness of band (dissolving of cement), which leads to food impaction and caries ^[6, 23, 25].

The fixed appliances should be removed every six months or year depending on the position and possibility of caries or decalcification of the base tooth. The base tooth should be

polished and the appliance should be cemented again. Moreover, regular radiographic examinations are necessary to analyze the eruption and interference with the permanent teeth. After eruption of the substitute permanent tooth, the appliance can be removed at a proper time ^[6, 14].

Advice to the patients

1. Not pulling or pressing the space maintainer by fingers or tongue, which bends, deforms, or lessens it. If the space maintainer is loose, the risk of aspiration into the lungs will be high.
2. Not using sticky chocolates or gums
3. Regular dental flossing and tooth brushing
4. Regular dental visits ^[6, 14]

Conclusion

Various types of designs are used to maintain the space of primary teeth. Research has shown that mandibular appliances undergo more fracture than other appliances. Further, fixed appliances cause less damage to the oral tissue and bring about fewer problems for the patient. The differences of SMs can be investigated in three domains: survival rate, gingival health, and caries rate. Prefabricated bands along with custom-made loops show the highest survival rate and gingival health among different appliances. Band and loop has the highest survival rate. However, frequent patient examination in close intervals are required for better efficacy of the appliance and longer longevity ^[23].

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