Report

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Space maintenance: An overview for clinicians

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ABSTRACT:
Primary teeth play an important role in aesthetics and function in the developing child. They also help to hold space for the permanent successors and guide them into occlusion. Space maintenance for early loss of primary teeth has therefore become an important part of interceptive orthodontic and paedodontic treatment. This review discusses the literature surrounding current techniques for space maintenance. Space requirement estimations and the indications and contraindications of space maintenance will be also be evaluated.

INTRODUCTION

Common causes for premature loss of primary teeth include caries and trauma (Ngan et al., 1999). Changes such as centreline shifts and dental arch length reduction can be seen in the permanent dentition as a result of early loss. The loss of a deciduous canine tooth is more likely to result in a centreline shift, whereas loss of a second deciduous molar, especially if the loss occurs before nine years of age, can result in a decrease in arch length (Freer and Ho, 2009). The occurrence of space loss is said to increase with time following premature extraction, with deciduous upper second molar spaces showing the greatest rate and amount of space loss (Owen, 1971). Approximately 51% of prematurely lost first deciduous molars and 70% of prematurely lost second deciduous molars result in loss of space in the dental arch (Owen, 1971). Consequently, impaction or malposition of a permanent successor, tipping of adjacent molars and crowding may occur (Laing et al., 2009; Viglianisi, 2010).

Primary canines and molars, when added together, take up more space in the dental arch than permanent canines and premolars. The potential space created by this size differential is defined as the leeway space. Maintaining leeway space can potentially prevent up to 4.3 mm of crowding (bilaterally) on eruption of the permanent dentition (Gianelly, 1995). Thus, space maintenance following early loss of deciduous teeth can help to prevent the need for future extensive fixed appliance treatment in mild to moderate crowding cases.

Management of cases with premature loss of primary teeth often requires multidisciplinary interaction between general dental practitioners, orthodontists and paediatric dentists. A survey of members of the American Board of Pediatric Dentistry showed that space maintenance was performed by 95% of paediatric practitioners in the United States (Hilgers et al., 2003). As appropriate case selection is critical, some clinical situations where space maintenance should or should not be considered are discussed below.

INDICATIONS AND CONTRAINDICATIONS FOR SPACE MAINTENANCE

Space maintenance appliances should be prescribed on an individual need basis (Laing et al., 2009). This interceptive treatment may be indicated if the likelihood of complex orthodontics at a later stage will be reduced (Brothwell, 1997; Littlewood et al., 2001). Special consideration should be given to maintaining arch length when there has been early loss of deciduous second molars, where deciduous first molars are lost before the eruption of the permanent first molars, or following unilateral loss of deciduous canines (Gill, 2008).

There are several situations where space maintenance is contraindicated, such as when the successor tooth is close to eruption. As an assessment guide, for every 1 mm of bone over the permanent successor, eruption of a premolar into the mouth will likely take four to five months (Bijoor and Kohli, 2005). In cases of severe crowding where there may not be space for the permanent tooth even if space is held, space maintenance may not be beneficial. Where there has been unilateral loss of a primary canine or first molar, shifting of the centreline may be a concern. This can be challenging to correct, and therefore, contralateral extraction may be advised to counteract this phenomenon (Freer and Ho, 2009). Space maintenance is not required for early loss of primary incisor teeth unless it is for aesthetic reasons (Bijoor and Kohli, 2005). Removable appliances are not recommended in children that are unlikely to comply with full time wear, or if the space will need to be held for an extended period of time. Fixed space maintaining appliances are usually plaque retentive and may predispose to caries and periodontal problems. Hence, they are not recommended in high caries risk patients (Laing et al., 2009).

DETERMINATION OF SPACE REQUIRED FOR ERUPTION OF PERMANENT TEETH

To help determine if space maintenance is a suitable option, the amount of crowding in the permanent dentition should be estimated by comparing the size of the unerupted teeth to the space available in the arch (Ngan and Fields, 1995). One of several approaches the clinician can use to predict the size of unerupted teeth is the radiographic method. Bitewings or periapical films are preferable to panoramic radiographs as they are less subject to distortion (Proffit et al., 2006). The unknown tooth width can be predicted by dividing the actual width of an erupted tooth by it's radiographic width and multiplying it by the radiographic width of the unknown tooth.

Another approach commonly used to estimate the size of unerupted teeth is Tanaka and Johnston's 75th percentile (Tanaka and Johnston, 1974). This method uses the four lower incisors to predict the size of the unerupted canines and premolars. The widths of teeth 31, 32, 41 and 42 are added together and divided by two. This number plus 10.5 mm is the estimated width of mandibular canines and premolars in one quadrant. In the maxillary arch, 11.0 mm is added instead.

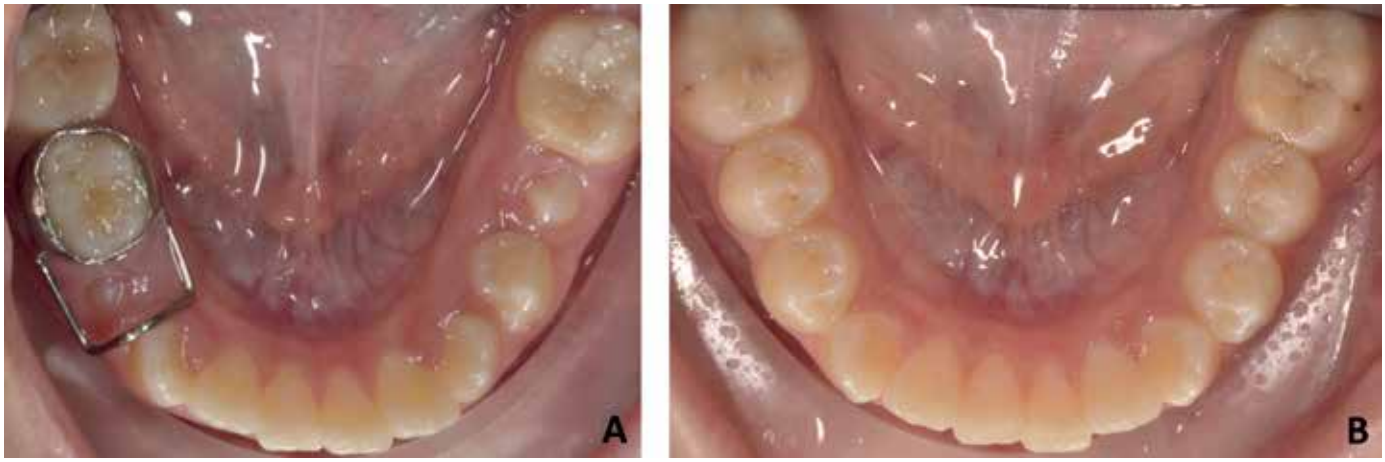

Figure 1: Band and loop off lower right second primary molar (A) allowing successful eruption of lower right first premolar (B).

The Tanaka and Johnston method has a tendency to over – rather than under – estimate tooth size (Nourallah et al., 2002). Its main advantage is that it does not require radiographs or reference tables; however, a disadvantage is that it does not allow for size differences for race and/or sex.

Moyer's prediction tables are a third method providing useful information about the size of unerupted teeth. The mesio-distal widths of the four lower incisors are measured and this measurement is then matched to reference tables used to predict the widths of the canine and premolars on the upper and lower arch in each quadrant. The prediction tables are available at different levels of accuracy (Freer and Ho, 2009).

TYPES OF SPACE MAINTAINERS

Space maintainers can be fixed or removable, unilateral or bilateral appliances (Laing et al., 2009). Few studies have compared different types of space maintainers with each other, making relative evaluations difficult.

The band and loop (Figure 1) is a unilateral fixed cantilevered space maintainer, commonly used in the posterior segments (Sasa et al., 2009). It consists of a band fitted around a tooth soldered to a loop of heavy gauge stainless steel that maintains arch length (Gill, 2008). The appliance can be used in the maxilla or mandible, and must be wide enough bucco-lingually to allow eruption of the permanent successor (Nayak et al., 2004; Bijoor and Kohli, 2005). As the loop has limited strength and cannot withstand high chewing forces, the appliance should be restricted to holding the space of one tooth (Proffit et al., 2006). For early loss of a primary first molar, it is useful to place the band and loop as soon as possible and before the force of eruption of the first permanent molar causes mesial drift of the second primary molar (Laing et al., 2009). When a second primary molar is lost early, the band and loop is usually placed on the first permanent molar (Proffit et al., 2006). Modifications such as the use of an occlusal rest may help prevent mesial tipping of adjacent teeth and gingival dislodgement of the appliance during mastication (Laing et al., 2009). As over-eruption of the opposing tooth is a common problem with these kinds of space maintainers, an occlusal bar is sometimes placed to prevent this (Bijoor and Kohli, 2005; Gill, 2008). However, this can also interfere with the eruption of the permanent successor.

The crown and loop space maintainer is a less commonly used variation of the band and loop, and can be used when there is less tooth structure remaining and the tooth may benefit from a stainless steel crown (Qudeimat and Fayle, 1999; Bijoor and Kohli, 2005). A stainless steel crown soldered with a loop to span the edentulous space is placed over the compromised tooth. This type of appliance has not gained popularity, as failure of the loop requires replacement of the whole stainless steel crown. As an alternative, it is preferable to crown the tooth, and then place a separate band and loop appliance that can be easily removed and replaced if required (Proffit et al., 2006).

Figure 2: Nance Palatal Arch placed to allow eruption of upper first premolars.

The lower lingual holding arch (LLHA) is one of the most popular space maintainers used in clinical practice. The appliance consists of a heavy gauge stainless steel wire adapted to the lingual aspect of the mandibular arch, soldered to molar bands bilaterally. It is recommended that the wire contacts the cingulae of the lower permanent incisors staying 1-1.5 mm above the gingiva (Laing et al., 2009). LLHAs are an ideal appliance to use when there has been bilateral loss of lower primary molars. They can also be used to preserve leeway space when there is mild crowding and non-extraction treatment is planned, if they are cemented before exfoliation of the primary molars (Gill, 2008). The LLHA has been shown to effectively hold arch length by preventing lingual tipping of anterior teeth and mesial movement of posterior teeth (Bijoor and Kohli, 2005; Viglianisi, 2010). However, there is evidence that some lower incisor proclination also occurs (Rebellato et al., 1997; Owais et al., 2011). As permanent incisors initially erupt lingually to their primary predecessors, a lingual

arch appliance is not recommended prior to eruption of the permanent lower incisor teeth so that their eruption is not hindered (Proffit et al., 2006). Common problems with the lingual arch include distortion and breakage. Plaque retention and caries can also occur if the extra effort necessary to keep the appliance clean is inadequate.

There are several maxillary appliances that aim to hold the position of the upper molars. A modified LLHA can be fabricated for the upper arch if the bite is not deep, otherwise lower incisal contact makes these appliances very difficult to tolerate (Proffit et al., 2006). The Nance Palatal Arch (NPA) maintains arch length when primary molars are lost unilaterally or bilaterally (Bijoor and Kohli, 2005). There is an acrylic button lightly contacting the palate on the most anterior and superior part of the heavy gauge transpalatal archwire that is soldered to molar bands bilaterally (Figure 2). This adds stability to the appliance and allows the palatal vault to be utilized as anchorage (Laing et al., 2009). The NPA can also be useful in preventing rotation and tipping of the upper permanent molars following early loss of deciduous second molars. One drawback of the NPA is that it has been reported to cause palatal mucosal irritation and it can be difficult to clean (Kupietzky and Tal, 2007; Singh and Cox, 2009).

Another type of maxillary space maintainer is the transpalatal arch (TPA). As with the NPA, it consists of heavy gauge stainless steel wire extending across the palate between contralateral molars. It is adapted to the curve of the palatal vault and an omega loop is usually incorporated at the midline (Laing et al., 2009). The TPA can be adjusted to maintain molars in three planes of space, and can be used for expansion or constriction via adjustment of the omega loop (Kupietzky and Tal, 2007). An advantage of the TPA over the NPA is a reduction in mucosal irritation as there is no acrylic incorporated into its design. It is also less likely to interfere with speech or oral hygiene (Kupietzky and Tal, 2007; Kojima and Fukui, 2008). The space maintaining properties of TPA's are controversial, however. Studies have assessed the ability of a TPA to prevent forward movement of molar teeth, and some authors failed to find a clinically significant difference in molar position with or without the use of TPAs (Zablocki et al., 2008). Thus, it is the opinion of the present authors that the TPA not be used solely for space maintenance.

The Groper Fixed Anterior Bridge can be used when anterior teeth have been lost and aesthetics is a concern. This appliance consists of a lingual archwire attached to bands on the deciduous second molars. Replacement anterior teeth are attached to the wire (Bijoor and Kohli, 2005). Distortion and/or breakage of this appliance can be a potential problem.

A partial denture is commonly used when there is early loss of an incisor, if teeth have been lost on both sides of the arch,

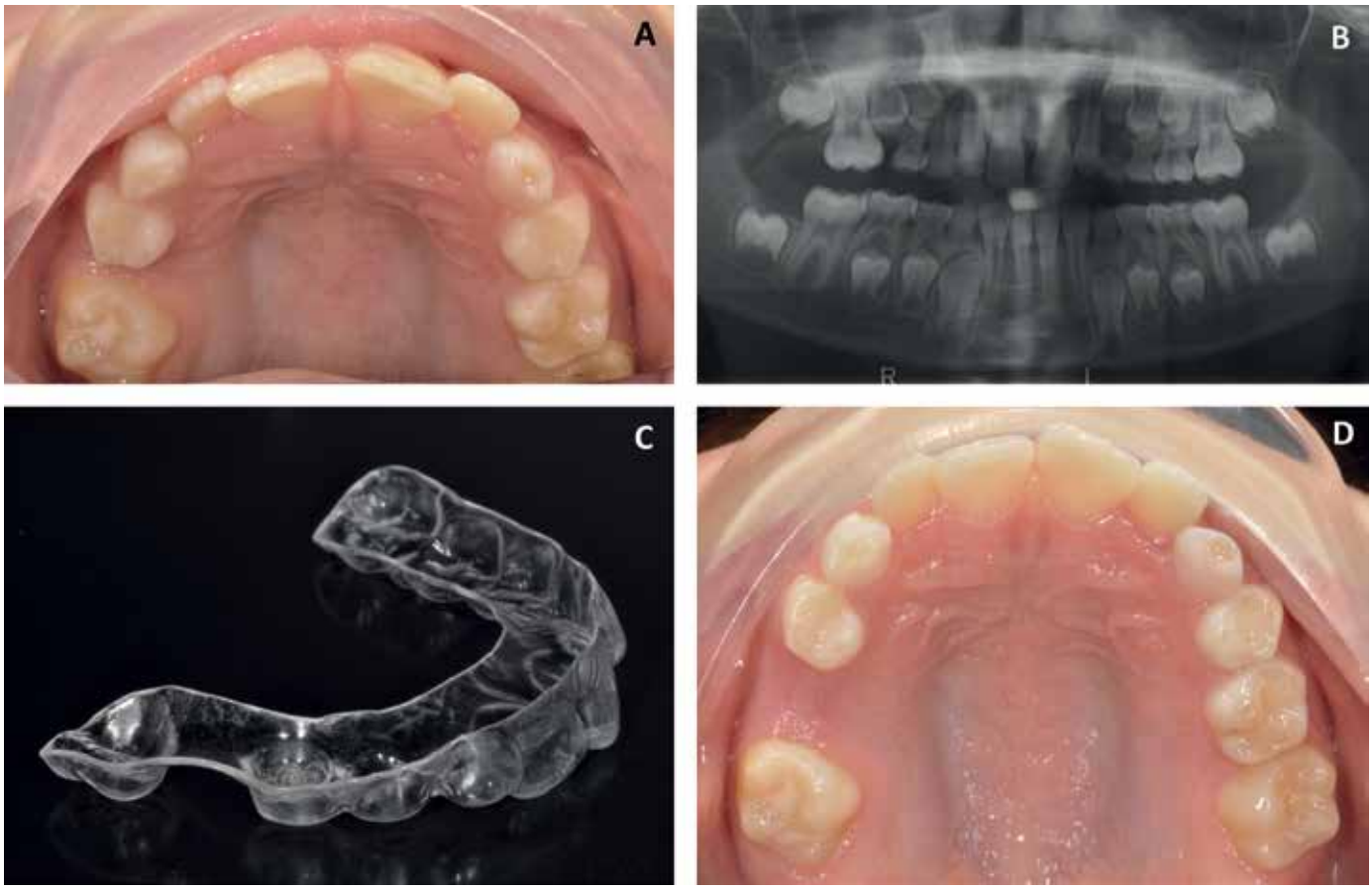

Figure 3: An interesting case where there was early loss of the upper right second primary molar with resulting space loss (A). The patient was Class I with minimal crowding in all other quadrants. The panoramic dental radiograph showed mesial crown tip of the upper right first molar with room to regain the space by moving the crown of the tooth distally (B). Partial fixed appliances were used to distalise the adult tooth. Once sufficient space was gained a VFR was made for night-time wear as a space maintianer (C). The 7 mm space at debond was still present 3 months later and will allow sufficient space for future eruption of the adult premolar tooth. This will avoid the need for orthodontic extractions and possibly even future orthodontic treatment.

or when a band and loop space maintainer cannot span the required length of the edentulous space (Proffit et al., 2006). The partial denture is also useful because it can replace occlusal function when multiple teeth are missing. As early loss of a primary incisor is not an indicator for space maintenance, partial dentures are placed in these situations solely to improve appearance. Adjustment is required as permanent teeth erupt.

Vacuum formed retainers (VFRs) are a commonly used type of removable space maintainer (Figure 3). Usually night time wear is sufficient to prevent drifiting of adjacent teeth and resulting space loss. VFRs are clear sheets of plastic which are heated and adapted to stone models of a patient's teeth using a vacuum machine. Several varieties of plastic are available for purchase. These space maintainers are inexpensive to make and easy to replace as other teeth are lost or begin erupting and displace the retainer.

Oral hygiene management is more difficult with fixed space maintainers than removable types (Littlewood et al., 2001). However, fixed options decrease the need for patient compliance, and usually have a greater acceptance due to decreased bulk and speech alterations compared to their removable equivalents (Bijoor and Kohli, 2005). Speech disturbances from removable appliances tend to be short lived, however, with significant or complete resolution by the seventh day of wear (Haydar et al., 1996).

SURVIVAL RATES OF SPACE MAINTAINERS

Few studies compare the survival rates of the various types of space maintainers commonly used in clinical practice. In 1998, Qudeimat and Fayle compared the longevity of over 300 fixed and removable maintainers finding the median survival time to be as low as 7 months (Table 1). Other groups found higher survival rates with around 70% of appliances still in place at approximately 23 months (Baroni et al., 1994). Unilateral space maintainers, appliances fitted less than two times, and those placed on the left side had higher survival rates (Qudeimat and Fayle, 1998). The most common causes for appliance failure include cement failure, breakage, poor appliance design, soft tissue impingement, and interference with eruption of the permanent teeth (Qudeimat and Fayle, 1998; Baroni et al., 2004).

ALTERNATIVE APPROACHES TO SPACE MAINTENANCE

When a permanent second premolar is congenitally missing and prosthetic replacement is indicated, retaining a primary second molar to hold space is preferred to the long-term use of a space maintainer. As the deciduous molar is wider than the space required for a premolar implant when the patient is fully grown, reduction of the mesiodistal width of the primary tooth is advised (Kokich, 2005). The tooth should first be evaluated by assessing the crown width and root divergence on a periapical film. If the roots are not hyperdivergent it may be possible to remove up to 1.5-2 mm from the mesial and distal surfaces of the primary tooth before sealing the dentine with a thin layer of composite resin. If the patient is over 14 years old, local anaesthetic may not be necessary as the pulp has already undergone significant constriction (Kokich, 2005). However, it may also be necessary to build up the occlusal surface to gain sufficient crown height and occlusal contact to prevent over-eruption of the opposing tooth.

Another alternative approach prior to fixed appliance treatment can be the use of serial extractions. Originally considered a method to treat severe crowding with or without follow-up treatment with fixed appliances, serial extractions are now viewed as an aid to comprehensive orthodontic treatment at a later stage (Proffit et al., 2006). A decision is typically made in the early mixed dentition that extraction of permanent teeth will be required for alignment. Serial extraction is a procedure involving the sequential removal of primary teeth to facilitate a more favourable eruption path of the adjacent permanent teeth. Serial extraction usually results in the removal of some permanent teeth, commonly the four first premolars (Freer and Ho, 2009). Serial extraction does not preclude future comprehensive orthodontic treatment needed to obtain the best alignment and occlusion possible for the individual patient. Particular characteristics of the malocclusion and the timing of the sequential extractions are critical to the success of the procedure and a detailed description is beyond the scope of this review. Serial extractions were used more frequently in previous decades. If used correctly they can be a useful adjunct to comprehensive orthodontic treatment (Proffit et al., 2006).

Table 1: Median survival time of various space maintainers according to Qudeimat and Fayle (1998)

Space Maintainer	Median Survival Time
Lower lingual holding arch	4 months
Nance appliance	6 months
Removable partial denture	9 months
Band and loop	13 months

CONTROVERSY SURROUNDING SPACE MAINTENANCE

Some authors have questioned the efficacy of space maintenance at preventing malocclusions in the permanent dentition and there are contrasting opinions on this topic (Owen, 1971; Sonis and Ackerman, 2011; Rubin et al., 2012). Recent research has suggested that maintaining arch perimeter in the mixed dentition can lead to posterior space deficiencies in the long term. These space deficiencies can increase the probability of eruption disturbances or impaction of permanent second molars (Rubin et al., 2012). It has been shown that after placement of a lingual arch, 8.5% of lower second molars became impacted compared to 0.2-2.3% in the general population (Sonis and Ackerman, 2011). In addition, young patients with space maintainers must be monitored regularly to avoid complications arising from poor oral hygiene, distortion/breakage of the appliance, and for the eruption of the permanent teeth for which the space has been maintained.

CONCLUSIONS

The use of space maintenance for the early loss of primary teeth should be considered in carefully selected cases. Prior to prescribing appliances, the amount of space required should be determined by predicting the likely size of the unerupted permanent teeth. If holding enough space is likely to decrease treatment complexity at a later date, then the clinician should consider the location of the teeth lost early, the likelihood of patient compliance, and the time that the appliance will need to remain in situ before placing the space maintainer. If in doubt, multidisciplinary opinions should be sought to aid in treatment planning.

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