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Space maintenance

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Objective. The use of a space maintainer appliance, or restoration of a carious primary tooth that can then act as a natural space maintainer, may potentially obviate the consequences of loss of arch length and the need for complex orthodontic treatment at a later stage. Nevertheless, all space maintainer appliances are plaque retentive and may predispose to dental caries and gingival inflammation. Space maintainer appliances may also impinge on the soft tissues, interfere with eruption of adjacent teeth, fracture, and become dislodged or lost. This review article provides a summary of the available evidence, and considers the indications for space maintenance.

Methods. Medline and Ovid Medline were scanned, and additionally a hand-search of non-listed peer-reviewed papers written in English was performed. A total of 16 pertinent papers published between 1987 and 2007 that satisfied the inclusion criteria were selected for discussion.

Conclusions. There is limited evidence to recommend either for or against the use of space maintainers to prevent or reduce the severity of malocclusion in the permanent dentition. Decisions regarding the use of space maintainers should be guided by balancing the occlusal disturbance that may result if one is not used against the potential plaque accumulation and caries that the appliance may cause.

Introduction

Space maintainers are fixed or removable appliances used to preserve arch length following the premature loss or elective extraction of a tooth/teeth. Retained primary teeth can also act as space maintainers. Space maintainer appliances are most commonly used to maintain the space created by early loss of a first or second primary molar while awaiting the eruption of its successor. Space management is an important responsibility of clinicians who are involved in monitoring the developing dentition, as the loss of arch length may lead to problems such as crowding, ectopic eruption, dental impaction, crossbite formation, and dental centreline discrepancies. The use of space maintainers may potentially obviate the need for later extractions and/or complex orthodontic treatment. Despite the possible benefits of space maintainers, there is limited evidence to support their use and there have been no prospective randomized controlled trials into the consequences of premature loss of teeth. Most of the research is based on cross-sectional data with limited sample sizes, and the data are not always separated into maxillary or mandibular arches. The purpose of this article was to summarize the evidence from previously published papers, discussing the premature loss of primary molars and the options available for space maintenance.

The Clinical Effectiveness Committee of the Faculty of Dental Surgery of The Royal College of Surgeons of England [RCS(Eng)] first published clinical guidelines on the extraction of primary teeth and the use of space maintainers in 2001, and these were updated in 2006[1]. The Scottish Intercollegiate Guideline Network (SIGN) classification was used to denote the quality of the evidence used to produce the guidelines' recommendations[1]. Most of the recommendations were assigned SIGN grades B and C, denoting that they were based on currently accepted clinical practice and limited scientific evidence that would not stand up to scrutiny.

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Materials and methods

Database

This was a descriptive rather than analytical review, and as such the method employed was to scan Pubmed and Ovid Medline using the following search terms: space maintainer, premature loss and primary molar, band and loop space maintainer, crown and loop space maintainer, distal shoe space maintainer, removable appliance and space maintainer, Nance appliance, transpalatal arch (TPA), and lingual arch. A hand-search of non-listed peer-reviewed papers was also performed, and the reference section of the identified papers was also searched in order to identify additional articles. In total, 16 out of 218 papers identified matched the inclusion criteria which were: papers written in English, and papers published between 1987 and 2007, in order to avoid unduly lengthening the paper, however, four key earlier papers have been alluded to. Given that there is limited evidence in this area, there was no restriction on the type of studies included; however, as space maintainers are intended to function for some time, longitudinal studies with sound methodology were favoured for discussion over lower-quality cross-sectional studies.

Results and discussion

Premature loss of primary molars

The RCS(Eng) guidelines on the early loss of primary teeth state that the main indications for space maintainers are in the event of early loss of: (i) primary second molars; and (ii) primary first molars where crowding is severe, so that extraction of one premolar may be insufficient to relieve resultant crowding[1].

This is in accordance with the 11th UK National Clinical Guidelines in Paediatric Dentistry by Rock (2002)[2]. The concept of space loss resulting from early exfoliation of primary teeth was described as early as the 1880s by Davenport[3]. Early investigators, such as Liu in 1949, who conducted the first known study that attempted to quantify space loss, were handicapped by a lack of longitudinally derived data and limitations in measurement technique[4]. More recently, there has been a limited number of longitudinal studies that have utilized subjects in whom there is unilateral premature loss, using the unaffected side as a control (Table 1)[5–7]. The main observations are that following premature loss of a primary molar, mesial migration of molars and distal drift of canines occur, and the extent to which these occur will depend upon the timing of tooth loss, the severity of crowding, and the actual tooth lost (Table 1). The reduction in arch length is more severe in the maxilla, but there is more distal movement of the primary canines in the mandible, in the order of 1 mm[8]. There is less space loss following loss of primary first molars compared to second molars, but eruption of maxillary canines can be impaired following early loss of primary first molars[9].

In order to prevent arch length changes, the best space maintainer is a well-maintained

Table 1. Summary of longitudinal studies investigating the effects of premature loss of primary molars.

Author	Sample size	Follow-up period (months)	Teeth lost	Main findings
Lin *et al.* (2007)[5]	19 children	6	Maxillary primary first molar (unilateral)	Distal drift of primary canines
				Palatal migration of incisors
				1 mm D space lost
Padma Kumari and Retnakumari (2006)[6]	40 children	8	Mandibular primary first molar (unilateral)	Space loss on extraction side ($P < 0.01$).
				No significant space loss on non-extraction side ($P > 0.05$)
Lin and Chang (1998)[7]	21 children	8	Mandibular primary first molar (unilateral)	Distal drift of primary canines
				At 8 months post-extraction, D + E space is significantly shorter than control side ($P = 0.025$)

primary tooth, as all space maintainer appliances are plaque retentive, thereby placing patients at a greater risk of developing caries and gingival inflammation. Space maintainer appliances may also impinge on the soft tissues, interfere with the eruption of adjacent teeth, fracture, and become dislodged or lost. Therefore, every effort should be made to retain primary molars until they are naturally exfoliated; studies have shown that even grossly carious primary molars can often be restored for a few years[10]. Roberts (1996) observed 175 primary molars, in a prospective study, having had formocresol pulpotomies performed by a single operator. The success rate was 99.3% among 143 vital teeth, and 84.8% among 33 non-vital teeth[10]. There was no significant effect upon the age of exfoliation after either type of pulpal treatment.

Types of space maintainer

A summary of the various types of space maintainer and their advantages and disadvantages is shown in Table 2. Space maintainer appliances can be unilateral or bilateral and fixed or removable. Fixed appliances are easier to maintain, and they are less likely to be damaged, lost, or removed. Contraindications for all space maintainers are: children with poor oral hygiene, children with a high caries rate, uncooperative children, and children with irregular attendance, as the gingival tissues may grow over the space maintainer, necessitating surgical removal of the appliance.

Fixed space maintainers: unilateral. Band and loop, crown and loop. The band and loop is a cantilever type of fixed space maintainer that consists of a band cemented commonly to the tooth posterior to the edentulous space and a loop of wire across the edentulous space abutting the anterior tooth Fig. 1. It can be used either unilaterally or bilaterally, although bilaterally, appliances such as the Nance palatal arch appliance tend to be preferred. An occlusal rest can be soldered on the anterior end of the loop to avoid gingival dislodgement of the appliance from masticatory forces and subsequent mesial tipping of the posterior tooth. In the case of premature loss of primary first molars, it is important to place a band and loop 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.

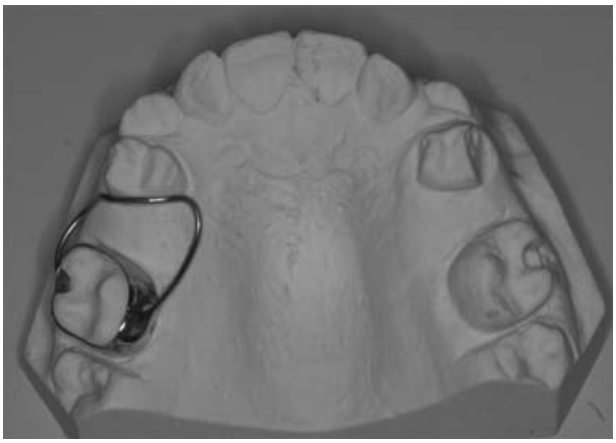

Fig. 1. Band-and-loop space maintainer.

The band and loop is a commonly used space maintainer appliance for single unit spaces, partly due to its durability. In a retrospective study in the UK of the longevity of 301 space maintainers fitted in 141 patients, 190 (63%) failed over the 4-year study period for reasons such as cement failure or breakages[11]. However, the band and loop space maintainers lasted the longest out of all the appliances, with a mean survival time of 13 months. It is important that the appliance is restricted to single unit spaces as the loop has limited strength and will not withstand the forces of mastication if the span is any longer.

The crown and loop is a variation of the band and loop appliance, and is used where stainless steel crown therapy is necessary on the abutment teeth; however, it has not gained popularity. The band and loop tends to be preferred, as if the band and loop fails or is no longer needed, replacing the stainless steel crown will not also be necessary. In a Pubmed search of the literature, only one paper could be found on the crown and loop, which was a case report written 15 years prior to the inclusion period for this review.

Distal shoe. Also known as distal extension space maintainers, these appliances are a type of fixed band-and-loop space maintainer, usually

Table 2. Summary of space maintainers.

Type of space maintainer	Space maintainer	Description	Advantages	Disadvantages
Fixed, unilateral	Band and loop	A loop of heavy gauge wire is soldered to a band on an abutment tooth adjacent to the edentulous space and closely adapted to the edentulous space	• Can be used bilaterally • Simple to fabricate • Well-tolerated by patients	• Single span • Plaque retentive • Increased risk of caries
	Crown and loop	A variation on the band and loop, whereby the wire is soldered to a crown rather than a band	• As for band and loop • Useful if abutment tooth also needs a crown	• As for band and loop • If the space maintainer part (loop) is no longer required or fails, a new crown may be necessary
	Distal shoe	Typically, a crown on the primary first molar with a distal segment extension soldered to the crown. The distal segment (distal shoe) is extended into the tissue mesial to the unerupted first permanent molar (FPM)	• Effective at guiding eruption of FPM • Can use preformed distal shoes, although as they are not customized to an individual, they cannot be used in all cases	• Technically difficult • Requires excellent oral hygiene • Requires local anaesthetic and a surgical incision • Once the FPM has erupted, it often needs to be swapped for a band and loop until the second premolar erupts, entailing several appointments
Removable, unilateral	Removable unilateral space maintainer	Acrylic base carrying 1–4 pontics supported by clasps at either end	• Can be removed for cleaning	• Dangerous as easily swallowed/inhaled due to small size. Now an archaic method
Fixed, bilateral	Transpalatal arch (TPA)	Comprises a heavy gauge wire soldered to molar bands on each side of the mouth with a central 'U' loop	• Good where bilateral premature loss of maxillary primary molars has occurred. • Stable as anchored to two teeth	• FPM's may move forwards simultaneously approximately 1 mm
	Nance palatal arch appliance	As for TPA, but has a central acrylic button resting against palatal tissue anteriorly instead of the 'U' loop	• As for TPA but more stable as additional anchorage gained from palatal vault	• Button can cause palatal tissue irritation
	Lingual arch	Consists of a heavy gauge wire soldered to molar bands on each side of the mouth, extending anteriorly to contact the lingual surfaces of the incisors	• Very stable, because two abutments • Can be used in primary/mixed dentition as bands can be cemented to primary/permanent molars • Can use in hypodontia cases where premolars are absent, prior to prosthetic treatment	• If used in the primary dentition, the wire may obstruct the eruption of the lower incisors • Some clinicians favour bilateral band and loop appliances in the primary dentition
Removable, bilateral	Upper or lower removable appliance	Acrylic baseplate with pontic teeth filling the exact dimensions of the edentulous space	• Good for multiple spaces • Appliance can also be used for active orthodontic treatment	• Compliance • Susceptible to breakage/loss by the patient • Less retention in lower arch as reduced undercuts

indicated when a second primary molar (commonly mandibular) is lost early, prior to the eruption of the first permanent molar. In an early study regarding space maintenance, Richardson (1965) observed that there is significant mesial movement of the first permanent molars in these cases, if space maintainers are not used[12]. The distal shoe consists of a plastic or metal guide plane that guides permanent molar eruption. The loop carrying the intra-alveolar distal shoe is soldered onto a band or crown on the first primary molar. To be effective, the distal shoe must extend into the alveolar process so that it contacts the first permanent molar approximately 1 mm below its mesial marginal ridge, or at its emergence from the bone. Once the molar erupts, the distal shoe should be replaced for a band and loop as the distal shoe is less hygienic, due to its extension under the gingival tissues. Consequently, meticulous oral hygiene must be maintained, and it should be borne in mind that the use of a distal shoe space maintainer entails several appointments and is contraindicated in patients with infective endocarditis. Given the disadvantages of distal shoes, most clinicians prefer to try to save the primary second molar with a pulpectomy prior to the eruption of the adjacent first permanent molar, or use a removable appliance[13].

The procedure for distal shoe placement involves a first appointment for extraction of the primary second molar and impression taking. At the second appointment, an incision is made in the gingival tissues immediately mesial to the first permanent molar so that the distal shoe can be embedded in tissue, and the appliance is then cemented into place. Some clinicians combine the extraction and placement procedure to reduce patient discomfort from local anaesthetic administration at both appointments. Alternatively, prefabricated distal shoes may be used, although as they are not customized to the patient, they are unlikely to be acceptable in every situation.

Removable space maintainers: unilateral. These appliances present swallowing and choking hazards for children due to their small size. They are rarely used and are considered dangerous appliances. A preferable alternative would be a fixed unilateral space maintainer as previously described.

Fixed space maintainers: bilateral. Lingual arch. This custom-made appliance, popularized by Burstone, consists of a single heavy-gauge [0.036 inch (0.9 mm) or higher] stainless steel wire adapted to the lingual aspect of the mandibular arch, attached to bands on the first permanent molars[14]. The appliance is stable as it is anchored to two teeth, and the design can incorporate two U-loops bent into the wire mesial to the first molars, which permit adjustment in the sagittal direction. Lingual arches are commonly used in the primary and mixed dentitions where there has been premature loss of multiple posterior primary teeth. The appliance is cemented onto either the lower primary second molars or first permanent molars, and can be of fixed (soldered) design or removable design. A conventional lingual arch, contacting the cingulae of the mandibular incisors while staying approximately 1–1.5 mm away from the soft tissue laterally, can prevent anterior movement of the posterior teeth and posterior movement of the anterior teeth. The evidence demonstrates that it is effective at maintaining the arch perimeter in the transition from the mixed to the permanent dentition, but at the expense of slight (mean 0.44 mm, SD 0.31) lower incisor proclination[15,16].

The lingual arch is commonly placed once the mandibular incisors have erupted, as otherwise the appliance may obstruct eruption of the lower incisors. If a bilateral space maintainer is required prior to the eruption of the mandibular incisors, some clinicians prefer to place bilateral band-and-loop appliances instead of a lingual arch. Either of these options is preferable to a lower removable appliance, due to difficulties with compliance and the limited retention provided by mandibular molars.

TPA. Originally described by Robert Goshgarian in 1972, the Transpalatal arch is a maxillary fixed or removable appliance consisting of a heavy-gauge [0.036 inch (0.9 mm) or higher] stainless steel wire that extends from one maxillary first permanent molar, along the contour of the palate, to the contralateral first molar (Fig. 2). It is adapted to the curvature of the palatal vault,

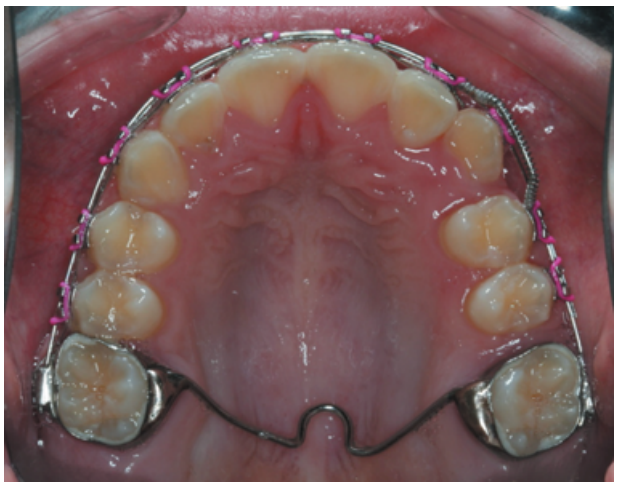

Fig. 2. Transpalatal arch.

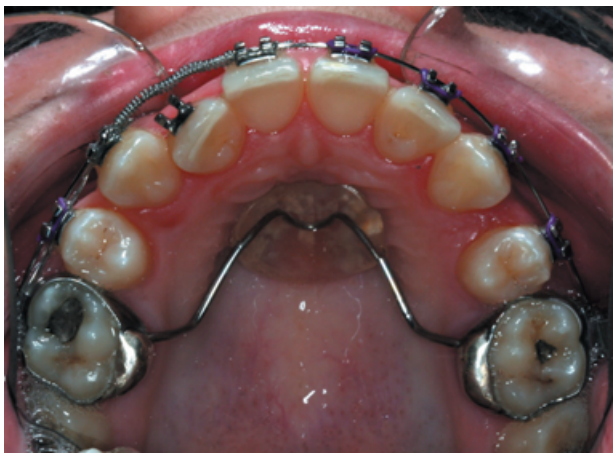

Fig. 3. Nance appliance.

so that it lies 2–3 mm away from the palatal mucosa, and an omega loop is usually incorporated midway across the span. A TPA would theoretically bring the roots of the upper molars into contact with cortical bone if they were forced to move mesially, which would supplement their anchorage. Cortical bone provides greater resistance to tooth movement than cancellous bone due to its reduced vascularity and increased density.

The TPA can be adapted to produce a range of forces and couples to move and/or rotate maxillary molars in all three planes of spaces[17]. Changing the palatal arch form can produce expansion or constriction of the intermolar width, and activation of the inserts of the TPA will produce couples at the molar sheaths. Following early loss of second primary molars, mesial rotation of the maxillary first permanent molars around their palatal roots commonly occurs and the TPA can be activated to derotate them such that the mesiobuccal cusps move distofacially[18]. Due to their rhomboidal shape, maxillary molar derotation is an efficient way of gaining arch length as it opens up space mesial to the molars (mean 0.4 mm, SD 2.0)[18].

Alternative space maintainers in the maxillary arch following premature loss of primary molars are bilateral band-and-loop appliances, a Nance palatal arch appliance, or an upper removable appliance.

Nance palatal arch appliance. This is a maxillary custom-made fixed appliance developed by H.N. Nance in 1947, consisting of a heavy-gauge [0.036 inch (0.9 mm) or higher] stainless steel wire soldered to the palatal aspect of the first permanent molar bands (Fig. 3). The wire is directed from the molars anteriorly and is attached to an acrylic button that rests against the most superior and anterior aspects of the palatal vault. It is used as a space maintainer, such as in cases where bilateral loss of maxillary primary teeth has occurred, or as a means to reinforce anchorage, and it has some scope for acting as a habit breaker. The advantage over the TPA is that additional anchorage is gained from the palatal vault, which helps to resist mesial movement of the terminal molars. It follows that the Nance arch is more suited to patients in whom the palatal vault is deeper; however, if excessive anchorage demands are placed on the Nance, then it can become embedded into the palatal mucosa and can be difficult to remove. Kupietzky and Tal (2007) compared the use of the TPA and the Nance appliance, and found that the TPA can be just as effective as the Nance for space maintenance, and advocated its use[19]. The advantage of the TPA over the Nance is that there is less potential for irritation of the palatal mucosa. The Nance arch is useful in the case of missing maxillary anterior teeth, as an additional wire can be soldered onto the palatal aspect of the first molar bands extending anteriorly to support acrylic pontic teeth[20]. This can give acceptable aesthetics, although the patient must also clean meticulously under the pontics.

Removable space maintainers: bilateral. Removable appliances are particularly useful in cases of multiple spacing, and a recent study by Kupietzky discussed their usage for free-end space maintenance following very early loss of primary second molars[13]. Kupietzky concluded that removable appliances are often preferred to distal shoes as they are simple to fabricate and place, and by maintaining the integrity of the gingival tissues they avoid the complications of subgingival appliances[13]. However, removable appliances rely on patient compliance and are less likely to be worn and can be damaged or lost more easily than fixed appliances. The acceptance of removable appliances in children may be improved by using multicoloured acrylics and by minimizing the number of wires needed anteriorly for retention[13]. Wire stops, however, are usually needed mesial and distal to edentulous spaces to maintain their patency, even if pontic teeth are placed, as pontic teeth can fracture off from the acrylic baseplate (Fig. 4). The decision of whether or not to replace multiple missing maxillary primary teeth is controversial. If there is parental motivation to restore the space for aesthetic reasons, the child is co-operative and it will be more than 6 months until the eruption of the permanent central incisors, then this may be an appropriate option. From a dental health point of view, it is acceptable to not replace missing anterior teeth, as space loss does not readily occur.

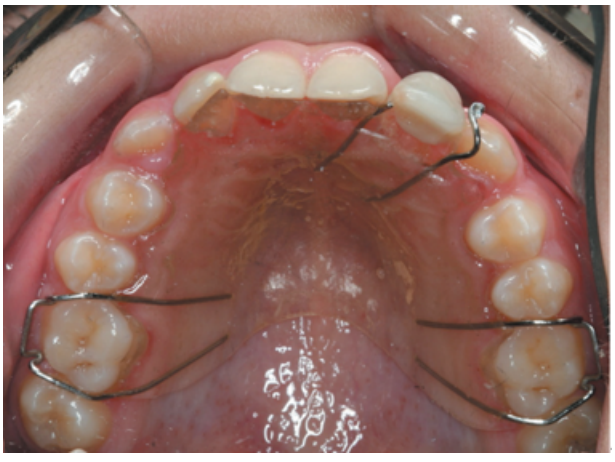

Fig. 4. Upper removable appliance to maintain space for uppe

Conclusions

This descriptive review has shown that there is poor evidence to recommend either for or against the use of space maintainers to prevent or reduce the severity of malocclusion in the permanent dentition. Decisions regarding the use of space maintainers must therefore be guided by factors other than scientific evidence at the present time. Practitioners involved in monitoring the developing dentition should prescribe space maintainers on an individual needs basis, balancing the occlusal disturbance that may result if one is not used against the plaque accumulation and caries that the appliance may cause.

What this paper adds

- This paper reviews and presents clinically relevant evidence regarding the use of space maintainers which will benefit clinicians who are involved in management of the developing dentition.

Why this paper is important to paediatric dentists

- Space management is an important responsibility of paediatric dentists, as loss of arch length may lead to problems such as crowding, ectopic eruption, dental impaction, crossbite formation, and dental centreline discrepancies.

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