

surface of deciduous molar is essential for guidance for eruption of first permanent molar, it's premature loss leads to severe space loss and tipped position due to mesial eruption pathway of permanent molar.⁵

Space Loss due to Early Loss of Primary Second Molars:

The concept of space loss due to premature loss of deciduous teeth was described by Davenport as early as 1887.⁶ In 70% the space loss and subsequent malpositioning of permanent teeth is seen due to premature loss of deciduous second molar.³ According to Lundstrom, Davey and Beaver the space loss and mesial tipping of permanent molars is seen more with premature loss of deciduous second molars. Even Høffding and Kisling also is in view with this point and also concluded that it also had an influence on the sagittal molar relation to a greater degree.⁷ Table: 1 gives the various studies and the amount of space loss.⁸

Table 1: Studies on amount of space loss in both the arches

Author	Year	% of space loss	Space loss in maxilla (in mm)	Space loss in mandible (in mm)
Liu	1949	-	2.5	1.4
Breakspear	1951	70	2.2	1.7
Jarvis	1952	-	M- 4.2 F- 2.1	M- 2.7 F- 2.9
Rannerman and Thilander	1977	-	3.7-4.5	2.1
Brauer	1982	59	-	-
Rao and Sarkar	1999	-	2.05	1.23
Northway	2006	-	-	0.9mm/yr

However a distal space maintainer may not be indicated if active eruption of the first permanent molar has started.⁵

Indication and Contraindications

Hicks (1973) suggested the indications and contraindication for the distal shoe appliance. The indications are; unsuccessful pulp therapy, periapical bone destruction and advanced root resorption, extensive carious destruction of the crown which cannot be restored, ankylosis and ectopic eruption of first permanent molar. Conversely the following conditions contradict their usage; poor parent and patient compliance, congenitally absent first permanent molar, multiple loss of teeth leading to inadequate abutments.⁹ Other contraindications as suggested by other authors are, in a patient with a history of systemic illness such as kidney disease, rheumatic fever, low resistance to infection, juvenile diabetes, or certain blood diseases and for patients with congenital heart defects who need prophylactic antibiotics.²

Criteria for the Appliance Selection and Fabrication

Because the eruption of maxillary and mandibular first permanent molars differ. The design and placement of the appliance differ for the maxillary and mandibular arches. The maxillary first permanent molar erupts in a distal and facial direction until it meets muscular resistance. It then erupts in a mesial direction until contact is made with the distal surface of the second primary molar.⁹ Hence this appliance is not

advised in the maxillary arch.

In contrast in case of mandibular arch the 1'st permanent molar erupts in a lingual and mesial direction using the distal surface of the 2;nd primary molar as the buttress to guide into position. Hence the design of the distal extension of the appliance should have a slight lingual position over the crest of the alveolar ridge in order to engage the mesial contact area of the 1'st permanent molar. This consideration is important in preventing the erupting permanent molar from slipping contact with the appliance, resulting in rotation of both the molar and the appliance. The occlusal radiograph is helpful in checking the facio-lingual placement of the gingival extension.

The decision regarding the length of the horizontal bar is confronting to the dentist. The best approach is if the 2'nd primary molar is present it can serve as a guide on the working model until the fabrication of the appliance. If it is missing then the mesio-distal width of the contra lateral side can be taken. The gingival extension of the appliance should be constructed to extend about 1mm below the mesial marginal ridge of the first permanent molar. A good preoperative radiograph that is slightly underexposed will show the thickness of the over lying soft tissues which will aid in determining the depth of the groove to be cut in the working model in indirect techniques.⁹

Advantages and Disadvantages

The advantage is that this appliance is effective at guiding the eruption of first permanent molar in it's proper position, it prevents supraeruption of opposing teeth, can be fabricated by indirect or direct means. However the disadvantages of this appliance include the requirement of local anaesthetic and surgical incision, patient compliance to maintain excellent oral hygiene, technically difficult procedure, the patient must be under close scrutiny while the appliance is in place, there is no allowance for inaccuracy in the measurement or fabrication and the appliance needs to be changed once the first permanent molar erupts until the eruption of second premolar, entailing several appointments.¹⁰⁻¹¹

Designs of Distal Shoe Space Maintainer

As discussed above there are many factors to be considered in the design of the appliance so as to develop a long range of treatment plan in a growing child who needs the surveillance through three stages of occlusion development, that is, primary mixed and the permanent dentitions.⁹ There have been many designs of the distal shoe depending on the purpose that it serves. Hence it can be classified as:

- Fixed or removable appliance
- Intra-alveolar or extra-alveolar appliance
- Pressure or non pressure appliance
- With or without lingual holding arch appliance
- Unilateral or bilateral appliance
- Adjustable and rigid appliance
- Functional or non-functional appliance
- Special modification

(Table: 2 shows the examples of distal shoe space maintainer based on above classification).

Table 2: Description of distal shoe space maintainer by various authors

Author's Name	Year	Fixed / Removable	Intra alveolar/ Extra alveolar	Pressure/ Non pressure	Unilateral/ Bilateral	Adjustable/ Rigid	Functional/ Nonfunctional	Special modification	Follow up
Willet RC ²	1929	Fixed	Intra alveolar	Non pressure	Unilateral	Rigid	Nonfunctional	-	-
Starkey PE ²¹	1967	Removable	Intra alveolar	Pressure	Unilateral	Rigid	Functional	-	-
Roche JR ⁴	1968	Fixed	Intra alveolar	Non pressure	Unilateral	Rigid	Nonfunctional	-	-
Oldenburg TR ⁹	-	Fixed	Intra alveolar	Non pressure	Unilateral	Rigid	Functional	-	-
Croll TP, Sexton TC ¹⁵	1981	Fixed	Intra alveolar	Non pressure	Unilateral	Adjustable	Nonfunctional	-	10 months
Carroll CE, Jones JE ²¹	1982	Fixed/ Removable	Extra alveolar	Pressure	Unilateral	Rigid	Functional	-	-
Psaltis GL, Fischer TJ ⁷	1982	Fixed	Intra alveolar	Non pressure	Unilateral	Rigid	Nonfunctional	-	Till eruption of first permanent molar
Garcia-Godoy ¹³	1983	Fixed	Intra alveolar	Non pressure	Unilateral	Rigid	Nonfunctional	-	Till eruption of first permanent molar
Chawla HS ¹⁷	1984	Fixed	Intra alveolar	Non pressure	Unilateral	Adjustable	Nonfunctional	-	Till eruption of first permanent molar
Geneheimer, Donly ¹⁸	1992	Fixed	Intra alveolar	Non pressure	Unilateral	Rigid	Nonfunctional	Special gingival extension	-
Brill WA ¹⁶	2002	Fixed	Intra alveolar	Non pressure	Unilateral	Rigid	Nonfunctional	-	Till eruption of first permanent molar
Barberia ¹	2006	Removable	extra alveolar	Pressure	Unilateral	Rigid	Nonfunctional	-	-
Dhindsa, Pandit ⁴	2008	Fixed	Intra alveolar	Non pressure	Bilateral	Rigid	Nonfunctional	-	7 months
Dhull et al ¹⁹	2011	Fixed	Intra alveolar	Non pressure	Unilateral	Rigid	Nonfunctional	Buccal and lingual arms to accommodate supra erupted tooth	1 ½ years
Kirshenblat, Kulhar ²⁰	2011	Fixed	Intra alveolar	Non pressure	Unilateral	Rigid	Nonfunctional	-	4 years
Gujjar et al ¹²	2012	Fixed	Intra alveolar	Non pressure	Bilateral	Rigid	Nonfunctional	-	2 months
Bhat et al ¹⁴	2014	Fixed	Intra alveolar	Non pressure	Unilateral	Rigid	Nonfunctional	-	10 months

The initial designs are the one's given by Willet and Roche which are fixed intra- alveolar passive non functional, non pressure unilateral type of appliance which served to maintain the mesio-distal width needed for the second premolar as well as the guiding appliance for the eruption of first permanent molar.

In 1929 Willet presented the first space maintainer with a distal extension for the premature loss of primary second molar. Since the abutment teeth need to resist the strong eruption force of the lower first permanent molar he covered both the first primary molar and the canine teeth together in a casting which extended distally as a "shoe," hence the name distal shoe for this appliance. The distal extension consisted of an L- shaped bar with an intra-alveolar extension which was soldered to the crown.^{2,5} In 1942 Roche modified the distal extension with a V shaped intra-alveolar extension. The V shape offers a broader surface area and helps prevent rotations. Also it holds a greater chance of success if the unerupted tooth is positioned buccally or lingually in the arch.^{2,4}

The fixed and removable appliance has its own advantages and disadvantages. The fixed appliance does not need the compliance of the patient and are non pressure appliance. These appliances when designed appropriately will not promote mesial migration; however they are contraindicated in certain health conditions. On the other hand the removable appliance are easy to clean unlike intra-alveolar, however it needs a high level of patient compliance and strong motivation from parents and it cannot be used in patients with severe gag reflex.^{2,7}

As stated previously there are some contraindications for the intra-alveolar designs of the appliance the design of extra-alveolar pressure type appliance have come up. Theoretically the terminal end of this type of space maintainer exerts pressure which is received by the neuromuscular spindles in the area, also called proprioceptive receptors, which absorb directional information regarding the tooth eruptive movement, hypothetically permitting an eruption without mesial migration. However this type of appliance should be monitored regularly once in 2 months by radiograph especially when the tooth bud is intra-alveolar as there are high risk of mesial migration.²

The conventional designs can be used successfully for unilateral loss of deciduous second molar however they poses a variety of problems in case of bilateral loss of mandibular second primary molar hence Dhindsa and Pandit suggested the need to modify the appliance design with a lingual holding arch. However this type of appliance may create hindrance in the path of eruption of permanent mandibular incisors and hence may later need to be changed.³ Alternatively Gujjar et, al; suggested the placement of the lingual component far lingually so as to prevent the hindrance of eruption of permanent mandibular incisors.¹² Also the lingual holding arch is said to maintain the integrity of lower dental arch in case of inadequate abutments following unilateral loss of two primary molars by using the canine next to the lost molar and contra lateral molars as abutments.^{7, 13-4}

The conventional designs of distal shoe were made of cast metals hence they did not facilitate minor adjustments for the

proper adaptation of the vertical extension of the distal shoe. Some authors have given modifications which help in minor adjustments for proper adaptation of the vertical arm.¹⁵⁻⁶ also some authors have placed loops to permit accurate placement of distal shoe against first permanent molar as well as to regain small amount of space or to correct mesial tipping.^{13, 17}

The functional design maintains the occlusion as well as prevents the supraeruption of opposing teeth. Also the same appliance can be used as a spacemaintainer after the removal of gingival extension after the eruption of first permanent molar. However the high cost, more time in fabrication and difficulty with adjustment of the appliance and behaviour management of the patient disfavour this design. In such instances a non-functional appliance is of choice.⁹

Gegenheimer and Donly gave a special modification where in along with the gingival extension a distal loop was fabricated and cemented in patient's mouth. On eruption of permanent molar the gingival extension was removed and the remaining appliance acted as a crown and loop appliance till the eruption of premolar thereby avoiding the fabrication of another appliance.¹⁸ Dull et al, gave a special modification which had a buccal and lingual arms instead of horizontal bars, whose buccolingual width was in accordance with the opposing supra erupted molar. This appliance gave better stability as the horizontal bar posed no hindrance during occlusion.¹⁹

Trauma to the Succeeding Tooth

Malformed succedaneous tooth is seen in some cases due to trauma to the follicle caused by improper placement of the gingival extension of the appliance or traumatic extraction of ankylosed primary molar.²⁰

4. Conclusion

A dentist has to constantly evaluate the dental space requirements during the transition from primary to permanent dentition in a growing child. The space loss can lead to problems such as crowding, ectopic eruption and impaction. Many factors have been discussed in the literature regarding distal shoe appliance, however the longevity and failure have not been discussed. With the knowledge that is provided in the literature regarding the of pattern of eruption and sequence the clinician can design an appropriate appliance for maintaining the space for premature loss of deciduous second molar. The ultimate goal is to develop a perfect and healthy occlusion in permanent dentition.

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