# Premature loss of primary molars in children: space recovery through molar distalisation. A literature review

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## Abstract

**Aim** The integrity of primary dentition is essential in the development of the jaws and permanent occlusion. The consequences of a premature loss of primary molars are: space loss, crowding, risk of impaction of the permanent teeth, ectopic eruption, anomalous inclination of the teeth adjacent to the loss molar, reduction of arch length. The mesial displacement of the posterior permanent teeth during eruption can cause a loss of space, which can be regained with orthodontic appliances. Therefore, a careful diagnosis is of great importance to be able to decide what appliance is indicated to recover from this situation. Molar distalisation consists in displacing permanent molars distally, allowing them to reach class I relationship and to recover the correct space for the second bicuspids when the second deciduous molar has been lost early.

**Study design and methods** The aim of this study is to carry out a narrative literature review regarding the different appliances and their effectiveness in regaining space after premature loss of the upper primary molars.

**Results and Conclusions** The paediatric dentist should be aware of the advantages and disadvantages related to each device and select the most appropriate distalisation appliance based on an individual plan of diagnosis and a careful treatment. The distalisation of the upper molar must be adequately stabilised and so it is important to consider also some retainers such as Nance's appliance, the Palatal Plate, the extraoral traction, the utility arch, or II Class elastic bands.

KEYWORDS Paediatric dentist, arch length reduction, molar distalisation, dental class II.

## Introduction

The preservation of an intact and healthy primary dentition is of the utmost importance not only for the proper growth of the jaws but also for the development of a correct and functional occlusion throughout permutation until in full permanent dentition. If the physiological process of tooth exfoliation is altered by an earlier loss of a deciduous tooth, a series of pathological alterations can be observed that the paediatric dentist must be aware of. Although deciduous molars are replaced by permanent molars, their early loss can have significant consequences on oral health. First described by Davenport in 1887 [Davenport, 1887] and later confirmed in more recent literature [Kaklamanos et al., 2017; Shakti et al., 2023], the consequences of premature loss of primary molars are: space loss, crowding, risk of impaction or ectopic eruption of the permanent teeth, anomalous inclination of the teeth adjacent to the loss molar, reduction of arch length. The reduction in maxillary arch length is the most frequently occurring phenomenon after early loss of primary molars, and it can be corrected through molar distalisation. The first orthodontic device designed for this purpose was introduced by Kingsley to reduce dental crowding. Over the years, several studies have analysed different methods to achieve distalisation, therefore today orthodontists can confidently use various appliances to obtain it. Distalisers can be categorised as fixed and removable, intraoral and extraoral devices [Abate et al., 2020; Garrocho-Rangel et al., 2022; Maspero et al., 2019; Maspero et al., 2020]. In recent times, extraoral appliances such as the combination of Cetlin plate or Wilson arches with headgear have almost fallen into disuse as they require active patient collaboration, which is not always obtainable, whereas intraoral appliances require less patient collaboration [Cenzato et al., 2021; Tortora et al., 2023; Lombardo G et al., 2020]. Nowadays, the most commonly used intraoral appliances are: the Jones's Jig, the Pendulum, the Jasper Jumper, and the Fastback [Jung et al., 2011]. These appliances are mainly used for the correction of Class II malocclusions, for some extracting cases and for the recovery of space lost due to the mesialisation of the first molars after premature exfoliation of the primary molars [Turner et al., 2021]. The paediatric dentist should be aware of the risk of space loss after an earlier exfoliation of a deciduous tooth, especially if the lost element happens to be a deciduous second molar. Growing patients may lose a deciduous second molar due to caries, premature extraction or rhizolysis of the distal root induced by a mesially erupting permanent first molar. Moreover, slicing of the distal wall of the deciduous second molar can lead to the eruption of the first permanent molar in a more mesial or mesially-inclined position (Figs. 1, 2). Distalisers used in mixed dentition during permutation may allow not only for maxillary molar distalisation, thus correcting a molar class II in a class I relationship, but also for the recovery of space needed for the eruption of maxillary second bicuspids. This study aims to carry out a systematic review of the literature regarding the different distalising appliances and their effectiveness in recovering space loss in primary dentition.

## Materials and Methods

An electronic search was conducted via PubMed, Scopus, the

FIG. 1 Orthopantomography of a paediatric patient (MCMG, 10 y.o.), with premature loss of upper second deciduous molar, mesialisation of upper first permanent molar and subsequent space deficiency.

FIG. 2 Cephalometric radiography of a paediatric patient (MCMG, 10 y.o.), with premature loss of upper second deciduous molar, mesialisation of upper first permanent molar and subsequent space deficiency.

Cochrane Library, Open Grey, and LILACS. The chosen keywords were "molar distalisation", "distaliser", "deciduous second molar". Articles providing information on the distalisation methods, clinical and experimental studies performed on distalisers, and articles reporting therapeutic results obtained through distalisers were included in the analysis. Among the retrieved articles, only those published between 2010 and 2023 were selected. Using the limit options, only the articles referring to "Humans" were considered. Furthermore, a manual search of grey literature was performed and articles were then added from non-indexed journals. Duplicated articles were excluded from the analysis, as well as research conducted on adult patients and/or on patients in full permanent dentition. The study was founded by the Italian Ministry of Health-Current Research IRCCS.

## Results

A total of 176 articles were retrieved from the systematic search of the databases; additionally, 50 articles were added from the manual search of non-indexed journals. After duplicates removal, 150 articles were screened by reading the abstract, resulting in the exclusion of other 100 papers. The remaining 50 articles were read full-text and, according to the eligibility criteria, only 15 articles were included in the analysis. Due to the lack of homogeneity of results reporting, a metanalysis of the results was impossible to perform. Therefore, a narrative description of the distalisers and their effects is presented in the following paragraphs.

### Description of appliance and clinical results

In Literature the elaboration of several studies on the types of orthodontic devices used to distalise upper molars has highlighted their characteristics, therapeutic indications and, eventually, their side effects.

### Headgear

Among the extraoral distalisation systems, the most important is the headgear [Hubbard et al., 1994]. It consists of a head cap with a pericranial support point that can be cervical, oblique, middle or occipital and a facial arch. The latter is made of two arches, one external and one internal welded to it. According to the direction of the pull determined by the straps of the head cap, it is possible to choose between:

- Horizontal traction: known as "combined-pull headgear", it is indicated for the mesomorphic biotype;
- Low traction: known as "low-pull headgear", indicated for the brachyfacial one;
- High traction: known as "high-pull headgear", indicated for the dolichofacial.

There are several studies whose purpose is to provide information on the effects of these appliances. Siqueira DF and Coll, in 2007 [Siqueira et al., 2007], after performing a selection of clinical cases treated with CHG (Cervical Head Gear, with downward and backward vector directionality), evaluated the obtained results and concluded that the effects of CHG therapy are:

- Improvement of skeletal relationship in Class II malocclusion;
- Inhibition of the forward growth of the maxillary bone.
- Decrease of facial convexity;
- Extrusion and distalisation of upper first molars;
- Extrusion of mandibular incisors.

In 2003 Taner et al. [2003] examined the distalisation of upper molars in patients treated with headgear and observed that the mean values of achieved tooth movement were:

- Distalisation of the first molars: 3.15 ± 1.94 mm;
- Distalisation of the second molars: 2.27 ± 1.33 mm;
- Distalisation period: 11.38 ± 3.18 months.

In a study conducted in 2005 [Godt et al., 2005] Godt and Coll. highlighted the changes in dental casts of vertical growing patients after headgear treatment. The Authors achieved an over-jet reduction from 6-8 mm to 0.6-1.2 mm, an increase of vertical dimension in patients with deep-bite (> 4 mm) and a decrease of vertical dimension in patients with Overbite <3 mm. In the literature, there are several studies that evaluate the effects of headgear from a cephalometric point of view too. For example, in 2005 [Sun Y et al., 2005] Sun Y and Coll observed a reduction in both SNA and SNB angle and a decrease in the inclination of the upper incisors after headgear treatment. After the application of headgear, the upper molars undergo both pure and accompanied translational movements accompanied by rotation, with the effect of moving the elements into the three dimensions of space: horizontal, vertical and sagittal [Altug-Atac and Erdem, 2007]. As a consequence of the application of these devices, the mandibular and the maxillary bone also undergo modifications, which are inhibition of the maxillary bone extension and mandibular rotation [Siqueira et al., 2007].

FIG. 3 Distal jet.

FIG. 4 Pendulum appliance.

### Distal Jet

The Distal Jet is an orthodontic device consisting of two tubes per side joined to a continuous Nance button at the first or second premolar through the presence of a stripe (figure 3). By solidifying the Nance button to the first premolars during the distalisation of the molars, the distal displacement of the second premolars will result in a greater loss of anchorage. If it is chosen to attach it to the second premolars, the overall distalisation time will be greater as you will need to distalise the canines, the first and the second premolars [Kinzinger and Diedrich, 2008]. The distalising movement is accomplished by the total compression of the Ni-Ti spring inserted into the lingual tube of the band in the first molar. The resulting distalisation is a corporeal translation as the force (180 or 240 gr per arch) causing movement of the dental elements in the three planes of the space is constant and close to the molar resistance centre [Kinzinger and Diedrich, 2008]. Once the active phase of malocclusion correction is completed, the Distal Jet can be used as a retainer. In 2001 Ngantung and Coll. [Ngantung et al., 2001] highlighted the effects caused by the use of Distal Jet and they consisted of the following:

- a body distalisation of the upper molar that does not increase mandibular divergence;
- high biomechanical control;
- minimal interference with deglutition, phoning and chewing;
- an anchorage loss, equal to 20% of the mesial space with respect to the first molar.

The Authors also pointed out that Distal Jet is an adequate device for the compliance of the patients. In 2002 Bolla and Coll. [Bolla et al., 2002], through cephalometric analysis and observations on dental casts of patients treated with Distal Jet, showed that the crowns of the upper primary molars were distalised a maximum of 3.2 mm. Moreover, during distalisation, the average anchorage loss at the level of the first premolar was equal to 3.2 mm and the inclination of the maxillary incisors amounted to 0.6 °; on the other hand, neither the mandibular plane angle nor the height of the lower third of the face were altered. In 2005 a comparative analysis between the use of Distal Jet and other orthodontic devices was carried out by Ferguson and Coll. [Ferguson et al., 2005], which showed a greater distal inclination of the first superior molars with the use of headgear (13.5 ° +/- 8.1 °) compared to the Distal Jet (3.2 ° +/- 2, 8 °), as the applied force is closer to the centre of resistance of the molars. The inadequate control of the entity and direction of the forces with unwanted rotations, tipping and/or palatal inclination of the molars represent the main problems that arise in Distal Jet use [Bolla et al., 2002].

### Hilgers Pendulum

Hilgers Pendulum represents a fixed orthodontic device for both monolateral and bilateral distalisation of the first and second molars, conceived by Dr. James Hilgers in 1991 (figure 4). It consists of a stabilising part, a Nance button (palatal anchorage), four metal supports cemented to the premolars and titanium-molybdenum 0.32 springs inserted into the palate tubes of the upper molars (active component) [Bennet and Hilgers, 1994]. The Pendulum exerts continuous mechanical forces in the anteroposterior direction on the upper molars, thus causing a distalisation movement. The achieved effects are [Bussik and McNamara, 2000; Fuziy et al., 2006]:

- Distalisation of the first upper molar around 5 mm;
- Distal inclination of the first molar approximately 8 °;
- Mesialisation around 2.5-3 mm and mesial inclination of 1.5 mm of the first upper premolar;
- 0.7 mm intrusion of the first molar and 1.5 mm extrusion of the second premolar;
- Rotation of the molars;
- Increased of the inferior-anterior facial height.
- Reduction of overbite;
- Clockwise rotation of the mandible.

Escobar et al. [2007] clinically evaluated the distalisation of the upper molars in patients with a pendulum over a 7-8 month period, demonstrating a molar distal movement equal to 6 mm, a molar distal inclination of 11,3° +/- 6.2°, second premolars distalisation of 4.85 +/- 1.96 mm and their inclination of 8.6 ° +/- 5 °. In addition, it was observed a palatal inclination of 2.5 ° +/- 2.98° of the front teeth and a clockwise rotation of the mandibular plane of 1.27° +/- 1.1°. Finally, no anchorage loss was observed during the distalising movement. The effectiveness of Pendulum variants was analysed by Caprioglio et al. [2014]. In detail, the inspected devices were the Segmented Pendulum (SP), a version of the pendulum that distalises firstly the second molars and then the first molars, and the Quad Pendulum (QP), an appliance that allows for simultaneous distalisation of the upper first and second molars. The Authors observed that:

- the distalisation achieved was similar with both devices (SP: 1.8 ± 0.8mm; QP: 1.5 ±0.7mm);
- the observed reduction in OVB was greater with the QP (-1.3±0.5mm) than with the SP (-0.7±0.7mm).

In a 2000 study [Bussik and McNamara, 2000] Bussick and Coll. analysed skeletal and dentoalveolar changes following Pendulum treatment, and stressed that this device should be used in the presence of dental crowding and in combination with Multi-brackets fixed therapy. Finally, Caprioglio et al. [2013] proved that the

dentoalveolar effects achieved by using the Pendulum appliance in growing patients are mostly stable over time, and hypothesised that the increase in lower facial height may be only a temporary side-effect of the distalisation, as it relapses in the long-term.

### Retention

According to some authors, the distalisation of the upper molar relapses if not adequately stabilised [Andreasen and Naessig, 1968]. With the purpose of achieving a stable result, Favero has proposed the use of some retainers such as Nance's appliance, the Palatal Plate, the extraoral traction, the utility arch, and Class II elastic bands [Favero et al., 2018; Lanteri et al., 2020].

## Discussion

The paediatric dentist should be aware of the advantages and disadvantages related to each device and select the most appropriate distalisation appliance based on an individual plan of diagnosis and careful treatment. The distalisation of the upper molar must be adequately stabilised, thus it is important to use as retainers appliances such as Nance's appliance, the Palatal Plate, the headgear, the utility arch or Class II elastics. The systematic review of the Literature analysed the dental-skeletal changes determined by the use of distalising devices in patients with II Class malocclusion due to maxillary protrusions. Such devices may have extraoral anchorage (headgear) or intraoral anchorage (Distal Jet and Pendulum). The indications and contraindications, the effects and the problems arising from their use have been presented and the present study highlighted that headgear represents the only device capable of inducing a scientifically proven orthopaedic displacement of the maxillary bones. Indeed, a reduction in the SNA angle was observed after treatment with headgear, resulting from the control of the posterior-anterior growth of the maxillary bone thanks to the application of forces that are not only greater (600 gr per side) but also dissipated in longer treatment times in comparison to the forces used with the Distal Jet and the Pendulum. The advantages of using extraoral forces for correcting Class II malocclusions are: improvement of skeletal relationships; decreased facial convexity and distalisation of upper molars. The average amount of tooth movement achieved through distalisation has been studied by various authors, with distal movements of 3.15 mm + - 1.94 mm of the upper molars during the treatment period of 11.38 ± 3.18 months [Taner et al, 2003]. Distal Jet is a device that, through its activation (thanks to a spring) exerts a bodily distalisation of the upper molars with a maximum of 3.2 mm, however it can induce possible rotations, inclinations and/or unwanted palatoversion of the upper molars [Ngantung et al., 2001]. Likewise, Hilgers Pendulum causes distalisation movements of 6 mm on the upper molars, accompanied by their rotation and distal inclination of 11.3 ° ± 6.2 ° [Escobar et al., 2006]. The main purpose of these devices is to achieve a bodily distalisation of the molars, avoiding excessive coronal tipping effects in the distal direction to prevent recurrence in the second phase of therapy and finally to retreat the frontal teeth. Considering the unwanted effects, it is noticeable the anchorage loss in lateral and anterior-superior sectors, determined by the discharge of reciprocal forces on the molars and premolars, leading to a mesial inclination of the premolar and an increased pro-inclination of the upper incisors [Serafin et al., 2021; Caprioglio et al., 2013]. Another element that accompanies intraoral devices is that they don't need the patient's collaboration [Sfondrini et al., 2002], a key element for the resolution of malocclusion. Molar distalisation and molar expansion can be considered the most used non-extraction orthodontic techniques to correct crowding of the upper arch [Farronato et al., 2009; Farronato et al., 2012; Gianolio et al., 2014; Lanteri et al., 2020; Maschio et al., 2023]. In light of the dental and skeletal modifications observed in literature not only as desirable outcomes but also as uncontrolled side-effects of molar distalisation, it is important to debate about the appropriateness of distalising in specific malocclusions. For instance, the patient's vertical dimension should be carefully taken into account during treatment planning, as distalisation was proved to induce a clockwise rotation of the mandible, therefore increasing anterior facial height. Thus, high-angle patients and patients with a reduced OVB may not benefit from molar distalisation, as it might not only impair their profile and overall facial aesthetic but also lead to an open bite and labial incompetence in extreme cases; in these clinical conditions, other therapeutic options such as extractions of upper premolars or of four premolars could be more favourable. Another pivotal element for an appropriate treatment plan is represented by the position and inclination of upper frontal teeth. It was observed that distalisation with intra-oral conventional mechanics (not supported by mini-screws) consistently induces a pro-inclination of upper incisors and is accompanied by a mesial movement of the anchorage unit (generally, the first premolars) [Serafin et al., 2021]. Therefore, if the upper incisors are already pro-inclined and/or protruded, intra-oral distalisers may not be the most sensible choice, whilst headgear is more suitable. Unfortunately, however, headgear is not a compliance-free device: if compliance cannot be expected by the young patient, this device is not a fitting therapeutic option. On the other hand, if the upper frontal teeth pro-inclination is desirable for the resolution of the malocclusion (i.e.: class II division 2 or class III malocclusion), intra-oral distalisers find a strong indication. Moreover, the amount of distalisation needed for the resolution of the malocclusion is crucial in treatment planning. Indeed, our study highlights that the average distalisation achievable is equal to 3mm; therefore, if the needed space exceeds 3mm or if molars are in full-cusp class II, distalisation of upper molars alone is not sufficient for class correction and for ensuring a stable and functional occlusion. In these cases, after careful consideration of the patient's profile and face, either the extractive treatment may be a valuable option or more elaborate treatment plans may be carried out: for instance, the distalisation of the upper molar can be followed by mandibular advancement which can be either spontaneous, if horizontal mandibular growth is expected, or obtained using functional therapy, if the patient's skeletal pattern and expected mandibular growth are favourable. Finally, the amount of compliance and time needed for the distalisation should be taken into account. As already mentioned, using devices that require compliance (such as headgear) in patients who are not willing or able to actively comply with treatment will inevitably lead to failure and endless therapies, frustrating for both the dentist and the young patient. Additionally, the need for complex movements or long distalisation distances may prolong the treatment, which could have proceeded hastily if space closure following extractions was preferred over the non-extractive option; under these circumstances, a more "conservative" choice, not sacrificing premolars for orthodontic purposes, might result not only in lengthy and tiring treatments, but also in a procedure more costly for the patient's parents.

## Conclusions

The loss of upper deciduous molars and the subsequent space recovery is an important topic in the growth and development of the oral cavity. Understanding the role of these teeth, the causes of their loss and the impact on dental structure is crucial for both professionals and patients seeking preventive measures and management of therapy. The early loss of deciduous teeth due to caries or early extractions may cause a decrease in arch length,

class II molar relationship, and complication in the eruption of canines and premolars, with consequent functional and occlusal problems. The paediatric dentist should be aware of the advantages and disadvantages related to each device and select the most appropriate distalisation appliance based on an individual plan of diagnosis and careful treatment. From the analysis of the literature, it can be concluded that intraoral and extraoral devices allow the disto-inclination and distalisation of permanent molars, allowing to restoration of a functional occlusion and creating space for the correct eruption of the premolars. The distalising devices described in this paper are recommended after the loss of primary second molars to regain space. Paediatric dentists are advised to select the most appropriate device according to the diagnosis and patient compliance. Finally, we emphasise the importance of assessing the cost-benefit ratio of prolonged treatment for the family, where the maximum intervention effectiveness does not always align with its overall efficiency.

## Author Contributions

All authors actively participated to all phases of the manuscript.

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## Conflicts of Interest

The authors declare no conflict of interest.

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