Maxillary molar distalisation using palatal TAD-supported devices in the treatment of Class II malocclusion: a systematic review

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Objectives: To evaluate the quantitative effects of palatal Temporary Anchorage Device (TAD)-supported appliances for the distalisation of maxillary molars in Class II patients.

Methods: An electronic search was conducted in PubMed, CENTRAL, Scopus and the Web of Knowledge databases using specific key terms. The selection process was independently conducted by two researchers to identify relevant articles, published in English until January 2021. After the removal of duplicate articles and data extraction according to the PICOS scheme, the methodological quality of the included papers was ranked on a 9-point scale, from low to high quality.

Results: The initial search identified 14,830 articles, 536 of which were selected by title and abstract. After full-text reading, eleven articles were selected. The quality of evidence was moderate for ten studies, but high for one study. A total of 230 subjects in the permanent dentition were analysed. The mean molar distalisation values ranged from 3.0 millimetres (mm) to 5.3 mm. The mean molar distal tipping varied from –1.20° to 11.24°. The mean mesial movement of premolars showed negative values.

Conclusions: In Class II patients, palatally placed TAD-supported devices are more effective in maxillary molar distalisation compared to conventional appliances, thereby minimising molar distal tipping and preventing premolar anchorage loss during the distalisation mechanics.

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Introduction

Maxillary molar distalisation is a common treatment approach for the correction of Class II malocclusions that are due to maxillary skeletal or dentoalveolar protrusion.[1] Molar distalisation is often indicated as an alternative to extraction treatment in Class II patients, because the posterior movement of the maxillary dentition induced by distalising forces facilitates a Class I molar and canine relationship, and gains additional space that could avoid tooth extractions.[2] The distalisation treatment is often recommended before the full eruption of the permanent dentition, especially before the emergence of the second molars.[3] As reported, a higher success rate with fewer complications occurs when maxillary molars are distalised during the mixed dentition stage.[4] The eruption stage of the upper second and third molars could influence the amount and type of first molar movement, and thereby increase the duration of the overall treatment.[3] However, although the eruption of second molars may create a resistance to distalisation and limit the bodily distal movement of the first molars, some authors have reported that the presence of the second molars induces minimal or insignificant effects on first molar distal movement.[5–7]

The type of first molar movement and the timing of treatment are not the only clinical variables that influence the success and the stability of treatment,[8] because the distalisation methods should also be considered in the efficiency of treatment.[9]

The distalisation of molars may be achieved by using extraoral[8] or intraoral appliances.[4] Since extraoral devices require high patient co-operation and are not aesthetically acceptable, several intraoral devices, such as the pendulum[10] or distal jet[11] appliances, have been introduced as an alternative for non-compliant patients.[4] Although the major advantages of these intraoral appliances are their continuous activity and independence of patient compliance,[12] the devices are attached to teeth which serve as anchorage units. During distalising mechanics, a combination of dental and soft tissue anchorage structures[12] induce several dental side effects related to anchorage loss, distal tipping and molar extrusion, with a consequent clockwise rotation of the mandible.[13]

The recent advent of Temporary Anchorage Devices (TADs) has increased the effectiveness of molar distalisation and reduced the adverse effects associated with conventional distalisation devices.[14] As a result, several appliances supported by orthodontic TADs as skeletal anchorage have been recently introduced.

Several devices have been placed in the buccal bone of the maxillary arch, to prevent dental side effects.[15] Although the buccal approach provides stable distal movement of the maxillary first molars, it has been associated with an increased impact risk on the roots of adjacent teeth because the interradicular TAD placement may be affected by insufficient space.[16]

Sugawara et al.[17] proposed the placement of anchorage miniplates in the zygomatic region to improve molar distalisation mechanics. Although reporting promising results, this method required invasive surgical procedures and did not allow an immediate application of the distalising force after the placement surgery.[17]

Recently, the thickness and the density of the palatal bone, as well as the thickness of the palatal soft tissues, have been evaluated in adults and adolescents for the application of skeletal anchorage devices.[18] The palatal area has become a popular site for the placement of TADs because of its easy access and greater quality of bone density and keratinised mucosa.[14] Moreover, the palatal insertion avoids the need for relocating TADs during molar distalisation.[19] and prevents any potential trauma to the adjacent dental roots that could occur if a buccal approach was used.[20]

A recent review performed by Mohamed et al.[1] confirmed the effectiveness of maxillary molar distalisation by using skeletal anchorage in Class II treatment,[1] with minimal molar distal tipping and without premolar anchorage loss.[1] However, the review included studies performed on distalising appliances supported by both buccal and palatal TADs, and concluded that palatal compared to buccal anchorage enabled greater molar distal movement.[1]

It is known that a large amount of molar distal movement is difficult to achieve using interradicular TADs because the buccal TADs may contact the neighbouring roots during molar distal movement.[9,21]

Currently, distalisation mechanics using palatal TADs have become an essential part of routine orthodontic practice, and several studies have been performed to assess the dental movements obtained using different distalising palatal appliances.[22–24] Therefore an update of the existing literature[1] is required to synthesise the evidence of the dental effects associated with the use of palatal TAD-supported devices.

The aim of this systematic review was to evaluate the quantitative effects of palatally TAD-supported appliances for maxillary molar distalisation in Class II patients in the permanent dentition.

Material and methods

Protocol

The present systematic review was performed according to the PRISMA statement.[16]

Eligibility criteria

The search hypothesis was defined according to Participants-Intervention-Comparison-Outcome-Study design schema (PICOS), in which:

P (Population): Subjects with a Class II malocclusion in the permanent dentition and with erupted second molars.

I (Intervention): Maxillary molar distalisation using intraoral distalisers supported by palatal skeletal anchorage.

C (Comparison): Subjects treated with conventional distalising appliances.

O (Outcome): Molar distal movement (millimeters, mm), molar distal tipping (grades, degree), mesial premolar movement (mm), premolar mesial tipping (degree)

S (Study design): Randomised clinical trials or non-randomised, prospective or retrospective, cohort studies.

The included studies were performed on a sample of at least 10 patients.

The exclusion criteria were: articles not published in English, animal studies, systematic reviews and meta-analyses, in-vitro studies and case reports.

Information sources and literature search

The search for articles was carried out using PubMed, CENTRAL, Scopus and the Web of Knowledge databases, and included publications in the English language from 1970 to January 2021. The search strategy for keywords is reported in Table I. The reference and citation list of the included trials and relevant reviews were also manually searched.

Study selection

All identified titles were screened and selected by two independent authors (G.M., G.F.). Duplicate studies were eliminated. The abstracts were examined, and full texts were obtained if additional data were needed to fulfil the eligibility criteria. Conflicts were resolved by discussion with a third author (G.G.).

Data collection

Two authors (G.M., G.F.) independently extracted the characteristics of the included studies, related to

Table I. Search strategy.

Search strategy for Pubmed	1. Micro-implant OR "micro implant" OR "micro implants"
	2. Mini-implant OR "mini implant"
	3. "Orthodontic implant"
	4. Mini-plate OR "mini plate"
	5. "Palatal implant" OR "midpalatal implant"
	6. Miniscrew OR mini-screw OR "mini screw"
	7. Microscrew OR micro-screw OR "micro screw"
	8. 1 OR 2 OR 3 OR 4 OR 5 OR 6 OR 7
	9. Orthodontic
	10. Distalizers OR "distalization appliance" OR "orthodontic distalization" OR "noncompliance appliances" OR "first molar distalization" OR "upper molar distalization" OR "maxillary molar distalization"
	11. 8 AND 9 AND 10
Search strategy for CENTRAL	1. (maxillary OR upper) AND ("molar distalization" OR distalization)
	2. ("Class II") AND ("Temporary anchorage device" OR TAD OR TADs)
	3. ("Class II") AND (miniscrew OR "mini screw" OR miniimplant OR "mini implant")
	4. 1 AND 2
	5. 1 AND 3
Search strategy for Scopus and for Web of Knowledge	1. (maxillary OR upper) AND ("molar distalization" OR distalization)
	2. ("Class II") AND ("Temporary anchorage device" OR TAD OR TADs)
	3. ("Class II") AND (miniscrew OR "mini screw" OR miniimplant OR "mini implant")
	4. 1 AND 2
	5. 1 AND 3

author and year of publication, study design and sample size, average age at the start of treatment and gender distribution, assessment method, the amount of first maxillary molar distalisation and tipping, the amount of premolar mesial movement and tipping, mean treatment duration, distalisation rate, the type of distalising appliances and the number of TADs, TAD length and diameter, skeletal anchorage site, and magnitude of the applied distalising force. In the case of missing or unclear information, additional clarifications were directly requested from the authors of the articles.

Methodological quality assessment

The methodological quality of the included studies was assessed according to a 9-point scale using an updated version of the method previously proposed by Fudalej et al.[25] Each article received a score according to the criteria described in Table II. Based on the score, the quality of the articles was ranked into three levels: high, for a total score of 7 to 9 points; medium, for a total score of 4 to 6 points; and low, for a total score below 4 points.

Table II. Methodologic quality scoring protocol (maximum score, 9 points).

Study design
3 points: randomized clinical trial
2 points: randomization process not well described or controlled prospective study
1 point: uncontrolled prospective study
0 point: retrospective study or not mentioned
Sample size
1 point: larger than or equal to 15 subjects
0 point: less than 15 subjects
Sample description
2 points: description of all 3 items (age, sex, mean treatment duration)
1 point: only 2 items described
0 point: only 1 item described
Error analysis
1 point: error analysis value cited
0 point: error analysis value not cited, or error analysis not performed
Statistical analysis
2 points: adequate
1 point: partially adequate
0 point: no statistical tests conducted

Data synthesis

Due to the heterogeneity of the studies, only a systematic review could be conducted.

Results

Study selection and characteristics

The initial search identified 14,830 articles from Pubmed, CENTRAL, Scopus and the Web of Knowledge databases. After eliminating duplicates and ineligible studies by title and abstract, a total of 54 full texts were screened. Finally, a total of eleven papers were identified according to the eligibility criteria. The flow chart for the selection of eligible studies is summarised in Figure 1.

Assessment of methodological quality

According to the 9-point scale tool, the quality of evidence was medium for ten studies, and high for

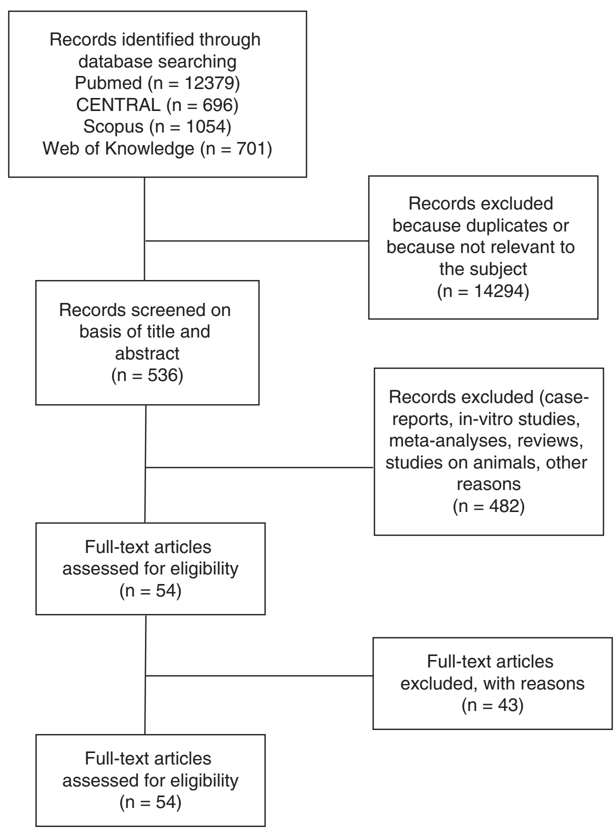

Figure 1. Flow diagram of the included studies according to the PRISMA scheme.

only one study (Table III). No articles received a low-quality evaluation.

According to each criterion for quality analysis, the following results were obtained:

1. Study design: Two studies had a prospective design,[23,26] 6 studies had a retrospective design,[22,27–31] while in three articles[24,32,33] the study design was not mentioned, and therefore 0 points were scored.
2. Sample size: Ten studies[22–24,26–30,32,33] had sample sizes greater than or equal to 15 patients; only one study[31] received 1 point-score because, although it was conducted on 2 groups of patients, one group consisted of 23 subjects (adolescents with second molar in place) and the other group contained 14 subjects (adults).
3. Sample description: Nine studies[22,24,26–29,31–33] reported three items (age, gender, and mean treatment duration), and therefore a full 2-points were scored. One study[23] did not mention gender distribution, while another[30] did not report gender distribution and mean treatment duration, and therefore received 0 points. All studies showed the mean age at the start of the treatment.
4. Error analysis: Five studies[22,26,28–30] described the method error results, while the another six[23,24,27,31–33] did not report.
5. Statistical analysis: Two studies[23,33] performed a partially adequate analysis, while another 9[22,24,26–32] performed an adequate statistical analysis.

Results of individual studies

The results are summarised in Table IV.

A total of 230 patients in the permanent dentition were analysed. The mean age at the start of treatment ranged from 13.1 to 30.9 years. All studies included patients with erupted second molars, except one study[22] that reported a full or partial eruption. Five studies[22,23,26,28,32] were performed on adolescents, five studies[24,27,29,30,33] on adults and one study[31] on both groups.

In all studies, the TAD placement was performed in the paramedian area of the anterior palate, with slight differences in the number of TADs inserted (two or three). In two studies,[28,31] two TADs were inserted along the median palatine suture.

In eight studies, rigid devices supported by TADs were used for molar distalisation and included the distal jet appliance,[23] a modified C-palatal plate (MCPP),[24,27] a distaliser with a modified hyrax screw,[26] a modified palatal anchorage plate (MPAP),[29] the beneslider[31] and iPanda.[24] In the other three studies, pendulum-derived devices with TMA arms, a TAD-anchored pendulum appliance,[32] a bone-anchored pendulum appliance (BAPA),[22] and an implant-supported pendulum (ISP), were used.[28]

In the included articles, one to three TADs were inserted for skeletal anchorage. The TADs showed a variable diameter from 1.6 mm to 2.4 mm, and a variable length from 6 mm to 14 mm. The mean

Table III. Assessment of the study quality.

Author (year)	Study design 0–3	Sample size 0–1	Sample description 0–2	Method error analysis 0–1	Adequacy of statistical analysis 0–1	Quality score 0–9	Quality standard
Cassetta (2019)	2	0	1	0	1	4	Medium
Jo (2018)	0	1	2	0	2	5	Medium
Kircali (2018)	0	1	2	0	2	5	Medium
Lee (2018)	0	1	0	1	2	4	Medium
Cambiano (2017)	0	1	2	1	2	6	Medium
Park (2017)	0	1	2	0	2	5	Medium
Duran (2016)	1	1	2	1	2	7	High
Kook (2014)	0	1	2	1	2	6	Medium
Nienkemper (2014)	0	1	2	0	2	5	Medium
Kaya (2013)	0	1	2	1	2	6	Medium
Suzuki (2013)	0	1	2	0	1	4	Medium

Table IV. Characteristics of the included studies.

Author (year)	Study design/ Sample size	Average age in years (M/F)	Assessment method	Molar distal movement (mm)	Molar distal tipping (°)	Premolar mesial movement (mm)	Premolar mesial tipping(°)	Mean treatment duration	Distalization rate	Distalizing appliance (N° of miniscrews)	TAD's lenght (L) and diameter (D)	Skeletal anchorage site	Applied distalization force
Cassetta (2019)	Prospective (case control)/10	13.1 (-/-)	Lateral cephalograms + Digital cast models	5.30	0.01	-4.30	-7.70	6.0 months	0.88 mm/ month	TAD-supported distal jet appliance (2)	D = 2.5 mm L = 8.5 mm	Paramedian area of the anterior palate	Coil spring compressed with a force of 250N (200–400g)
Jo (2018)	Retrospective/20	22.4 (4M/16F)	Lateral cephalograms	3.97	2.93	-	-	25.8 months	0.15 mm/ month	Modified C-palatal plate (3)	D = 2 mm L = 8 mm	Paramedian area of the midpalatal suture	300g/side
Kircali (2018)	-/20	14.05 (7M/13F)	Lateral cephalograms + Dental cast models	4.20	8.90	-2.20	-3.40	8.4 months	0.50 mm/ month	TAD-anchored pendulum appliance (1)	D = 1.9 mm L = 9 mm	Paramedian area of the anterior palate	250g/side
Lee (2018)	Retrospective/22	21.9 (-/-)	Lateral cephalograms	4.20	2.00	-	-	-	-	Modified C-palatal plate (3)	D = 2 mm L = 8 mm	Paramedian palate	300g/side
Cambiano (2017)	Retrospective/18	14.0 (4M/14F)	Lateral cephalograms	3.45	11.24	-1.65	0.46	4.8 months	0.72 mm/ month	Bone-anchored pendulum appliance (2)	D = 2.4 mm L = 14 mm	Paramedian area of the anterior palate	250g
Park (2017)	-/22	24.7 (6M/16F)	Lateral cephalograms	4.22	3.85	-	-	29.9 months	0.14 mm/ month	Modified C-palatal plate (3)	D = 2 mm L = 8 mm	Paramedian palate	300g/side
Duran (2016)	Prospective/21	13.6 (12M/9F)	Digital cast models	4.10	11.02	-2.90	-6.21	5.3 months	1.02 mm/ month	Hyrax screw (2)	D = 1.7 mm L = 8 mm	Anterior palate	The screw was activated by 0.2 mm every 5 days
Kook (2014)	Retrospective/20	22.9 (7M/13F)	CBCT's derived cephalograms	3.30	3.42	-3.05	-8.38	12.5 months	0.30 mm/ month	Modified palatal anchorage plate (3)	D = 2 mm L = 8 mm	Paramedian palate	300g/side

Nienkemper (2014)	Retrospective/A: 23 B: 14	A: 13.7 (12M/11F) B: 30.9 (4M/10F)	Lateral cephalograms	A: 3.70 B: 3.30	A: 2.40 B: -1.20	-	-	7.5 months	A: 0.50 mm/month B: 0.44 mm/month	Beneslider (2)	D = 2 mm L = 9 mm/ 11 mm	Median area of the anterior palate	5N (510g)
Kaya (2013)	Retrospective/20	14.3 (5M/10F)	Lateral cephalograms	3.00	8.80	-1.83	-6.10	8.1 months	0.37 mm/ month	Implant-supported pendulum (2)	D = 2 mm L = 8 mm	Paramedian area of the anterior palate	230g/side
Suzuki (2013)	-/20	23.2 (8M/12F)	Lateral cephalograms + Dental cast models	4.50	4.10	-	-	3.2 months	1.40 mm/ month	iPanda (2)	D = 1.6 L = 6	Midpalatal suture	1N (102g)

treatment duration ranged from 3.2 months to 29.9 months. Contrarily, Lee et al.[30] did not report mean treatment duration, and so the distalisation rate was not noted.

The maxillary first molar distal movement ranged between 3.0 mm to 5.3 mm, with similar results between the studies. The distal tipping of the maxillary first molar varied between –1.20° to 11.24°, with greater variability between studies. The molar distalisation using the MPAP device[29] showed the lowest value, while the TAD-supported distal jet device[23] reported the highest distalisation value.

Data about maxillary second premolar movements were described in only six studies.[22,23,26,28,29,32] In all, the premolar mesial movements reported negative values, indicating that the premolars distally moved during molar distalisation. Similar results were obtained when assessing premolar mesial tipping, which showed negative values in the six studies, except in the report by Cambiano et al.[22] in which the premolars tipped 0.46°.

Of the studies, the applied distalisation force ranged between 1 Newton (N) (102 g) and 5 N (510 g).

Discussion

In all identified and included studies, the TADs were inserted in the anterior palatal area because of its great bone quality and density and reduced risk of damage to neighbouring anatomic structures.[14] In addition, the anterior palate allowed the insertion of TADs of larger diameters, which contributed to their primary stability.[34] The paramedian area is also characterised by thin soft tissues and by a large amount of available space that facilitates TADs insertion and management.[35] Moreover, the palatal application of the distalising forces induces reactive forces localised at a gingival level and close to the centre of resistance of the molars, thereby increasing their distal bodily movement and decreasing their distal tipping.[7,36]

The main objective of molar distalisation treatment is to obtain molar bodily movement and to minimise molar distal tipping.[36] Several studies reported molar tipping occurred as a result of distalisation and, although tipping movement increased the total distalisation rate, the risk of molar anchorage loss during anterior tooth retraction occurred because the molar crowns uprighted mesially more than the roots during retractive mechanics.[7] The amount of tipping could be reduced using more rigid distalisation mechanics, as reported by Keles,[37] in which the use of a heavy rod in the distalising appliances improved the control of force direction, and achieved bodily molar distalisation by sliding mechanics.

In addition, the support of palatal TADs in distalising appliances overcame the main side effect of conventional distalising appliances, expressed as the anchorage loss that occurs during molar distal movement due to the simultaneous mesial movement of the premolar and incisor segments.[38] As confirmed in the present review, palatal TAD anchorage not only prevented the forward movement of the anchoring teeth, but also induced a spontaneous distal drift of the premolars.[1]

While the anchorage of conventional palatal distalisers is supplied by the palatal mucosa and by the periodontium of the anchorage teeth, in TAD-supported appliances the reactive forces are directed onto the intra-osseous anchorage devices rather than the teeth, thereby allowing the premolars to move distally via transseptal fibre connectivity during molar distal movement.[39]

Several palatal TAD-supported devices have been introduced for maxillary molar distalisation. Jo et al.[27] Lee et al.[30] Park et al.[24] and Kook et al.[29] proposed the use of rigid devices to connect two or three TADs, and so increase mechanical stability and the biomechanical stress capacity of the modified anchorage plates.

Kinzinger et al.[12] proposed a modified distal jet supported by both dental and skeletal anchorage, and a similar device was introduced by Cassetta et al.[23] The TAD-supported distal jet appliance showed maxillary molar distalisation of 5.30 mm,[23] which was the highest value reported. In addition, the device caused a minimum molar distal tipping of 0.01°, indicating control of molar bodily movement during distalisation.

Kircelli et al.[40] proposed a bone-supported pendulum for maxillary distalisation; however, an important distal tipping of the first molar (10.9°) was associated with this device, likely because the applied force vector for distalising the molars was similar that of conventional devices.

This finding is consistent with the results described by Kircali et al.[32] Cambiano et al.[22] and Kaya et al.[28] who reported the highest values of distal molar tipping among the included studies. A distal molar tip of 8.90°, 11.24° and 8.80° was reported when distalisation was performed through a TAD-anchored pendulum appliance, a bone-anchored pendulum appliance and an implant-supported pendulum, respectively.

The distal tipping values reported by the remaining studies[23,24,26,27,29–31,33] of the present review were significantly lower (from −1.2° to 4.1°), which could be due to the better control of the distalising force vector which promoted bodily movement instead of a tipping movement. As reported by a previous study,[41] the design of TAD-supported appliances may induce excessive distal molar tipping.

In the present review, except for Kircali et al.[32] Cambiano et al.[22] and Kaya et al.[28] who used a modified pendulum appliance with TMA arms, the remaining included studies[23,24,26,27,29–31,33] evaluated the effects of devices with rigid distalising arms, which minimised the distal tipping of the maxillary first molar, and increased the amount of molar bodily movement.

Of the included studies, the distal tipping values showed high variability, and this may have depended on individual variations (such as the shape and extension of the maxillary sinus and maxillary alveolar arch) or on different levels of distalising force required by each patient.

However, MPAP palatal plate devices have been efficiently used to distalise posterior teeth in adults and adolescents.[29] A finite element analysis showed that the distalisation using a palatal plate improved the bodily movement of molars without tipping or extrusion, compared to devices in which TADs were buccally positioned.[42] The distal molar tipping seemed to be minimal when the distalising force was palatally applied because the force vector was closer to the molar centre of resistance.

This hypothesis was confirmed by Lee et al.[30] in which maxillary molar distalisation was compared between two groups, one of which used a modified C-palatal plate (MCPP), and the other which used buccally positioned TADs. The group with buccal TADs reported 2 mm of molar distalisation, 0.1 mm of first molar intrusion with 7.2° of distal tipping, and 0.3 mm of incisor extrusion. The group with the palatal plate showed 4.2 mm of molar distalisation, 1.6 mm of first molar intrusion with 2° of distal tipping, and 0.8 mm of incisor extrusion. Therefore, Lee et al.[30] concluded that a greater amount of molar distalisation and intrusion, with a lower value of molar tipping and incisor extrusion, were a result of TAD-supported palatal devices, compared to buccally positioned TADs.

Suzuki et al.[33] showed 1.0 mm of first molar intrusion during the distalisation process. Similar results were reported by Yamada et al.[21] who found molar intrusion of 0.6 mm during molar distalisation carried out using TADs positioned in the interradicular spaces. These results suggested that TAD-supported distalising devices produced intrusive forces during distalisation mechanics which prevented the clockwise rotation of the mandible.[21]

Using the MPAP appliance, Kook et al.[29] also observed 1.8 mm of molar intrusion which maintained anterior facial height.

The majority of studies on molar distalisation used 2D lateral teleradiographs to perform the cephalometric analysis. The disadvantages of this approach are due to the presence of distorted images caused by the superimposition of different anatomical structures, by the vertical and horizontal radiographic magnification, and by the overlapping of the right and left side.[43] In Kook et al.[29] the maxillary distalisation was evaluated through CBCT scan-derived cephalograms, therefore a lateral cephalogram was independently created for each side to eliminate the overlapping of anatomical structures, and provided higher accuracy and reliability of the reconstructed images compared to conventional radiographs.[44]

Although the influence of a patient's dental and chronological age on the prognosis of distalisation treatment is still controversial, most of the studies on distalisation have focused on adolescents,[3] and only few studies have investigated the distalisation effects in adults following complete eruption of the maxillary second molars.

In the present review, patients were selected in the permanent dentition, and a variable amount of distalisation was recorded with a range from 3.0 mm to 5.3 mm.

Suzuki et al.[33] observed 4.5 mm of molar distalisation after the extraction of the maxillary second molars using closed Sentalloy NiTi springs applied directly to the maxillary first molars. A distalisation rate of 1.4 mm/month was observed, which was the highest of the analysed devices. In addition, maxillary second molar extraction produced good results by the application of a minimum force of 1 N, the lowest force value noted among the analysed studies.

Nienkemper et al.[31] used high distalising forces up to 5 N per side, to compensate for the resistance provided by the second molars, without reducing the rate of distalisation (from 0.44 mm to 0.50 mm per month). According to Kook et al.[29] and Kaya et al.[28] the distalisation force values were reported to produce 0.33 mm/month and 0.37 mm/month of molar movement, respectively.

Jo et al.[27] Park et al.[24] and Kook et al.[29] reported a relevant long treatment duration of 25.8 months, 29.9 months and 12.5 months, respectively. However in the studies, distalisation of the entire maxillary arch was performed, and not just the upper first molars.

In a recent systematic review,[45] the distalisation of the upper molars using conventional distalising devices (not TAD-supported) was investigated, resulting in an average of 2.9 mm of distal molar movement, with a loss of anchorage of 1.8 mm due to the mesial movements of the incisors. In the present review, using TAD-supported distalising devices, the molar distalisation ranged from 3.0 mm to 5.3 mm, which was greater than the values obtained using conventional devices. Moreover, no loss of anchorage was observed as the mesial movement of the premolars had negative values (indicating a spontaneous distal shift of the premolars during molar distalisation) and the position of the maxillary incisors remained stable.[22,23,26,28,29,32]

According to the present analysis, several studies reported similar distalising effects using TAD-supported devices, with movement values ranging from 3.9 mm to 6.4 mm.[7,36,46] Moreover, in a previous systematic review and meta-analysis performed by Grec et al.[47] the average amount of molar distalisation was 3.34 mm for traditional devices, and 5.10 mm for TAD-supported appliances. Furthermore, a loss of anchorage was found for conventional appliances with 2.30 mm of noted premolar mesialisation, while a spontaneous distal premolar migration of 4.01 mm was observed following the use of TAD-supported devices.

Limitations

The limitations of the present review were the clinical heterogeneity of the studies; therefore, a meta-analysis could not be performed. Additional RCTs or prospective studies on the effect of various designs of TAD-supported devices are indicated.

Conclusions

According to the 9-point scale tool, the present review may draw conclusions reflecting a moderate level of evidence.

1. In the permanent dentition, palatal TAD-supported distalising devices are effective for the distalisation of maxillary molars. The amount of distalisation ranged from 3.0 mm to 5.3 mm.
2. Palatal TAD-supported distalising devices are effective in minimising distal molar tipping and in preventing premolar mesial tipping during distalisation mechanics.
3. Palatal skeletal anchorage avoids the anchorage loss that occurs using conventional distalising systems. A spontaneous distal movement of premolars was observed, ranging from 1.65 mm to 4.30 mm.

Conflict of Interest

The authors declare that there is no conflict of interest.

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