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Systematic Review

Mandibular Molar Distalization in Class III Malocclusion: A Systematic Review

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Abstract: Class III Malocclusion presents a complex orthodontic challenge with various treatment options, including orthodontic camouflage and orthognathic surgery. Among these, mandibular molar distalization stands as an orthodontic approach for treating Class III Malocclusion in adults. This systematic review aims to evaluate the current evidence regarding mandibular molar distalization techniques in the treatment of Class III. The search across PubMed, Scopus, Cochrane, and Web of Science databases yielded 582 articles, from which eight met the inclusion criteria. These inclusion criteria were as follows: English language, full text, studies randomized clinical trials, and retrospective studies that evaluated various methods of mandibular distalization for Class III Malocclusion in adult patients, from 2013 to May 2023. Lower molar distalization has gained attention as a non-surgical alternative with effective and efficient outcomes. However, various treatment modalities have limitations, including reliance upon malocclusion severity, diagnosis, patient cooperation, and operator experience. From the studies analyzed, it was found that techniques using skeletal anchorage with TADs, mini-plates, or ramal plates, offer stable anchorage and controlled tooth movement, they allow unilateral action in cases of asymmetry, and they are the most effective methods for achieving distal body displacement of the tooth. Despite the promising results, the relatively small number of studies calls for more high-quality research to explore the efficacy and outcomes of different mandibular molar distalization approaches. The lack of standardized protocols and guidelines for mandibular molar distalization in Class III Malocclusion is also attributed to the limited available literature.

Keywords: distalization; lower molar; Class III; mandibular prognathism; mini-screw; ramal plate; clear aligners; orthodontics

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1. Introduction

Third Class Malocclusion (TCM), also known as mesiocclusion, is maxillofacial disorder, characterized by maxillary deficit and/or excess of the mandible, with lower molars positioned mesial to the upper molars and an inverted relationship of the incisors [1].

In adult patients, TCM can involve the basal skeletal when dimensional problems of maxillary bones or dentoalveolar structures occur due to the advanced position of the mandible caused by an occlusal interference [2,3].

The prevalence of TCM differs across different populations, with estimates ranging from 3% to 26% worldwide [4]. This condition poses significant functional, aesthetic, and psychological challenges for affected individuals, making its correction a crucial goal in orthodontic treatment [5–7] (Figure 1).

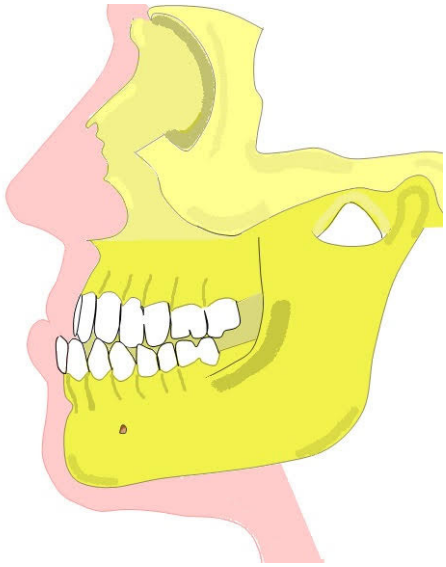

Figure 1. Schematic features of a TCM.

The treatment of TCM traditionally involved either orthodontic camouflage or orthognathic surgery, depending on the severity of the discrepancy [8–10].

Adult patients, who refuse to accept surgical therapy or who are satisfied with their facial appearance, can be treated with dentoalveolar compensation without correcting the underlying skeletal deformity [11–13]. Dentoalveolar compensation treatment offers the non-invasive correction of TCM without surgery, providing aesthetic improvement, enhanced function, and preventive benefits. It retains natural teeth, has a shorter recovery period, and carries a lower risk of complications compared with orthognathic surgery. The dentoalveolar Class III molar relationship can be corrected via differential extractions between the arches (lower arch extractions) or via distalization of the lower molar [14,15].

Mandibular Molar Distalization (MMD) is an orthodontic approach for non-extraction therapy, which aims to gain space in the mandibular arch by moving the mandibular molars distally [16].

The evaluation of mandibular bone quality is of utmost importance in orthodontic treatment planning, particularly when considering MMD. Sufficient space and good bone quality is required to perform MMD. Indications for MMD are TCM, adult patient refusing orthognathic surgery, good patient compliance, absence of third molars. The limitations of MMD concern growing patients, where traditional interceptive treatment is preferred, and patients with severe periodontal disease [17].

By evaluating the quality of the mandibular bone, clinicians can identify potential challenges, develop appropriate treatment plans, and minimize the risk of complications during the distalization process [18,19]. Several studies revealed that the success of this procedure heavily relies on the assessment of the mandibular bone's quality, as it directly influences the stability and efficiency of the distalization process [8,20]. In particular, assessing bone density and the architecture of retromolar trigone helps determine the feasibility of planning MMD. The retromolar trigone is a triangular area located in the jaw, posterior to the last molar, and it is used for the installation of devices that offer an anchoring system for the movement of the lower molars [21].

Radiographic imaging techniques such as panoramic radiographs, lateral cephalograms, and cone-beam computed tomography provide valuable information concerning bone density, root morphology, and cortical thickness. These imaging modalities aid in assessing the quantity and quality of bone, identifying anatomical variations, and limiting factors that may affect the success of MMD [22].

The evaluation of the external oblique ridge, which is observed as the anterior border of the ramus on lateral cephalograms, can be useful for predicting the distalization

distance [23]. The cortical contact with the mandibular second molar during MMD negatively influences the process [24]. Orthodontists carefully assess bone quality before starting treatment, as it directly affects treatment planning, mechanics, and appliance selection. Patients with compromised bone quality may require different treatment approaches or additional measures to safely achieve optimal results [22].

For MMD, bone quality must also be adequate because it improves treatment predictability, allowing better anchorage for orthodontic appliances, reducing treatment duration, and ensuring the long-term stability of orthodontic results [25].

This systematic review aims to investigate the various orthodontic methods of performing MMD in adult patients with TCM, and it provides insights into the clinical applicability of MMD. The null hypothesis is that there is no significant difference between the effectiveness of different methods of MMD in the treatment of TCM in adults.

2. Materials and Methods

In this paper, a systematic search was conducted in accordance with the PRISMA 2020 statement [26] to examine the clinical methods used to perform MMD for TCM resolution. The review protocol was registered at PROSPERO under the unique number 443313.

The search string included a combination of keywords related to distal movement and TCM ("Distalization" AND "Class III"). The search, conducted on 11 May 2023, set the time range at 10 years and it specified that the articles needed to be in the English language; the search retrieved 289 articles from PubMed, 88 from Scopus, 131 from Cochrane, and 74 from Web of Science (Table 1).

Table 1. Database search indicators.

Articles screening strategy	Keywords: ("distalization") AND ("Class III")
	Timespan: from January 2013 up to 11 May 2023
	Electronic Databases: PubMed, Scopus, Cochrane, and Web of Science.

Duplicate studies were removed manually. Two researchers independently (D.A., C.L.) performed the selection of articles. Initially, titles and abstracts were reviewed to exclude articles that were clearly not relevant. Then, potentially relevant articles were reviewed in their entirety to assess eligibility in accordance with the inclusion and exclusion criteria, and each discrepancy was resolved by a third researcher (A.P). The following criteria needed to be met by the studies to be included in the systematic review: randomized controlled trials, retrospective studies, studies that had adult patients with TCM as their population, studies in which the main intervention was to use orthodontic appliances to distalize the lower molars, articles that provided data on malocclusion resolution (overjet, cephalometric measurements), and English language publications. Studies with the following characteristics were excluded from the systematic review: studies that were not available as a full text, studies that were not in English, reviews, case reports, articles with patient populations that included children or adolescents, articles that addressed upper molar distalization, MMD achieved via invasive methods combined with orthognathic surgery, and papers that do not provide sufficient or adequate data to evaluate the effectiveness of MMD.

The researchers created a data extraction form, which they then used to extract the relevant data from the eligible studies.

Quality Assessment

Using the Cochrane risk-of-bias tool for randomized trials, Version 2, two reviewers evaluated the articles' bias risk (RoB 2). Any discrepancy was discussed with a third reviewer until an agreement was achieved.

3. Results

The search of the four electronic databases identified a total of 582 studies. After removing duplicates, 468 studies were screened for titles and abstracts. In total, 357 articles were not selected after abstract screening, and 111 were selected for an eligibility assessment. Subsequently, 14 articles were removed because it was not possible to view the full text. Out of the 97 remaining records, 31 articles were removed for research nonconformity, 21 studies focused on upper molar distalization, 5 articles addressed TCM resolution with orthognathic surgery, 11 studies involved underage participants, and 21 articles were excluded because they were case reports. Finally, eight articles were selected for the systematic review. The selection process is summarized in Figure 2.

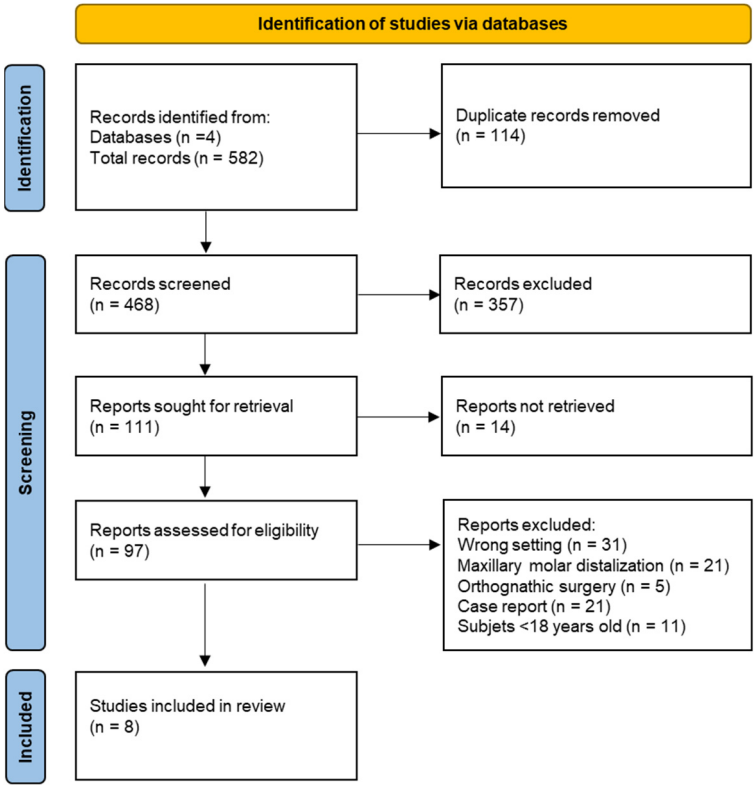

Figure 2. PRISMA flowchart diagram of the inclusion process. The literature search's Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

The articles included are retrospective, and one observational article is included which examines different methods of orthodontic MMD using fixed appliances, clear aligners, and temporary anchorage devices (TADs). The patient samples vary in number and average age, but the common theme concerns the comparison of different distalization methods for the orthodontic treatment of TCM in adult patients.

The data extracted from the studies concerned research characteristics (author year of publication, patient details, distalization method) (Table 2).

Table 2. Study characteristics and results.

Author (Year)	Study Design	Patient (Age)	Distalization Method
He et al. (2022) [27]	Retrospective Study	44 patients (mean age 21 yrs)	Comparison with TADs and fixed appliance
Guo et al. (2020) [28]	Retrospective Study	22 patients (mean age 21 yrs)	Fixed appliance
Nakamura et al. (2017) [29]	Retrospective Study	23 patients (mean age 25 yrs)	Comparison with TADs and fixed appliance

Table 2. *Cont.*

Author (Year)	Study Design	Patient (Age)	Distalization Method
Yeon et al. (2022) [30]	Retrospective Study	40 patients (mean age 26 yrs)	Comparison with TADs and Ramal plates
Azeem et al. (2018) [31]	Retrospective Study	60 patients (mean age 18 yrs)	Comparison with TADs and extraction
Rota et al. (2022) [32]	Retrospective study	16 patients (mean age 25 yrs)	Clear aligners
Yu et al. (2016) [33]	Retrospective study	22 patients (mean age 23 yrs)	Ramal plate and fixed appliance
Ye et al. (2013) [34]	Observational study	19 patients (mean age 20 yrs)	TADs and fixed appliance

Quality Assessment and Risk of Bias

Using RoB 2, the risk of bias was estimated and reported in Figure 3. Regarding the randomization process, 75% of the studies ensured a low risk of bias. However, 75% of the studies excluded performance bias, 75% excluded bias in reported all outcome data, and 25% of the included studies adequately excluded bias in the selection of reported outcomes, whereas 25% excluded bias in self-reported outcomes. Overall, all studies were shown to have a low risk of incurring in bias (Figure 3).

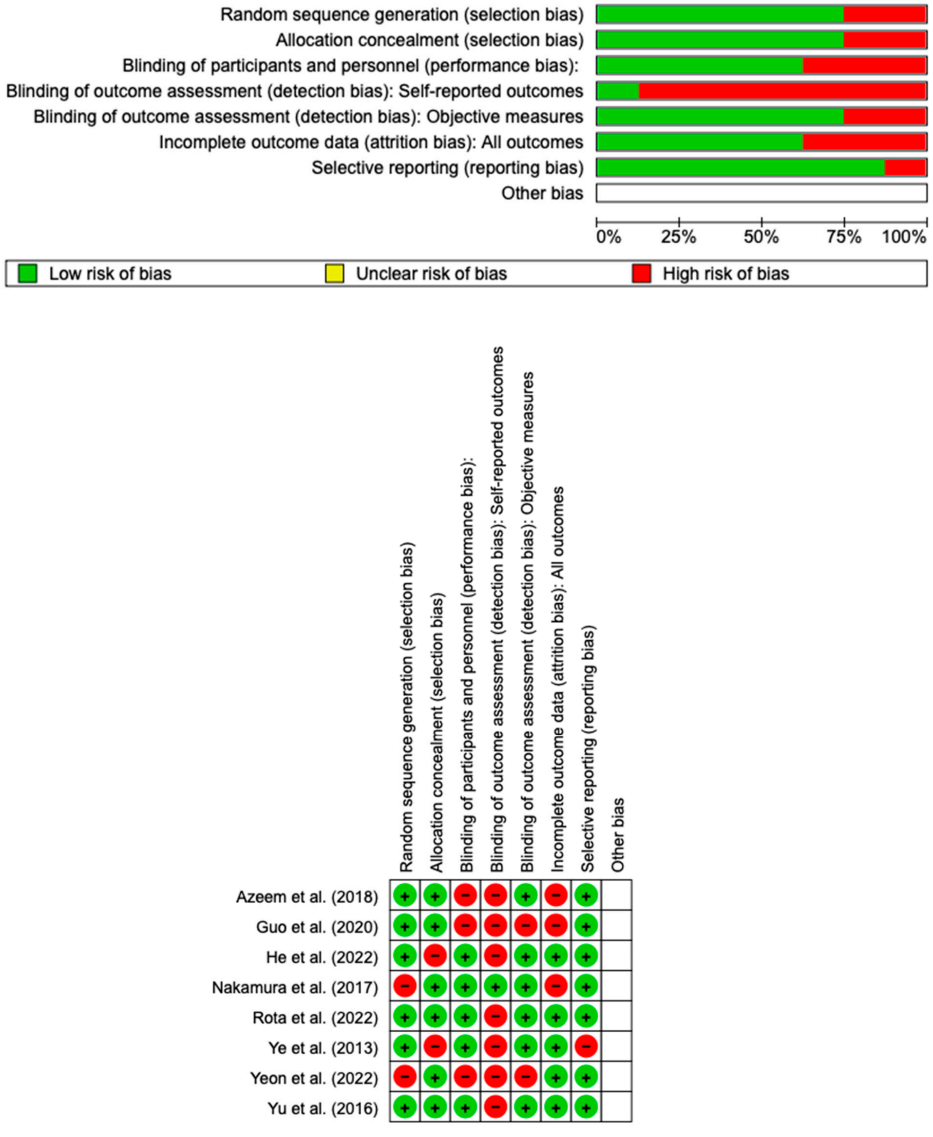

Figure 3. Risk of bias domains of the included studies [27–34].

4. Discussion

The purpose of this systematic review was to gather the most up-to-date scientific evidence available on techniques so that MMD can be used as a nonsurgical treatment for TCM in adult patients. The studies were divided in accordance with the type of method used.

4.1. MMD via a Fixed Appliance

In clinical practice, various mechanics with fixed orthodontic appliances can be used to implement the MMD. The most frequent is the use of intermaxillary elastics. Another technique involves the use of open spiral springs placed between specific brackets, which exert a distal force on the molars [35].

Guo et al. describe the use of the Multiloop Edgewise Arch Wire (MEAW) technique for dental compensation using MMD and the prevention of temporomandibular joint (TMJ) disorders. The MEAW technique uses L-shaped bending forces on the teeth. By applying a distal force to the L-shaped curve of the MEAW arch wire, the lower molars are tilted back towards the distal center and repositioned, helping to correct the anterior crossbite. This approach potentially reduces the risk of TMJ problems such as TMD symptoms or condyle displacement [28]. we inserted the bibliographic reference number next to the names, but unfortunately we could not make the zotero link in the numbers in this image

Hu et al. report a case of MMD with the use of fixed orthodontic appliances, intermaxillary elastics and open coil springs. The treatment resulted in a satisfactory facial profile and stable occlusion [36].

Hisano et al. describe the non-surgical treatment of a TCM with lateral deviation via the distal movement of the mandibular arch and extraction of the third molars. The mandibular molars were moved into an upright position and distalized using a light continuous tip-back force and short Class III elastics [37].

In addition to elastics and springs, modifications to the archwire can be made to incorporate distalizing components. For example, Oliveira et al. use a sliding jig (SJ) combined with intermaxillary elastics. The use of SJ, a type of orthodontic mechanic, allowed for efficient forces to be applied to individual teeth, promoting controlled molar movement. Despite the challenges associated with patient cooperation, the treatment was successful in achieving functional occlusion and dental aesthetics [38].

Nakamura compared the results of orthodontic treatment with TADs and Class III elastics. TADs have been shown to cause the anti-clockwise rotation of the occlusal and mandibular planes, whereas Class III elastics can lead to the clockwise rotation of the mandible. The distalization achieved with TADs results in the body movement of the lower incisors and distal tilting of the lower molars. The amount of distalization achieved with TADs is generally greater than with Class III elastics. They declare that TADs offer a reliable method of distalization for the treatment of TCM [29].

Is important to note that the success of MMD with fixed appliances depends on several factors, including the severity of the malocclusion, the patient's cooperation, and the orthodontist's expertise.

4.2. MMD with Skeletal Anchorage

Skeletal anchorage is highly effective for MMD in orthodontics. It eliminates the need for patient compliance and relies on stable skeletal implants or mini-plates [39]. This approach allows for controlled and predictable tooth movement, while minimizing unwanted side effects on adjacent teeth [25].

4.2.1. TADs

TADs are widely used as stable anchorage in orthodontic treatments in which significant tooth movement is required. TADs in various applications have been demonstrated to optimize orthodontic mechanics, they need very little cooperation from the patient, and they reduce adverse side effects such as mesialization of the anterior anchorage teeth, premolar tipping, molar extrusion, and protrusion of anterior teeth. Advantages of TADs

include a decreased treatment period, simple surgical insertion and removal, and a lower risk of potential morbidity [39,40]. Correction of an open bite in a TCM is more challenging when approached nonsurgically, but it is made possible through orthodontic methods with skeletal anchorage [41,42].

Several studies have reported that the total distalization of the mandibular dentition was successful when using skeletal anchorage, and maximizing the distalization of the mandibular arch was seen to reduce the effect of the increased concave profile; this is characteristic of a TCM, given the counterclockwise rotation of the mandible [34,43].

The results of Yan Jin et al. in 2013 also suggest that the application of TADs in the posterior area of the mandible is an effective systematic for nonsurgical TCM treatment [41] (Figure 4A,B).

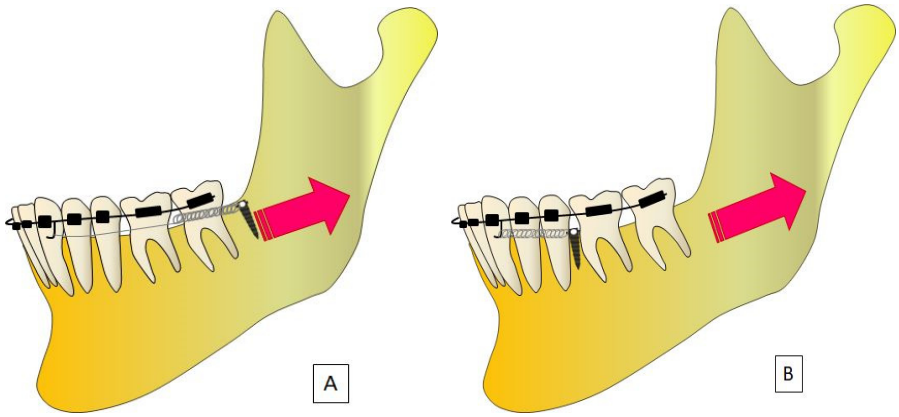

Figure 4. (**A**,**B**) TADSs application sites for MMD.

The application methods of TADs are varied. A study by Z. Zhi-he in 2013 showed that the direct use of mini-screws in the retromolar area required less time and more body movements to retract the mandibular arch without patient cooperation, and this was a better choice for patients with the potential for TJM disorders [34].

Park at al. evaluated cases in which TADs were used for MMD as a function of different force angulations to the mandibular occlusal plane, and for the camouflage treatment of various types of skeletal TCMs. The use of TADs between the roots of premolar and molar, coupled with a thorough knowledge of biomechanics and anatomic limitations, can successfully produce a correct and controlled MMD treatment [44,45].

Generally, two TADs were inserted into the mandibular arch after leveling the plane; one was inserted into the interradicular bone between the mandibular right second premolar and first molar, and the other was inserted between the mandibular left second premolar and first molar. The TADs were placed in different interradicular areas, such as the mandibular left first and second molars, to prevent root damage during installation [46].

Ma et al. used two TADs that were 1.5 mm in diameter in the buccal alveolar bone, one between the mandibular left second premolar and the first molar, and the other between the maxillary right second premolar and the first molar, to provide anchorage in order to correct of a case of TCM subdivision left [47]. TCM treated nonsurgically, with the help of Class III elastics, led to an increase in the angle of the mandibular plane, as compared with the use of TADs which decreased the angle [48]. Class III elastics were preferred for patients with a low angle and short face, whereas TADs were preferred for patients with a high angle and long face [29].

As the direction of the retraction force given to the mini-screws is above the center of resistance of the mandibular arch, the occlusal plane flattens, and the mandibular arch rotates counterclockwise during the distalization movement [49] (Figure 5). As the mini-screws' retraction force is delivered in a direction that is above the mandibular arch's center of resistance, the mandibular arch can be turned counterclockwise when distalized, creating an occlusal plane that is flat [50,51]

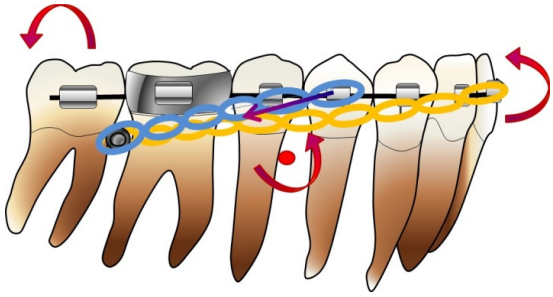

Figure 5. TADs' retraction force.

The goal of a study sponsored by Muhammad Azem and colleagues in 2018 was to compare the effectiveness of a TCM treatment with the removal of two mandibular premolars and the MMD technique. However, regarding the treatment of MMD with skeletal anchorage, it has been seen that the effectiveness of the two treatments when compared is similar in terms of greater patient comfort and less stress [31].

Contextually, regarding the distalization of the lower dental elements, when the closure of a TCM open bite occurs, due to two TADs, applied on the buccal and palatal surface of the upper molars, an intrusive body movement of the maxillary molars is possible with the help of elastic chains passing over the occlusal surface [52]. This system provides excellent control of 'molar inclination during intrusion by evenly distributing the force on the buccal and palatal sides of the elements [41] (Figure 6).

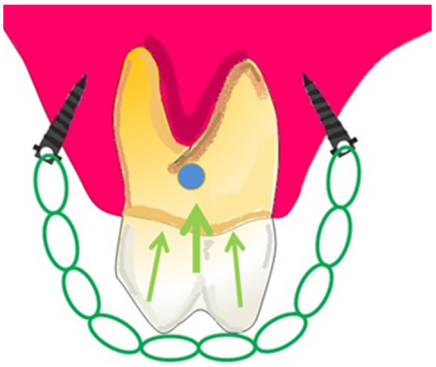

Figure 6. Use of TADs on the vestibular and palatal oral surfaces, for the equal distribution of the intrusive forces that occur with molar intrusions.

A further advantage of TADs is that they can be used monolaterally. In fact, Sha et al. emphasize the use of TADs in cases where the TCM is asymmetric. One of the treatment goals was to correct the mandibular asymmetry via MMD on the affected side. For this purpose, mini-screws were placed in the left retromolar area and between the second lower premolar and the first left molar. These mini-screws provided the anchorage for the distalization of the mandibular dentition. The patient wore Class III elastics to facilitate the desired tooth movement [53].

4.2.2. Mini-Plates

Mini-plates are very stable skeletal anchoring devices because they are held in place by two or more mini-screws [54] (Figure 7). This allows them to be used with heavy forces, and they have been used to good effect when performing distalization of the mandibular arch in adult patients with TCM. As this is a modern approach, there are still few studies and clinical cases in the literature [55]. These include Hakami et al. who published a case report of a TCM treated with the distalization of the lower arch on a mini-plate [56]. The heads of the mini-plates were placed between the first and second molars, and two elastomeric chains, stretched from the canine and first premolar to the mini-plate, on both sides, exerted

a force of about 250 g each; these were used to distalize. In this case, a significant MMD of about 4 mm was achieved [56]. In addition, because the force vector passed above the center of resistance of the mandibular arch, a moment was generated that produced the counterclockwise rotation of the anterior teeth, which helped in the correction of the anterior open bite [57].

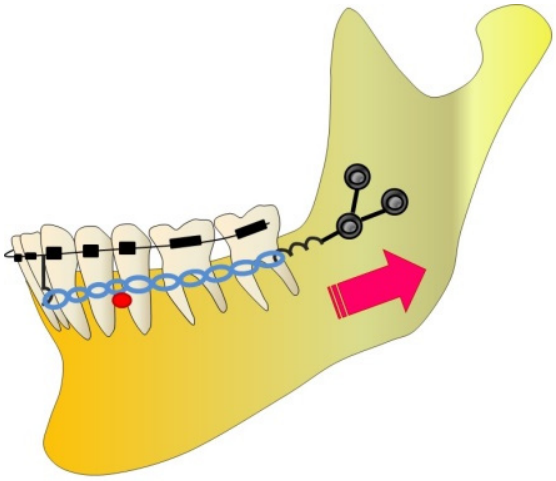

Figure 7. Mini-plates with TADs.

4.2.3. Ramal Plates

The lower arch distalization technique with Ramal Plates (Figure 8) has been proposed in several clinical studies that extoll its advantages.

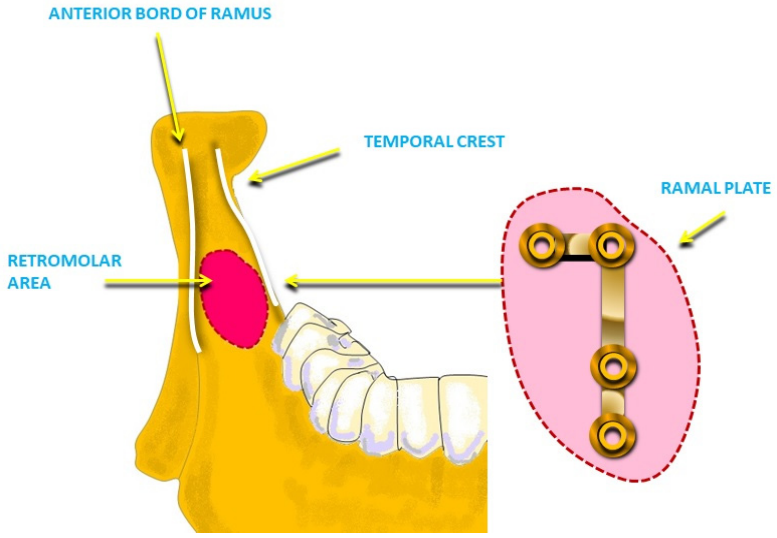

Figure 8. Ramal plate in the retromolar area.

Yoon-Ah Kook et al. published case reports in which they used the ramal plates to perform camouflage in adult patients with TCM who had refused orthodontic treatment combined with surgery [57]. In the case reports proposed by the authors, the insertion technique is described, as follows. The ramal plates were installed in the retromolar fossa, which is located between the anterior border of the mandibular ramus and the temporal crest. A flap was created in the retromolar area, and the L-shaped plate was fixed with two screws, 5 mm long, and 2 mm wide. Then, the flap was sutured so that the anterior hole of the plate was 3 mm lateral to the buccal surface of the second molar so that the force vector was as parallel as possible to the functional occlusal plane [58]. On leveled arches with steel posted arches, an elastic chain was applied between the last ring of the

plate and the arch hook. During distalization, it is important to control mandibular anterior tooth movements. As the force vector is above the center of resistance of the anterior teeth, counterclockwise rotation, and thus, uncontrolled tipping of the anterior teeth, must be prevented. To control the position of the root apices, third-order bending in the anterior section of the arch might be useful [57].

The technique proved to be effective and efficient; it allowed the distalization of the entire lower arch in the clinical cases mentioned, which were skeletal TCMs of medium severity, treated without surgery [57,59].

Encouraging results also came from a study by Ye et al., who evaluated the effects of distalization with ramal plates by analyzing the pre- and post-treatment latero-lateral teleradiographs of 22 patients [34]. After the completion of alignment and leveling, 0.019 × 0.025 steel arch elastic tractions were applied and stretched between the last ring of the plate and the bracket of the first molar, exerting 300 g of force per side. The tractions were replaced every 3 weeks, and distalization ended when an acceptable overjet was reached. The valid distalization of the mandibular arch was achieved with ramal plates, without significant changes in the vertical position of the mandibular molars or the angle of the mandibular plane; however, the amount of root distalization was not statistically significant. Therefore, a branch plate can be considered a viable treatment option for the total distalization of the lower arch in TCM patients who refuse surgical treatment or extractive treatments [34].

A clinical study by Byong Moo Yeon et al. made a comparison between distalization performed with ramal plates and distalization performed with mini-screws [30]. The latero-lateral radiographs of 40 patients with TCM, 20 of whom were treated with distalization via mini-screws, and 20 were treated via distalization with ramal plates, were analyzed. It was found that distalization on ramal plates is more effective, and it produces a clockwise rotation of the mandible, unlike distalization with mini-screws which is less effective, but produces greater molar intrusion and counterclockwise rotation of the occlusal plane [34]. Knowing these differences, one can be guided in the clinical choice of treatment, starting with the patient's verticality characteristics [30].

4.3. MMD with Clear Aligners

Currently, there is a shortage of research in the literature regarding MMD performed with aligners, however, there is evidence of the effectiveness of aligners in distalizing the upper molar by more than 2.7 mm with aligners. MMD requires significant force to move the tooth backward, but aligners are primarily designed to apply light and controlled forces for tooth movement [60–62].

In the study by Inchingolo et al., clinicians implemented a compensatory orthodontic treatment for a patient with TCM who had refused orthognathic surgery. The sequential distalization protocol was used, which consists of initially moving most distal teeth while keeping the rest of the arch anchored. Subsequently, the mesial teeth were moved, and the entire arch was repositioned distally (Figure 9). In this way, the distalization is guided tooth by tooth; the patient's cooperation in wearing the templates and the elastics of the third is obviously essential for the resolution of the case [2].

In the study by Rota et al., the effectiveness of the Invisalign system regarding MMD was analyzed. A standardized protocol of sequential MMD, like that used for the upper arch, was also used in this study. The results showed that although the aligner-only method is effective for MMD, the movement that is mainly achieved is not a body movement of the tooth but a tipping movement [32]. This can be explained by the fact that the lower molar has a complex root morphology and greater bone density, which makes it difficult to achieve effective distalization with aligners alone [63].

In a recent study by Auladell, however, the authors described how they planned an inferior distalization movement of more than 3 mm in two TCM patients using aligners and the assistance of mini-implants in the retromolar area. In these patients, the distalization method was proposed to resolve malocclusion and moderate crowding without premolar extractions [64].

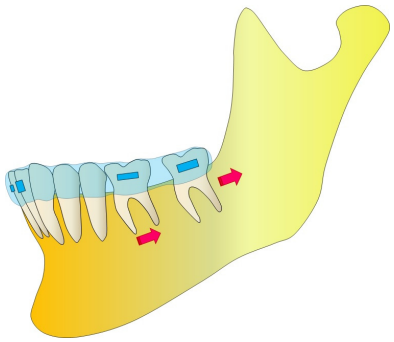

Figure 9. Aligners for the movement of MMD.

The studies highlight the use of sequential distalization protocols and the potential for incorporating mini-implants in the retromolar area to assist with distalization. Further research is needed to explore the efficacy of aligners for MMD and to develop optimal protocols that can achieve successful outcomes in these cases.

Comparing the methods, fixed appliances provide various mechanics with good outcomes, but success relies on patient compliance and orthodontist expertise [36,37]. Skeletal anchorage methods (TADs, mini-plates, and ramal plates) offer stable anchorage, eliminating the need for patient cooperation, and have shown promising results in achieving MMD in various TCM cases [27,29,30]. Clear aligners have limited evidence for MMD but offer benefits like aesthetics and patient comfort; however, their effectiveness in significant distalization remains a challenge [32].

This systematic review may have some limitations, even though MMD seems to be an additional orthodontic strategy for treating TCM in adult patients. First, the validity and representativeness of the results may be impacted by the small number of research papers that are currently available for this topic. Furthermore, the lack of a control group in certain studies makes it challenging to draw clear conclusions regarding the effectiveness of MMD procedures in comparison to other therapies. Furthermore, different research designs and treatment protocols may have been used in the numerous studies included in the review, making it challenging to directly compare and analyze data uniformly. The possibility of publication bias, wherein studies with positive results are more likely to be published than those with negative or insignificant results, as well as the risk of bias and confounding factors in specific studies, a lack of uniformity in reported data, among other issues, could also be limitations. Finally, the variability in patient characteristics, treatments, and evaluation criteria used in the included studies, could affect the generalizability of results for different populations of patients with TCM. Limited data availability may make it difficult to draw firm conclusions and make clinical recommendations based on solid evidence.

Future evidence is needed, such as long-term follow-up studies on the stability of MMD outcomes assessing the degree of recurrence, randomized controlled trials with large samples comparing different techniques to achieve MMD in TCM, and correlation studies with patient-specific factors to identify factors predictive of MMD treatment success.

5. Conclusions

In conclusion, this review sheds light on the potential of MMD for treating TCM in adults. However, it is important to recognize its limitations. Successful MMD depends on factors like malocclusion severity, proper diagnosis, patient cooperation, and the orthodontist's expertise. Patient compliance is crucial, especially for treatments involving elastics, springs, or aligners. Each method has pros and cons. Skeletal anchorage techniques (TADs, mini-plates, or ramus plates) offer stable anchorage and controlled movement, but require further research. Fixed appliances with springs or elastics are non-surgical but rely on patient compliance and have limitations. Aligners mainly provide controlled tipping movements, but they are less effective for significant molar movement. Overall, more research is needed to refine MMD approaches and establish standardized protocols for TCM treatment.

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Abbreviations

MEAW	Multiloop Edgewise Arch Wire
MMD	Mandibular Molar Distalization
P RISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SJ	Sliding Jigs
TADs	Temporary Anchorage Devices
TCM	Third Class Malocclusion
TMJ	Temporomandibular Joint

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