GRADUATION PROJECT

Degree in Dentistry

LITERATURE REVIEW: THE USE OF SKELETAL ANCHORAGE IN THE TREATMENT OF THE OPEN BITE MALOCCLUSION

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RESUMEN

Introducción: La mordida abierta anterior es una maloclusión compleja en ortodoncia. Existen varias opciones terapéuticas para su tratamiento en pacientes no en crecimiento. La cirugía ortognática se considera a menudo el tratamiento de elección para este problema oclusal, pero es más invasiva y puede presentar riesgo de recaída. Además, los dispositivos de anclaje temporal se han introducido como una alternativa, ya que sigue siendo una maloclusión difícil de tratar; **Objetivos**: Evaluar el rendimiento de los dispositivos de anclaje esquelético en el tratamiento de la mordida abierta en pacientes adultos y analizar las consecuencias de este tratamiento en términos de estética, complicaciones, invasividad y posibles recaídas en los resultados a largo plazo; **Metodología**: Se realizó una revisión de la literatura para examinar estudios sobre el uso de sistemas de anclaje esquelético, como miniplacas y microtornillos, en el manejo de la mordida abierta anterior, centrándose en la estabilidad, la duración del tratamiento, la mejora de la sobremordida y la intrusión molar; **Resultados:** Los dispositivos de anclaje esquelético permitieron lograr un cierre completo o parcial, gracias a la intrusión molar. Sin embargo, la falta de estudios de alta calidad y de estandarización hace que la estabilidad a largo plazo siga siendo incierta; **Conclusiones**: En pacientes no en crecimiento, los dispositivos de anclaje esquelético representan una opción terapéutica prometedora y eficaz, además de ser menos invasiva que la cirugía ortognática. Se requieren más estudios con muestras mayores y un seguimiento más prolongado, así como una mejora en los protocolos.

PALABRAS CLAVE

Anclaje esquelético, intrusión molar, microtornillos, miniplacas, mordida abierta, mordida abierta anterior, odontología, TADs.

ABSTRACT

Introduction: Anterior open bite is a complex malocclusion in orthodontics. Several management options can be used for its treatment in non-growing patients. Orthognathic surgery is often considered the treatment of choice for this occlusal problem, but it is more invasive and may present a risk of relapse. Furthermore, temporary anchorage devices (TADs) have been recently introduced as an alternative treatment option, as anterior open bite remains a challenging malocclusion to treat; **Objectives:** This review aims to assess how skeletal anchorage devices perform in the treatment of the open bite malocclusion in adult patients and to evaluate the consequences of this treatment in terms of esthetics, complications, invasiveness and possible relapse on the long-term outcomes; **Methods:** A literature review was produced to examine studies on the use of skeletal anchorage systems such as miniplates and miniscrews, in the management of the anterior open bite, focusing on the stability over time, treatment duration, overbite improvement and molar intrusion; **Results:** Skeletal anchorage devices helped patients with open bite achieving complete or partial closure, thanks to molar intrusion. However, the lack of high-quality studies and methodology or protocols standardization means long-term stability remains unclear; **Conclusions**: In non-growing patients presenting anterior open bite, TADs represent a promising and effective therapy option and less invasive than orthognathic surgery. More studies with greater sample sizes and extended follow-up are needed, as well as an improvement in the protocols.

KEYWORDS

Anterior open bite, dentistry, molar intrusion, miniplates, miniscrews, open bite, skeletal anchorage, TADs.

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1. INTRODUCTION

1.1. History of open bite malocclusion

Throughout history, orthodontics has evolved significantly. At the beginning of the 20th century, Edward H. Angle had a great influence in this domain and contributed to its development as a specialty. During this period, it focused mainly on teeth alignment and esthetics with poor interest in the occlusion (1,2). Whereas extraction was a key treatment, prevention was not yet an important principle of dentistry (1). Thanks to the development of new orthodontic university degrees, it became a real specialization (2). This evolution has reinforced the idea that it is not only about the motion of the teeth but highlights the importance of considering skeletal structure, dentofacial complex, and the patient's occlusion, in which the anterior open bite is frequently observed (2).

Historically, the term "open bite" was first introduced in the 19th century. Caravelli, an author and researcher specialized in orthodontics, is one of the first to use the term "open bite" as a classification for a type of malocclusion (3). In the articles by Rohit K, it is mentioned that Subtelny and Saduka defined the concept of open bite as a distinct diagnostic entity: *"Open vertical dimension between the incisal edges of the maxillary and mandibular anterior teeth"* (3). Their work helped to provide a clearer definition of what an anterior open bite is and to highlight its nature, which could be skeletal, dental or functional.

1.2. Definition of anterior open bite

Anterior open bite ranks among the most complex malocclusions in the world of orthodontics, defined as the absence of contact between the upper and lower anterior teeth, despite maintained posterior dental contact (4). This results in an abnormal occlusion which can lead to further complications with a prevalence ranging from 1.5% to 11% according to ethnicity (5). For example, studies have shown that there is a higher prevalence in African populations with a prevalence of 16% in black populations in comparison with 4% in white populations (5,6).

Worns, Meskin, and Isaacson, three American orthodontists, classified open bite depending on its extension: simple open bite from canine to canine, compound from premolars to premolars and infantile one including all the teeth in the arch (3). As seen before, anterior open bite can be classified depending on whether it has a dental or skeletal origin. In case of dental origin, it concerns mainly the anterior teeth and the surrounding tissues, but when the origin is skeletal,

it presents a vertical discrepancy in facial skeletal features that can be seen radiographically. This classification helps guide diagnosis and treatment planning (5,7).

In order to assess the tendency of a patient to develop an open bite, the overbite depth indicator (ODI) introduced by Kim can be used, which combines two cephalometric angles: ABpl-MP and PP-FH. A value of less than 75° suggests a higher risk of developing anterior open bite during the growing process (5).

1.2.1. Facial features

The characteristics of patients with an open bite are generally similar, although the cultural group may also play an important role in their facial morphology. Several studies indicate an important difference in cephalometric measurements between different ethnic communities such as Yemeni and Nigerian populations (5,7).

Facial features of patients with open bite malocclusion usually present a convex profile, increased vertical facial development, dental and alveolar prognathism and a posterior rotation of the mandible (5). In addition, an infraeruption of the anterior teeth or supraeruption of the posterior molars is frequent in this type of malocclusion (5).

From a cephalometric point of view, studies have shown an increase in vertical dimension, especially of the lower facial height (LFH) and total facial height (TFH) , along with an increased gonial angle observed in comparison with patients without an open bite (5).

1.2.2. Etiological factors

The origin of the anterior open bite can be skeletal or dental, which makes the identification of the problem difficult (8). Etiologies are multiple and varied, the main ones include genetic factors related to skeletal morphology, oral breathing, abnormal deglutition, forces applied by muscles and soft tissue during their development (4), as well as external factors such as the use of non-nutritive sucking habits during growth, the most common ones being thumb sucking or pacifiers (8). This type of malocclusion is also frequent in patients suffering with neurological problems (8) or syndromes such as Down syndrome. As in any treatment in dentistry, the complexity will depend on each patient and the combination of the factors seen above will significantly complicate the management and the results (9).

1.2.3. Consequences of the open bite

Patients affected by an open bite are more likely to have facial esthetic abnormalities, speech alterations and masticatory problems, that may lead to psychological problems as it can have an impact on self-esteem especially in complex cases (10).

Multiple studies have shown some interest in cases with open bite, looking to improve the understanding of the possible treatment (11,12). Even though new technologies in orthodontics have emerged, many new approaches have been proposed to treat this malocclusion. It remains a complex occlusal problem to treat and so current treatment results are very variable and contradictory (4). That shows the need for further investigation on the available treatment techniques addressing open bite and their outcomes in both the short and long-term (8,11).

1.3. Different types of treatment approaches

Nowadays, multiple approaches have been described for the correction of anterior open bite. Firstly, the cessation of parafunctional habits, particularly thumb sucking, usually associated with open bite development in pediatric patients, and oral breathing, whether in children or adults, can prevent its progression or allow a better identification of the source (3,8,13).

Secondly, orthognathic surgery represents the preferred surgical approach for managing skeletal anterior open bite malocclusion, in non-growing patients, to obtain improved esthetic and occlusal outcomes (11). Le Fort I (4), a type of orthognathic surgery, is one of the procedures used to improve this malocclusion by the repositioning of the upper maxilla.

A third option of treatment involves orthodontic correction of the anterior open bite. Incisor extrusion can be performed especially in patients presenting a dentally-derived open bite with a low smile, as it can affect the smile esthetics, however, this technique often results in unstable outcomes in the long-term (3). Extrusion techniques rely on the use of elastics combined with brackets or Invisalign. Nevertheless, incisor extrusion shows poor results in cases of extensive anterior open bite (14).

The procedures seen above have shown some limitations in treating anterior open bite malocclusion, resulting in doubtful long-term outcomes with frequent relapse of the treatment, post-treatment instability as well as esthetic problems (10,14,15).

1.4. Temporary anchorage devices

The introduction of temporary anchorage devices (TADs) has played an important role in modern orthodontics, since their stability allows controlled movement and avoids unwanted displacement of adjacent teeth, which enhances the precision of treatment (16). TADs were introduced in the field of orthodontics in 1945 as subperiosteal implants, but it was only around 1990 that miniplates and miniscrews were introduced as reliable devices for orthodontic correction. With the evolution of facial orthopedics, new temporary implants were introduced in the field during the beginning of the 21st century to treat malocclusions like severe anterior open bite (16).

TADs are composed of three parts: head, neck and body. They are classified into eight different types according to their location, composition, use, and form. These temporary implant devices can be used in cases where orthognathic surgery would have been the treatment of choice. As a comparison with orthognathic surgery, TADs are less invasive but still challenging, due to the risk of damaging adjacent structures in the oral cavity when they are implanted. TADs should be placed in the bone surrounded by attached gingiva to prevent the risk of soft tissue inflammation that would otherwise occur when placed in the oral mucosa (16). Besides, temporary orthodontic implants are rarely contraindicated unless the patient has important health problems or low bone support.

For the management of anterior open bite malocclusion, TADs have proven to be beneficial for posterior molar intrusion, either in the mandible or in the maxilla or both. There are two kinds of TADs: miniscrews and miniplates (12,17,18). Depending on the degree of tooth intrusion required, their degree of inclination, the patient's requirements, the teeth present in the mouth, we will choose between the use of miniplates or miniscrews. According to *Omidkahod et al.* 2023, miniplates allow a greater intrusion of molars than miniscrews, regardless of the level of force applied but the intrusion amount can be modified depending on the accessory devices used, such as transpalatal arch, quad helix (8). The choice of the type of the anchorage will depend on the needs of the patient, the dentist's preferences as well as the patient's financial status as miniplates are at a higher cost (11,16).

Different studies have proved that the use of TADs will lead to a counterclockwise rotation of the mandible. In other words, the mandible moves the chin upward and forward leading to a closure of the open bite as the mandible goes upward too. Consequently, it will improve the facial esthetic, reduce the anterior lower facial height and improve lip position (11).

The advantage of TADs is that they are very precise and allow the dentist to follow every modification in tooth positioning. In addition, it is a less invasive technique for the surrounding structures than orthognathic surgery, well known as the most suitable option when managing skeletal anterior open bite. Its effectiveness, predictability and quick recovery period make it an attractive treatment option (12).

The growing interest in the use of TADs in orthodontics reinforces the relevance of facial orthopedics, but more complex investigations are needed to be done due to their recent integration in the management of patients presenting anterior open bite.

1.5. Current state of the subject

The use of skeletal anchorage in the treatment of the anterior open bite is a recent topic in orthodontics, which means that there is limited information about their stability and effectiveness in the long term, where many studies suspect the possibility of relapse (12). According to *Gonzalez Espinosa et al.* 2020, the results in the short term are promising but in the long-term are variable and not reliable due to the lack of adequate follow-up protocols for patients and the heterogeneity of the study criteria (8).

In addition, *Akbaydogan and Akin.* 2020 added that the precision of the data is doubtful especially in the long term due to the lack of studies and mentioned the need for more data on the success or failure rate of molar intrusion when used to correct open bite over the long term (15). The quality of data is low with high controversy in the results and the presence of errors is possible, according to *Kwon et al.* 2024 (4).

The success rate of TADs for anterior open bite treatment is between 80% and 100% depending on different factors, including the clinician's ability, location, the type of implant, bone quality and patient hygiene (16).

1.6. Justification

Given its multifactorial etiology and elevated relapse risk, anterior open bite stands among the most demanding malocclusions in orthodontic practice (3,9). Therapeutic approaches vary from conventional techniques to complex surgical interventions depending on the complexity of the case (4). The recent introduction of skeletal anchorage, TADs, has significantly improved treatment methods by providing another promising alternative compared to orthognathic

surgery. Moreover, the use of miniscrews or miniplates has enhanced vertical control and stability (15).

Although there are recent studies, the available data remain limited and sometimes incompatible when talking about their efficacy, types of anchorage and influence on facial esthetic. In addition, studies demonstrating their clear benefits in comparison to clear aligners or surgical techniques have not yet been demonstrated (4,14).

Therefore, conducting a literature review is important and necessary to synthesize current knowledge and evidence in order to compare the different therapeutic methods, as well as their occlusal and esthetic effects in the long term.

The objective of this study is to better understand the treatment of anterior open bite using TADs techniques to provide an approach adapted to each patient based on reliable scientific data.

2. OBJECTIVES

The main aim of this review is to evaluate the treatment outcomes of anterior open bite with the use of skeletal anchorage. In addition, it will compare the different skeletal anchorage systems, including miniplates and miniscrews, as well as compare non-invasive TAD techniques with clear aligners, fixed orthodontic appliances, or surgical treatment.

Moreover, this review will evaluate the consequences of this procedure from an esthetic, occlusal and functional perspective. Finally, it is of great importance to examine the short and long-term stability as well as the recovery period of this procedure to use it in appropriate cases due to the number of other possible treatments for patients presenting open bite malocclusion.

3. MATERIAL AND METHODS

This study was conducted as a systematized literature review, following the guidelines of a systematic review but respecting the rules adapted to a university final year project. The main objective of this study is to analyze, summarize, and compile scientific data on the skeletal anchorage-based management of anterior open bite malocclusion. This technique of data analysis allows a more organized, precise and representative study by identifying reliable and useful scientific papers on the subject. For that purpose, inclusion and exclusion criteria must be set. Then, an evaluation of the quality of the articles and their results was carried out, to correctly answer the research question.

PICO:

- Population (P): Patients aged 12 years or older with permanent dentition presenting an anterior open bite.
- Intervention (I): Treatment with skeletal anchorage (miniplates, miniscrews)
- Comparison (C): Compared with conventional orthodontic treatment or orthognathic surgery.
- Outcomes (O):
  Primary outcomes: Occlusal results, anterior open bite closure
  Secondary outcomes: Esthetic improvement, long-term results, complication rate
- Study (S): Exclusively primary studies were included such as clinical trials, case series, case reports, etc.

In patients with permanent dentition presenting anterior open bite, how does skeletal anchorage in comparison with conventional orthodontic treatment or orthognathic surgery affect occlusion, open bite closure and secondary outcomes such as esthetics in the long term?

3.1. Selection criteria

The aim of establishing exclusion and inclusion criteria is to ensure proper analysis of the data. These requirements have been decided and formulated prior to the selection of the articles to be evaluated, in order to correctly define the scope of the selected review.

3.1.1. Inclusion criteria

Eligible research includes studies published between 2015 and 2025, articles in English and Spanish, and articles focusing on skeletal anchorage approaches for treating anterior open bite

malocclusion in humans. In addition, it requires human clinical studies including clinical trials that contain occlusal and cephalometric results.

3.1.2. Exclusion criteria

Studies were excluded if they comprised studies carried out on animals or anatomical models, systematic reviews, papers without treatment results or those in which skeletal anchorage is used for other orthodontic techniques other than managing anterior open bite malocclusion.

3.2. Search strategies

The search strategies included a structured electronic search on PubMed and Medline. This step of the literature review was carried out by using keywords from the previously identified PICO terms: “anterior open bite”, “skeletal anchorage”, “TADs”, “miniplates”, “miniscrews”, “molar intrusion”.

The search equation used in PubMed was based on the application of Boolean operators (AND/OR/NOT). To find articles possibly useful for the results section, the following search was made: (((((Anterior open bite) AND (Temporary anchorage devices)) OR (TADs)) OR (Miniscrew)) OR (Miniplates)) AND (Molar intrusion).

The search equation was adapted to the database Medline. To search for papers in Spanish, the same equation was translated to that language.

4. RESULTS

4.1. Search results

The electronic search established in Medline and PubMed on the 12th of December 2025 allowed the identification of 446 articles, both in English and in Spanish, potentially useful and relevant for this literature review. After the analysis of the selected articles, 149 were duplicates, leaving 297 articles for analysis based on the title and abstract. Date filters from 2015 to 2025 were applied to ensure the topicality of the literature review. Additionally, filters for primary studies were added to rule out secondary studies like other literature reviews. 262 were excluded since they failed to meet the inclusion criteria (non-primary studies, outside the 2015-2025 period, absence of skeletal anchorage, TADs or anterior open bite treatment).

For the full-text assessment, 35 articles were retained, 20 of them were excluded due to the absence of studies involving miniscrews or miniplates, the lack of relevant results or because they were incompatible with the objectives of this study.

Finally, 15 primary studies in Table 1 were kept and judged useful for this literature review. In the PRISMA diagram, shown in Figure 1, the selection process is displayed.

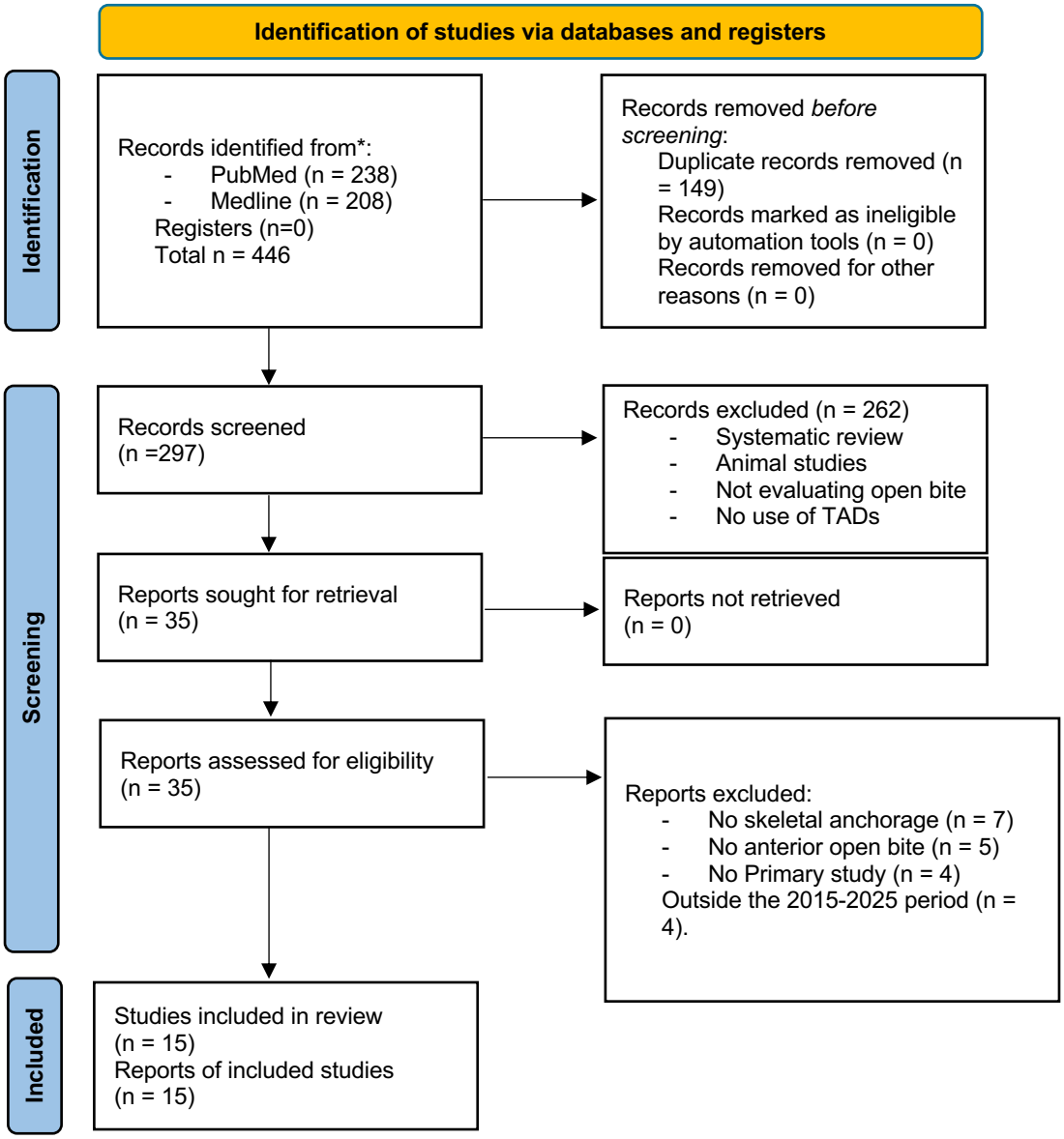


Figure 1. PRISMA flow diagram (19).

Source: Page MJ, et al. BMJ 2021;372:n71. doi: 10.1136/bmj.n71.
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Author, Year	Study type	Sample size	Treatment type	Treatment duration	Molar intrusion (mm)	Overbite increase (mm)
1. Akl et al. 2025 (20)	Randomized clinical trial	22 adults	Maxillary posterior intrusion with miniscrews	6 months (intrusion phase)	2.89mm (MIC) 2.26mm (BMI).	3.8mm
2. Gupta S. 2019 (21)	Case report	1 adult	Molar intrusion with TADs and elastics	23 months	Not reported	Not reported
3. Tenshin et al. 2025 (22)	Case report	1 adult	Bimaxillary molar intrusion with miniscrews	54 months	2.8 mm (maxillary) 0.9mm (mandibular)	1.7mm per 1mm molar intrusion
4.Shirasaki et al. 2020 (23)	Case report	1 adult	Molar intrusion with miniscrews	21 months	1.5mm in the maxillary	>2mm
5.Mehta et al. 2021 (24)	Case report	1 adult	Closure of AOB with TADs	Not reported	Not reported	Not reported
6.Iwasa et al. 2017 (25)	Case report	1 adult	Intrusion of molars with miniplates	44 months	7mm for maxillary and 1mm mandibular 1st molars	4.3mm
7. Wilmes et al. 2015 (26)	Case report	1 adult	Palatal mini screw mesial slider for intrusion	31 months	2-3mm	5.5mm
8. Marzouk et al. 2015 (27)	Clinical study	13 adults	Maxillary molar intrusion with zygomatic plates	± 9 months	3.1mm ± 0.74	6.55mm ± 1.83mm

9. Beycan K. Erverdi N. 2016 (28)	Case report	1 adult	AOB closure with the help of zygomatic plates	20 months	2.5mm	7.2 mm
10. Arveda et al. 2025 (29)	Case report	1 adult	Vertical control with miniscrews	Not reported	Not reported	Not reported
11. Kook et al. 2015 (30)	Case report	1 adult	AOB treatment with miniscrews and modified palatal anchorage plate	3 years and 10 months	Not reported	>1.5mm
12. Akl et al. 2020 (31)	Randomized clinical trial	20 patients	Maxillary molars intrusion with miniscrew	6 months (intrusion)	200g= 2.26mm 400g= 2.42mm	200g= 2.24mm 400g= 3.15 mm
13. Ogura et al. 2024 (32)	Retrospective study	10 patients	Maxillary molar intrusion using TADs	3 years	1.6mm	4.1mm
14. Chang et al. 2022 (17)	Retrospective study	42 patients	Maxillary miniscrews	Follow-up >1year	3.3mm	+4.5 to 5.1mm
15. Patel et al. 2024 (33)	Prospective study	40 patients	Molar intrusion with miniscrews	6.5 months	4.8 mm	Not reported

Table 1. Overview of the 15 included studies

The included studies in this literature review show a certain heterogeneity according to their design and sample size. Most of the studies selected are clinical reports focused on one case (21–26,28–30) and the rest are retrospective (17,32), prospective (27,33) or randomized clinical trials (20,31). The sample size varies between the studies, from one case (21–26,28–30) to small groups, for instance, 10 patients (27,32), and more important sample sizes such as 44 patients in the prospective study of *Chang et al*. 2022 (17).

Studies with a larger number of patients in their sample and a randomized selection tend to have more unequivocal results. Randomization reduces possible bias and improves the reliability of research. On the other hand, trials with a limited number of patients show a lower level of accuracy and a lack of generalizability of the results.

Overall, the selected studies present relevant clinical information about how skeletal anchorage can be used to manage anterior open bite malocclusion. The fact that TADs treatment for this malocclusion is a novel method, not widely used, and that there is a scarcity of studies on the matter, and that the existing ones are mostly clinical reports, focused on one patient, means that the global quality of the current studies can be considered as moderate. However, the quality of these studies on skeletal anchorage is sufficient to analyse and compare them with previous treatment methods.

4.2. Epidemiological data

The included studies were carried out in different countries such as the United States (17), Japan (22,32), Turkey (28), South Korea (23,30), Germany (26), Egypt (20), India (21) and Italy (29). The age of the different patients varies from 12-18 years to adulthood, with patients up to 40 years old (22,24,28,30). The mean age reported in multiple studies is between 20 and 25 years as most of the patients were young adults (20,27,32,33).

4.3. Anchorage devices used

Different types of skeletal anchorage were used in the selected studies such as miniscrews (20–23,26,30,32,33), miniplates (25,27,28), zygomatic plates (25,27,28), palatal plates (24,26,30). Other mechanisms were used to improve the treatment outcomes for instance, the mesial slider (26) or MARPE (Mini-implant assisted rapid palatal expansion) (24).

The mesial slider, is a palatal appliance that minimizes unwanted dental side effects while providing limited molar movement, thanks to the stability given by miniscrew anchorage in the anterior palate (26). On the other hand, MARPE is a fast palatal expansion device anchored by a mini-implant that is exclusively used in the maxilla to facilitate orthopedic expansion of the maxilla and achieve a correct vertical control of posterior teeth. This skeletal anchorage may contribute to anterior open bite correction through molar intrusion with the help of TADs (24).

Mainly used for posterior teeth intrusion in both adolescents and adult patients, these anchorage elements were used either in both arches or limited to the maxilla, like in the case of MARPE, depending on the clinical circumstances (22,25,27,32). Generally, these devices are used in association with other fixed orthodontic appliances such as rigid archwires, the mesial slider which is used in association with transpalatal arch, quad-helix or lingual arch to offer more support, as well as coil springs or elastomeric chains to improve and control movement of teeth (20,32).

4.4. Results of molar intrusion

The included studies showed variable extents concerning the intrusion of molars, predominantly targeting maxillary molars, with intrusion results varying depending on the technique, the intrusion force provided, and the anchorage used, with values ranging from 1.5 to 7 mm. Due to this molar intrusion, most studies report an increase in overbite leading to complete or partial closure of anterior open bite. In some studies, the intrusion of mandibular molars is also noteworthy, significantly improving the vertical dimension, as in the case report *by Tenshin et al.* 2025, where the first mandibular molars were intruded by 0.9 mm (22).

Molar intrusion results vary across the studies (17,20,32) and within the same study. The variability of intrusion results is more relevant in studies with a larger number of individuals, such as in the clinical study of *Marzouk et al.* 2015, which reported a mean molar intrusion of 3.1 mm with a standard deviation of ± 0.74 mm and *Akl et al.* 2025, who reported a standard deviation of ± 2.06 mm and ± 1.87 mm depending on the intrusion force used (Table 2) (20,27).

Author, Year	Intruded arch	Mean molar intrusion (mm)	AOB pretreatment (mm)	AOB posttreatment (mm)	AOB closure (mm)
1. Akl et al. 2025 (20)	Both	MIC: 2.89 ± 1.13 BMI: 2.26 ±1.62	MIC: 4.99 BMI: 6.70	Not reported	MIC: 3.8 ± 0.84 BMI:3.84 ± 1.47
2. Gupta S. 2019 (21)	Maxillary	Not reported	Not reported	Positive overbite	Not reported
3. Tenshin et al. 2025 (22)	Both	2.8mm (maxillary molars) / 0.9mm (mandibular molars)	-5.5	+1.0	6.5
4.Shirasaki et Al. 2020 (23)	Maxillary	1.5mm (maxillary 1st molars)	-2.0	Positive overbite	>2.0
5.Mehta et al. 2021 (24)	Not reported	Not reported	Not reported	Ideal overbite	Not reported
6.Iwasa et al. 2017 (25)	Both	Approximately 2mm	-2.0	+2.5	4.5
7. Wilmes et al. 2015 (26)	Maxillary	Not mentioned	-4.0	+1.5	5.5
8. Marzouk et al. 2015 (27)	Maxillary	3.1 ± 0.74mm	-8.5 to -3	+1 to +2	+6.55 ± 1.83
9. Beycan K. Erverdi N. 2016 (28)	Maxillary	2.5mm	-6.5	+0.7	7.2
10. Arveda et al.	Not reported	Not reported	Not reported	Positive overbite	Not reported

2025 (29)					
11. Kook et al. 2015 (30)	Maxillary	Not reported	-1.5	Positive overbite	>1.5
12. Akl et al. 2020 (31)	Maxillary	2.42 ± 2.06 (200g) 2.26 ± 1.87 (400g)	3-8	_	2.24 ± 1.18 (200g) 3.15 ± 1.06 (400g)
13. Ogura et al. 2024 (32)	Maxillary	1.6mm (maxillary first molars)	Open bite present	_	4.1
14. Chang et al. 2022 (17)	Maxillary	3.3	<1	Positive overbite	4.5-5.1
15. Patel et al. 2024 (33)	Maxillary	1.9	Not reported	Not reported	Not reported

Table 2. Comparison of open bite evolution

4.5. Overbite correction

The values of the overbite correction vary according to the study from 1.7 to 7.2 mm (22,28). Depending on the therapeutic protocols, a partial (17,31,33) or complete closure (23,25,26,32) of the open bite was observed, resulting in an increase in overbite.

As seen in the included studies, most of the cases show a transition from a negative overbite to a normal positive one upon treatment completion, as illustrated by the case by *Wilmes et al.* 2015 (26)**.** Overbite measurement was carried out before, during and after treatment, presenting variable results within and between studies as seen in Table 2.

4.6. Skeletal and cephalometric evolution

The included studies highlight some modifications in the skeletal and cephalometric results related to posterior teeth intrusion. The majority of articles report a counterclockwise rotation of the mandible due to maxillary molar intrusion which led to a decrease in the vertical direction of the lower third of the face (25–27,32).

According to *Iwasa et al.* 2017, molar intrusion in both arches contributes to a counterclockwise mandibular rotation of 4.2° associated with a movement of the chin of 4 mm forward (25). Other authors such as *Tenshin et al.* 2025 determined that this mandibular rotation is associated with an improvement of the condyle position, maximum intercuspation and reduces centric relation discrepancies (22).

4.7. Treatment duration

Treatment duration varied considerably among the included studies. Some protocols were relatively short, lasting approximately 6 to 9 months (20), while others extended over longer periods exceeding 18 months (17,25). Some studies such as *Akl et al*. 2020 (31) provided only information about the duration of the intrusion of the molars, in which the intrusion lasted for 6 months. On the other hand, other studies provided information about the whole active treatment that ranged from 20 months (21,23,28) to approximately 36 months (25,26,30).

Treatment duration represents an important parameter, as it influences the therapeutic effectiveness and the stability of the results. Moreover, the duration of a study will depend on its methodological design. Clinical studies involving larger samples (27,31,32) require longer observation period in comparison with case reports (22,23,26) where only one patient is analyzed.

4.8. Post-treatment stability

The stability of treatment differed among studies, while some showed good consistency (23,25,26), others presented some relapse over time (17,32). The included studies focused mainly on molar intrusion stability and anterior open bite correction after a significant period, although the evaluation criteria vary across studies (Table 3).

Author	Follow-up duration	Stability assessment	Relapse	Retention protocol
1. Akl et al. 2025 (20)	Not reported	Not reported	Not reported	Not reported
2. Gupta S. 2019 (21)	Not reported	Not reported	Not reported	Not reported
3. Tenshin et al. 2025 (22)	4 years	Stable occlusion, overbite and condylar position	Not reported	Begg retainers (20h/days first years, 8h/days after) Miniscrew retention with 0.008-in ligation wire
4.Shirasaki et Al. 2020 (23)	4.6 years	Clinical evaluation showed stable occlusion and overbite	Not reported	Lingual bonded retainer
5.Mehta et al. 2021 (24)	Not reported	Not reported	Not reported	Not reported
6.Iwasa et al. 2017 (25)	5 years	Stable occlusion, overbite and mandibular position	Not reported	Tooth positioner for both arches and lingual bonded retainers (3-3)
7. Wilmes et al. 2015 (26)	3 years	Cephalometric evaluation of overbite and molar space	Little relapse reported	Not reported

8. Marzouk et al. 2015 (27)	Not reported	Cephalometric evaluation of overbite and molar position	Not reported	Not reported
9. Beycan K. Erverdi N. 2016 (28)	Not reported	Cephalometric analysis of overbite and mandibular counterclockwise rotation	Not reported	Not reported
10. Arveda et al. 2025 (29)	Not reported	Not reported	Not reported	Not reported
11. Kook et al. 2015 (30)	Not reported	Cephalometric evaluation of molar position	Not reported	Not reported
12. Akl et al. 2020 (20)	Not reported	Cephalometric analysis of overbite and molars	Not reported	Not reported
13. Ogura et al. 2024 (32)	>1 year	Cephalometric analysis and 3D model control showed stable overbite and molar position	0.1 mm	Not described
14. Chang et al. 2022 (17)	≥1 year	Cephalometric evaluation at T0, T1, T2 and T3 comparing AOB	Yes, 1.0 mm OB decrease in retention period	Not described
15. Patel et al. 2024 (33)	Not reported	Cephalometric analysis of molar intrusion	Not reported	Not reported

Table 3. Stability, follow-up duration and retention protocol

5. DISCUSSION

The analysis of the 15 studies highlights a significant relation between the biomechanical effects and the clinical molars intrusion achieved through skeletal anchorage in the treatment of open bite.

Overbite is the outcome we want to achieve and corresponds to a vertical overlap of one-third of the upper incisors over the lower ones and it represents a fundamental parameter of occlusion which plays a very important role in orthodontic work and cephalometric studies especially in the evaluation of open bite treatment (17). Generally, anterior open bite improvement depends mainly upon the resulting intrusion of posterior teeth and the mandibular counterclockwise rotation (20,27,32).

5.1. Relationship between molar intrusion and closure of anterior open bite

The magnitude of anterior open bite correction achieved with TADs appears to exceed the actual molar intrusion obtained, suggesting the hypothesis that an amplification effect is mediated by mandibular autorotation (22,27). Thus, a maxillary molar intrusion between 1.6 mm and 3.1 mm has been associated with a correction ranging from 4 mm to 6 mm in different studies (27,32). *Ogura et al*. 2024 showed a mean intrusion of 1.6 mm that correlates with overbite improvement of 4.1 mm while *Marzouk et al.* 2015 document a 3.1 mm of intrusion associated with a closure of 6.55 ± 1.83 mm (27,32). This disproportionate gain is generally due to the counterclockwise autorotation of the mandible. This rotation occurs and is associated with a decrease in the posterior vertical dimension (22).

However, this relationship between molar intrusion and open bite closure does not appear to be strictly linear, and interindividual variability must be considered. In one randomized clinical trial, different types of maxillary intrusion resulted in an anterior open bite (AOB) closure of only 3.8 mm without relevant differences contrasted with cases that carried out a bimaxillary approach (20).

The findings of the selected studies demonstrate that the amount of molar intrusion alone cannot explain the improvement of AOB. The degree of mandibular autorotation and the molars involved in the intrusion process are important parameters that may have a substantial impact on the results of the correction (20,22,27,32). These factors influence the vertical dimension and the rotational response of the lower jaw, impacting the extent of the correction. Consequently,

it hinders the possibility to predict the association between molar intrusion and the improvement in overbite based only on the vertical displacement of the molars as it is not a linear relationship (27,32).

5.2. Maxillary intrusion alone vs. bimaxillary intrusion

The comparison between maxillary molar intrusion alone and bimaxillary intrusion shows similar results in terms of open bite treatment (20). These outcomes suggest that maxillary intrusion is the primary determinant of vertical dimension reduction, while mandibular intrusion plays a complementary role but is not necessary in all cases.

In addition, compensatory treatment for better results is frequently associated with molar intrusion such as the extrusion of incisors, but its use will depend on the case as it can produce undesired esthetic outcomes.

5.3. Magnitude of intrusion force

According to *Akl et al.* 2020, an increase from 200 g to 400 g of intrusion forces demonstrated little to no measurable impact on the degree of molar intrusion obtained. This lack of response indicates that moderate forces are sufficient to produce relevant clinical outcomes, with no benefit and possible adverse effects from increasing the force intensity.

5.4. Post-treatment stability

The medium-term outcome stability achieved using skeletal anchorage appears generally satisfactory, although some important nuances deserve to be highlighted. An average intrusion loss of approximately 0.1 mm after a year of retention has been reported, but this was considered not clinically significant, reporting an excellent short-term stability (32).

In the article by *Chang et al.* 2022, a comparison between surgical treatment using bimaxillary surgery and non-surgical treatment using molar intrusion with TADs was carried out for anterior open bite correction. This study documented an average decrease in overbite of 1 mm during the retention period, with a comparable stability between the two techniques, favoring less invasive treatments such as skeletal anchorage with TADs. Unfortunately, the authors highlight a major secondary extrusion of maxillary molars in the non-surgical group in the long term (17).

Furthermore, another study reports molar relapse rates of approximately 12% in the maxilla and 27% in the mandible, reporting the difficulty of reaching an adequate control of intrusion of

posterior mandibular teeth over the long term (22). Long-term follow-up outcomes tend to confirm the stability of this treatment method, although the level of evidence remains limited. Study design characteristics of most of the publications, which are mainly case reports, are less representative of the general population (21,25,26). This fact invites caution in interpreting the study's results.

According to the included studies, many factors such as the treatment techniques, patient compliance and the duration of the treatment may influence stability results.

5.5. Clinical application and functional considerations

From a clinical point of view, molar intrusion with skeletal anchorage is evolving as a credible non-surgical alternative for adults with moderate and severe open bite, depending on the case (17,26). This kind of approach allows avoidance of possible complications associated with orthognathic surgery.

In addition, some authors believe that beyond the skeletal and occlusal correction, the resulting mandibular autorotation is associated with additional benefits. An improvement in temporomandibular disorders and a modification of condyle-discal relationship secondary to mandibular repositioning has been documented (22,25). These findings are based on limited case reports and do not allow generalization of conclusions.

5.6. Limitations

Although most studies report successful outcomes in correcting anterior open bite malocclusion through TAD-assisted molar intrusion, some relevant limitations must be highlighted. First, the heterogeneity of the evidence is a major limitation. A significant number of publications are limited to case reports (22,23,26), which are less relevant in terms of results obtained than those from randomized controlled trials.

Secondly, the variability of cephalometric analysis methods limits our ability to compare study results. The lack of standardization in the way of obtaining outcomes and the methodology for assessing long-term stability diminishes study comparability.

Finally, the risk of bias presented in retrospective studies such as in *Chang et al*. 2022 could affect the samples studied. All these facts highlight the need to conduct randomized controlled

trials with a long-term follow-up to reinforce the level of relevant evidence available on the stability and on other important criteria assessed.

5.7. Future direction

The goal of future research should be to improve the level of evidence justifying the application of skeletal anchorage in managing anterior open bite problem. Many of the studies currently available are case reports or limited case series, which affects the extent to which their conclusions can be reproduced and may weaken the reliability. Therefore, well-designed studies with larger samples and rigorous methodology are required to obtain more trustworthy results.

Also, increasing the standardization of treatment protocols and outcome assessment would possibly facilitate more meaningful comparisons between various skeletal anchorage systems and techniques. The implementation of standardized criteria and measurement methods will allow researchers to show generalizable and reliable conclusions. Further research must focus on the long-term stability of this correction especially in relation to the molar intrusion stability, mandibular counterclockwise rotation and relapse over time. Indeed, a fundamental objective of orthodontic treatment is to establish and restore a stable occlusion for a long period of time.

Finally, since these elements are important for maintaining a stable occlusion and enhancing the quality of life of the patients, future studies should focus on the assessment of the functional outcomes of the treatment, including masticatory function, phonation, muscle adaptation and TMJ health.

6. CONCLUSION

In conclusion, this literature review aimed to evaluate the effectiveness of TADs in the correction of the anterior open bite in non-growing patients, as well as their stability over time, esthetic and functional outcomes. The critical analysis of the included studies shows that the intrusion of molars using skeletal anchorage is an effective therapeutic method and generally stable for the correction of anterior open bite in adults, which is accompanied by mandibular counterclockwise rotation and reduction of the vertical dimension.

When compared to non-skeletal methods, TADs present greater results in terms of true molar intrusion and skeletal correction. Furthermore, skeletal anchorage approaches are a realistic and less invasive alternative with reliable outcomes for moderate cases compared to orthognathic surgery.

From an esthetic and functional perspective, TADs contribute to a more harmonious facial profile thanks to the counterclockwise rotation of the mandible, along with documented improvements in masticatory function.

The results regarding post-treatment stability remain controversial, associated with a loss of overbite during the retention phase, which appears to be linked to subsequent extrusion of maxillary molars. This shows the importance of focusing on an adequate vertical and retention control post-treatment. The effectiveness of temporary anchorage devices depends on adequate patient selection as outcomes vary depending on the skeletal structure, the genetic features and etiology of the AOB.

Finally, it can be said that this treatment, molar intrusion, plays an important role in the improvement of cephalometric and skeletal variables, even if those changes will depend on the therapeutic techniques used and the skills of the practitioners. However, the variety of study designs, the prevalence of case reports, and small sample sizes, and the absence of standardized outcome evaluation continue to limit the present body of evidence. Further well-designed randomized controlled trials with long-term follow-up are necessary to optimize treatment protocols and determine stability.

7. SUSTAINABILITY

The sustainability of this literature review is mainly associated with social and economic sustainability aspects. Given its multifactorial etiology and the difficulty in establishing stable treatment results, anterior open bite remains among the most severe malocclusions in clinical orthodontic practice (5). Strengthening the understanding of the skeletal and dentoalveolar features associated with anterior open bite through cephalometric evaluation leads to more successful diagnosis and outcomes.

From a social sustainability point of view, TADs are a less invasive approach than orthognathic surgery which may improve the patient's quality of life. Early detection of open bite patterns can enable immediate and individualized correction minimizing functional and esthetic impairments with a surgery compromising patient comfort. This strategy is related to Sustainable Development Goal (SDG) 3 (good health and well-being).

From an economic sustainability standpoint, TADs represent a cost-effective treatment compared to orthognathic surgery, reducing hospitalization costs. TADs enable a lower consumption of surgical materials, which has a positive impact on the environment, reducing clinical supply waste used for invasive procedures. This point is related to SDG 12 (responsible consumption and production).

Moreover, disseminating the scientific data generated by this research supports SDG 4 (Quality Education) by encouraging evidence-based training for future dental practitioners.

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