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REVIEW

EVALUATION OF THE STABILITY OF ACHIEVED VERTICAL TOOTH MOVEMENT WITH SKELETAL ANCHORAGE: A SYSTEMATIC REVIEW

Evaluación de la Estabilidad del Movimiento Dental Vertical Logrado con Anclaje Esquelético: Una Revisión Sistemática

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ABSTRACT

Introduction: Skeletal anchorage is an effective and predictable complement during fixed orthodontic treatment since it allows tooth movements on the three dimensions. This study aims to evaluate the stability of vertical tooth movements using skeletal anchorage after six months of the retention stage.

Material and Methods: A systematic search was performed in the PubMed, Embase, Scopus, and Lilacs databases from January 2012 to May 2023. All the articles were selected by applying the inclusion and exclusion criteria. The methodological quality of the randomized clinical trials was evaluated using the Cochrane ROBINS-I tool.

Results: Five articles were obtained, all studies with a prospective design. A total of 114 patients was obtained, ranging in age between 21 and 41 years. The minimum follow-up time was 5 months, and the maximum 24 months. All studies showed significant changes when performing vertical tooth movements using skeletal anchorage during orthodontic treatment. Millimetric recurrences were observed between 6 and 36 months in the retention stage with no clinically significant differences. Four studies were classified as moderate in the overall risk of bias assessment, while one was classified as serious. In conclusion, the movements of tooth intrusion with skeletal anchorage in the maxilla cause significant changes during treatment. Meanwhile, when evaluating the stability of the intrusion movements, millimetric changes are observed with no statistical differences.

Conclusions: Studies with greater methodological rigor are needed, which follow up with three-dimensional imaging of tooth movement and which, in addition, assess the amount of force and its association with the amount of recurrence in the vertical movement.

Keywords: *Tooth movement; Orthodontics, corrective; Orthodontic anchorage procedure; Orthodontic miniscrew; Orthodontic mini-implant; Systematic review*

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RESUMEN

Introducción: El anclaje esquelético es un complemento eficaz y predecible durante el tratamiento de ortodoncia fija, ya que permite movimientos dentales tridimensionales. Este estudio busca evaluar la estabilidad de los movimientos dentales verticales mediante anclaje esquelético tras seis meses de la etapa de retención.

Material y métodos: Se realizó una búsqueda sistemática en las bases de datos PubMed, Embase, Scopus y Lilacs desde enero de 2012 hasta mayo de 2023. Todos los artículos se seleccionaron aplicando los criterios de inclusión y exclusión. La calidad metodológica de los ensayos clínicos aleatorizados se evaluó mediante la herramienta Cochrane ROBINS-I.

Resultados: Se obtuvieron cinco artículos, todos estudios con un diseño prospectivo. Se obtuvo un total de 114 pacientes, con edades comprendidas entre 21 y 41 años. El tiempo mínimo de seguimiento fue de 5 meses y el máximo de 24 meses. Todos los estudios mostraron cambios significativos al realizar movimientos dentales verticales utilizando anclaje esquelético durante el tratamiento de ortodoncia. Se observaron recurrencias milimétricas entre los 6 y los 36 meses en la etapa de retención sin diferencias clínicamente significativas. Cuatro estudios se clasificaron como moderados en la evaluación general del riesgo de sesgo, mientras que uno se clasificó como grave. En conclusión, los movimientos de intrusión dental con anclaje esquelético en el maxilar causan cambios significativos durante el tratamiento. Mientras tanto, al evaluar la estabilidad de los movimientos de intrusión, se observan cambios milimétricos sin diferencias estadísticas.

Conclusiones: Se necesitan estudios con mayor rigor metodológico, que den seguimiento a la imagen tridimensional del movimiento dentario y que, además, evalúen la cantidad de fuerza y su asociación con la cantidad de recurrencia en el movimiento vertical.

Palabras clave: *Técnicas de movimiento dental; Ortodoncia correctiva; Métodos de anclaje en ortodoncia; Minitornillo de ortodoncia; Microimplante dental; Revisión sistemática*

INTRODUCTION

Skeletal anchorage makes it possible to manage wider discrepancies than the biomechanics of conventional orthodontics because all the force for tooth movement is applied to the bone structure,[1] allowing for a correct leveling of the occlusal plane.[2]

Both conventional orthodontics and skeletal anchorage facilitate a successful treatment.[2] However, movements with skeletal anchorage[3] are considered more effective than conventional orthodontic methods because they allow for greater control of intrusion and distaliza tion movements,[4-6] shorten clinical treatment times, and reduce unwanted movements in neighboring teeth.[7]

Skeletal anchorage requires adequate depth and thickness to achieve primary stability[8] where the use of cone-beam computed tomography (CBCT) provides an accurate evaluation of the bone around the apices.[9] Despite the clinical advantages and the short time of use to generate the movement, caution should be taken with vertical movements because the magnitude of the force and the duration of the intrusion movement can cause root and pulp vitality complications.[10,11]

On the other hand, depending on the amount of movement force, the millimeters of the intrusion, and the time to make the movement, recurrences of the molars can occur after the devices are removed.[12,13] Therefore, monitoring the tooth position during the retention stage is necessary. This review aims to analyze the stability of vertical tooth movements achieved with skeletal anchorage after at least 6 months in the retention phase.

MATERIALS AND METHODS

Design

A systematic review was to the Cochrane Handbook for Systematic Reviews of Interventions and reported according to the update of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[14] to answer the following research question: Is there recurrence of vertical tooth movements performed with skeletal anchorage in adolescents and adults?

PICO

The sample comprised adolescents and adults with malocclusion who underwent tooth movements of intrusion or extrusion using an orthodontic treatment with skeletal anchorage. The millimeters of vertical tooth movement in the pre-treatment and post-treatment stages, at least 6 months after the retention stage, will be compared to measure the stability of the tooth movement (Table 1).

Search strategy

A systematic search was performed in the PubMed, Embase, Scopus, and Lilacs databases from January 2012 to May 2023. The terms used were: "tooth movement," "orthodontic anchorage procedure," "orthodontic anchorage," "orthodontic miniscrew," "orthodontic mini-screw," and "orthodontic mini implant".

Study selection

Two independent investigators (V.R. and L.B.) selected the studies. After applying the search terms, duplicates were eliminated using the Mendeley software (Reference Management, Elsevier, London, England). All the articles were selected using titles and abstracts independently. In case of discrepancy, consensus was obtained by discussion or consultation with a third investigator (S.O). Finally, a full-text selection was carried out by the same investigators (V.R. and L.B.).

Prospective and retrospective studies with no control group that evaluate only one type of intervention with a before-and-after design were included. Publications were in English, Spanish, or Portuguese. Adolescent or adult patients with dental malocclusion were included who received orthodontic treatment using braces with skeletal anchorage after at least 6 months in the retention phase. Studies on animals, using finite elements, on subjects with periodontal disease, procedures on mixed dentition or primary teeth or that presented orthodontic treatment with aligners or lingual orthodontics were excluded.

Data extraction

The data extraction was done by two investigators independently. The following data were collected: author(s) and country of origin; year of publication; study design; data on the study group; specifications of the procedure, software used, recording method, evaluation, and stability of the results.

a) Data on the study group (number of subjects, sex, age, and type of malocclusion);

b) Data on the study (design, level of evidence, and method of analysis);

c) Data on the orthodontics treatment (tooth movement, complementary procedure, follow-up time);

d) Type of data analyzed in the consultation (software use and benchmarks used for the measurement);

e) Type of captures of tooth movement (study models, cone-beam computed tomography (CBCT), and/or intraoral scanner).

2.6 Analysis of bias and study quality

Two observers evaluated the bias risk independently (RoB).

- The non-randomized studies were evaluated using the ROBINS-I tool.[15] The risk of bias was subdivided into 7 categories:

1) Confounding,
2) Selection of participants,
3) Exposure measurement,
4) Post-exposure interventions,
5) Missing data,
6) Measurement of outcomes, and
7) Outcome reporting.

Each category was rated as low, moderate, serious (critical) risk of bias, or no information.

- The quality of the evidence was assessed using the GRADE approach. The criteria evaluated were the study design, the number of studies included, the consistency of their results that evaluated clinical differences, reported bias, heterogeneity, and accuracy in the analysis of the confidence intervals, categorized as very low, medium, and high according to the score.

Figure 1. Flowchart of the selected studies identified and included in the review.

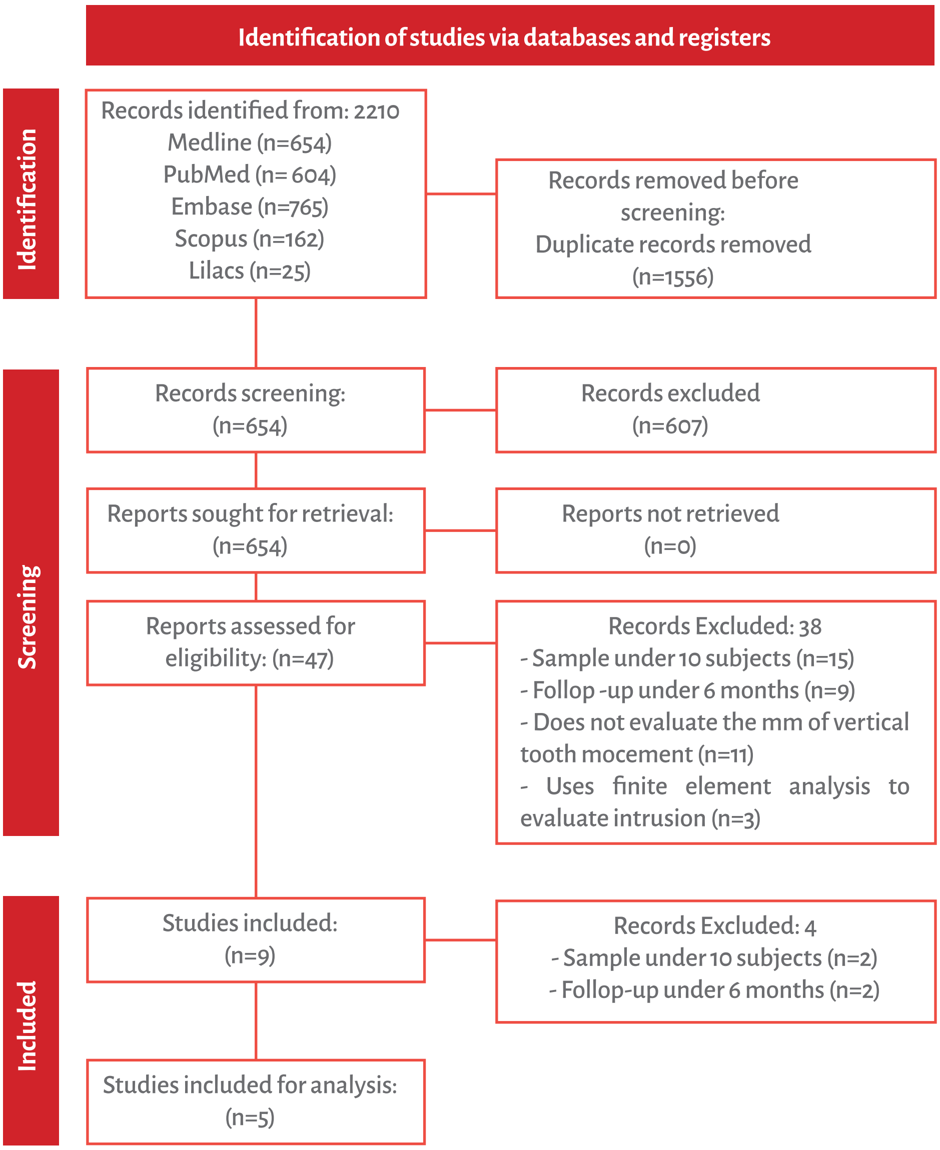


Figure 2. Risk of bias of the included studies as assessed with the ROBINS-I tool.

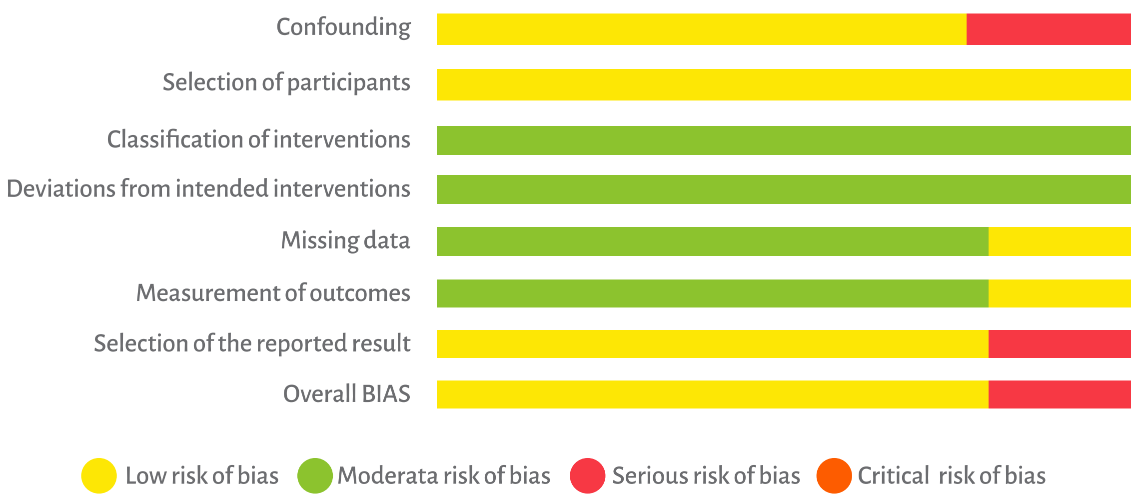
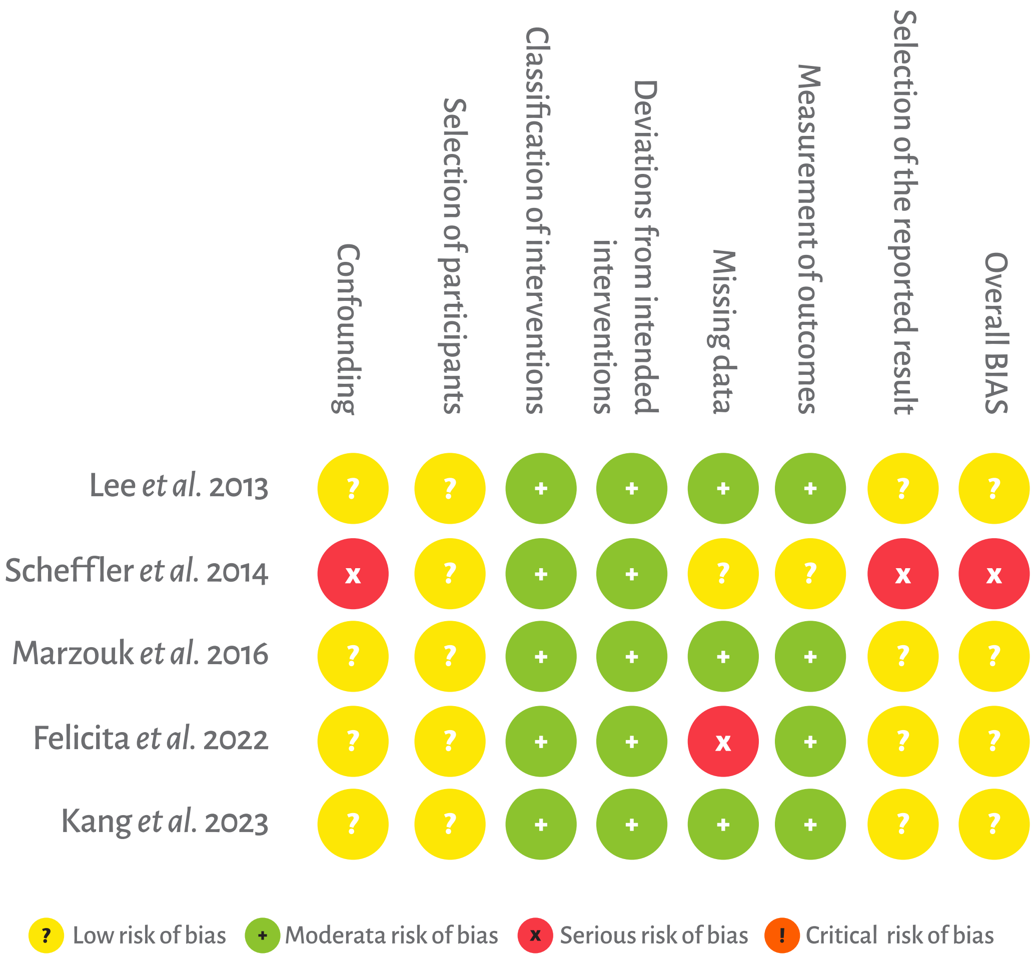


Figure 3. Risk of bias in each domain of the included studies as assessed.



RESULTS

Article selection

The systematic search identified 2210 articles. After excluding 1556 duplicates, 654 articles were selected to review titles and abstracts, which yielded 9 articles for full-text review (Figure 1). All the articles performed intrusion and/or extrusion movements using skeletal anchorage in permanent anterior and/or posterior teeth to achieve a harmonious smile and maximum intercuspation.

Of the 9 articles selected for full-text analysis, 2 were excluded for having a sample size of less than 10 subjects, and 2 studies were excluded for having a retention follow-up of less than 6 months, resulting in a total of 5 articles for the descriptive and methodological analysis.

Characteristics of the studies included

Of the five selected articles (Table 2), all the studies had a prospective design. A total of 114 patients was obtained, ranging in age between 21 and 41 years. The minimum follow-up time was 6 months, and the maximum 48 months.
Table 2 provides the descriptive results of each study included. At the diagnostic stage, two studies presented subjects with anterior open bite,[16,17] one study presented class I subjects with facial hyper divergence,[18] another study diagnosed subjects with gummy smile with lip incompetence to be skeletal class I or class II,[19] and the last study only diagnosed extrusion of extruded upper posterior teeth.[20]

In two studies, upper and lower first premolars were extracted[17,18] in two other studies, ex-tractions were not performed,[16,20] and one study mentions that of a total of 30 subjects, only 18 underwent premolar extraction, but it does not establish whether it was the first or second premolar.[19]

All the studies performed intrusion movements of upper molars and/or premolars. Two studies complemented upper arch intrusion with mandibular molar extrusion,[16,17] whereas Kang *et al.*,[19] aside from performing the intrusion of the upper posterior sector, intrusion of the upper incisors was also performed. Only Lee *et al.*,[20] performed an intrusion of molars and premolars in the maxilla and mandible.

In four studies,[16,18-20] micro-screws (mini-im-. plants) were installed in the vestibular region to perform the movements, whereas Marzouk *et al.*[17] used a miniplate anchored with 3 mini-implants in the zygomatic bone at the level of the first molar. Three studies[16,18,20] performed the installation between the second premolar and the first molar; one study performed the installation between the first and second premolar to be able to intrude the anterior sector and also installed between the second premolar and the first molar to intrude the posterior sector.

Analysis of outcomes

The measurement method was the super-position of images. Scheffler *et al.*,[16] Marzouk *et al.*,[17] and Kang *et al.*,[19] only performed superimposition of images and comparison of cephalometric measurements, whereas Felicita *et al.*,[18] apart from using image su-perimposition and comparison of cephalo-metric measurements, also compared the study models. Only Lee *et al.*,[20] performed a three-dimensional evaluation by superim-posing scanned models, wh ere the mesiodistal, palatal vestibule, and vertical position were evaluated during intrusion (Table 3).

All the studies showed significant changes when performing vertical tooth movements using skeletal anchorage. Lee *et al.*,[20] took 11.9 months to achieve a tooth movement of 1.35±0.48 mm intrusion in upper molars and premolars. For their part, Marzouk *et al.*,[17] took an average of 10 months to perform an intrusion of 3.04±0-79 mm in molars and an extrusion of 2.5 ± 0.11 mm in incisors. During the retention stage, with a follow-up between 6 and 23.3 months, no study showed significant changes in recurrence. On average, recurrence in the posterior sector ranged from a minimum of 0.05±0.07 mm to a maximum of 1±0.18 mm. In comparison, in the anterior sector, the minimum was 0.83±0.92 mm, and the maximum was 0.18±0.03 mm.

Table 1.
Search strategy in relation to P.I.C.O acronyms.

P.I.C.O acronyms	
Patients	Adolescents and adults with malocclusion.
Intervention	Intrusion or extrusion tooth movements trough orthodontic treatment with skeletal anchorage.
Comparison	Millimeters of vertical tooth movements in pre-treatment and post-treatment stages.
Outcomes	Measure the stability of minimum tooth movement 6 months after the retention stage.

Table 2.
Characteristics of the five potential articles related to the objective of the study and included patients.

Author and years	Objective	N	Sex (M/F)	Age (years)	Follow-up (months)
Lee *et al.*[20] 2013	Analyze three dimensional changes in the position of over-eruption posterior teeth using skeletal anchorage to bring to the occlusal plane.	14	2/12	41.9	23.3
Scheffler *et al.*[16] 2014	Evaluate the stability of the instrusion with skeletal anchorage in the retention stage and two years of retention stage.	30	11/19	24.1	36
Marzouk *et al.*[17] 2016	Evaluate molar intrusion stability and overbite correction in adults with anterior open bites using skeletal anchorage.	26	11/15	22.5	48
Felicita *et al.*[18] 2022	Evaluate the magnitude of intrusion in upper posterior teeth of subjects with tendency to hyperdivergence using skeletal anchorage	19	9/10	21	6
Kang *et al.*[19] 2023	Evaluate the stability after total arch intrusion using skeletal anchorage after one year.	30	6/24	23.1	12

N: Number. **F:** Female. **M:** Male.

Table 3.

Descriptive characteristics of the articles included during vertical movement with skeletal anchorage.

Author and year	Study design	Diagnosis	Extractions	Tooth	Localitation movement	Type of of the	Millimeters of the skeletal	Millimeters of movement	Millimeters of movement	Time to make movement T3-T4	Measurement tooth movemente	Software	Follow-up (months)
Lee et al. 2013	Prospective	Overerupted upper molars and premolars	No extractions	Intrusion of molars and/or premolars of both arches	Buccal alveolar ridge between molar and premolar	Mini-implant 1.2 mm diameter and 6 mm length	Intrusion of 1.35 ± 0.48	Recurrence of 0.03 ± 0.19	ND	11.9 months	Superposition with intra oral scanner	3Txer (Orapix, Seoul, Korea)	23.3
Scheffler et al. 2014	Prospective	Subjects with anterior open bite (2.2 ± 1.6 mm)	No extractions	Intrusion of maxillary molars and extrusion of mandibular molars	Betweent he second molar and first molar	Micro-screw 1.4 mm diameter and 8 mm long	Upper molar intrusion of 2.3 ±1.4 and lower molar extrusion of 0.6 ± 1.6	Upper molar recurrence of 0.5 ± 1.1 and lower molar recurrence of 0.6 mm ± 1.3	Upper molar recurrence of 0.5 ± 1.2 and lower molar recurrence of 0.3 mm ±1.3	ND	Superposition with lateral teleradiography	ND	36
Marzouk et al. 2016	Prospective	Subjects with anterior open bite (3 a 8 mm)	Upper and lower first premolars	Intrusion of upper molars and premolars and extrusion of lower molars	Zygomatic bone at the level of the first molar	7 mm long mini-implant to hold the mini-plate	Molar intrusion of 3.04 ± 0.79 and incisor extrusion of 2.5 ± 0.11	Molar recurrence of 0.31 ± 0.07 and incisor recurrence of 0.18 ± 0.03	Molar recurrence of 0.10 ±2.04 and incisor recurrence of 0.61 ± 0.17	10 months	Superposition with lateral teleradiography	ND	48
Felicita et al. 2022	Prospective	Skeletal class I individuals with a tendency to hyper-divergence	Upper and lower first premolars	Intrusion of upper posterior teeth	It was installed at the level of the gingival mucosa between the second premolar and the first molar	Mini-implant 1.2 mm diameter and 8 mm long	Molar intrusion of 1.47 ± 0.8	Molar recurrence 1 ± 0.18	ND	ND	Superposition Lateral radiography and study models	ND	6

Author and year	Study design	Diagnosis	Extractions	Tooth	location movement	Type of of the	Millimeters of the skeletal	Millimeters of movement	Millimeters of movement	Time to make movement T3-T4	Measurement tooth movement	Software	Follow-up (months)
Kang et al. 2023	Prospective	individuals with an elongated face, a gummy smile or lip incompe-tence who presented skeletal class I or class II	Mentions that 18 patients underwent premolar extraction, but does not define whether it is the first or the second	Intrusion of molars and upper incisors	Between the first and sec-ond pre-molar, and between the second premolar and first molar	Mini-screw 1.8 mm diameter and 7 mm long	Intrusion of upper molars of 2.30 ± 1.29 and upper incisors of 2.04 ± 1.66	Recurrence of 0.33 ±1.5 in the molars, and 0.83 ± 0.92 in the incisors	ND	ND	Superposition with lateral teleradio-graphy	Picture Archiving Communi-cation SySTEM (PACS)	12

T1: After the movement. **T2:** 6-month control in the retentive stage. **T3:** Second control in retentive stage. **T4:** Third control in retentive stage. **ND:** not described.

Only two studies had follow-up longer than 24 months. Scheffler *et al.*,[16] had a 36-month post-retention follow-up observing a recurrence of 0.5±1.2 in upper molars and 0.61±0.17 in lower molars. For their part, Marzouk *et al.*,[17] observed a recurrence of 0.10 ± 2.04 mm in molars and 0.61±0.17 in incisors at 36 months. Still, when performing the control on molars and the anterior sector at 48 months, no clinical changes were observed in relation to vertical tooth movements.

Risk of bias

The 5 selected articles were evaluated with the ROBINS-I tool (Figure 2). In confounding bias and selection of reported outcomes, 4 studies had a moderate score, and one had a serious score because it did not mention prior calibration methods or blinding of the investigator per-forming the measurements. In terms of parti-cipant selection, all the studies presented a moderate bias since it was by convenience, and they did not use blinding techniques to correct the presence of selection bias.

In relation to the classification of the interven-tion and the deviation from the interventions, all presented a low risk since they all mana-ged to achieve their treatment objectives, and no study mentioned changing the treatment protocol or that there was a loss of subjects during the orthodontic treatment. In the item measurement of outcomes and lack of data, only one study presented a moderate risk because some subjects already treated dropped out of the retention controls and could not be followed up; the remaining studies presented a low risk. In the evaluation of the general risk of bias, four studies were classified as moderate because they showed at least low or moderate bias in all the domains.

In contrast, one study had a serious risk of bias for presenting a serious level of proficiency, but with no critical risk in any of its domains. (Figure 3).

DISCUSSION

In this review, we observed heterogeneity regarding the diagnoses, as 4 studies included subjects with vertical skeletal problems (anterior open bite, facial hyperdivergence, gingival smile with lip incompetence), while 1 study only diagnosed extrusion of extruded upper posterior teeth. Such differences in diagnosis may have an effect on the stability of the movements.

Intrusion is a complex movement in orthodontics. Consequently, accessory devices are needed. In this review, the articles selected used different elements to produce the intrusion mechanics. Four of the five selected papers used microscrews as the anchoring mechanism.[16,18,19,20]

By contrast, Marzouk *et al.*,[17] were the only ones to use miniplates. First, stability is an important factor when selecting the system for this type of mechanics. Mattos *et al.*,[21] concluded that the most significant risk factor associated with stability is related to the type of device selected, with mini-implants being particularly susceptible to becoming dislodged. On the other hand, in a study of finite elements, Somaskandhan *et al.*,[22] showed that the distribution of forces is considerably more uniform in miniplates; nevertheless, mi-croscrews were particularly favorable when subjected to a vertical force. In this context, both devices present good characteristics for the intrusion movement for which they were selected.

In terms of anchor stability, another important parameter is position. Pan *et al.*,[23] and Erbay *et al.*,[24] noted the effects of the cortical bone thickness on primary stability, observing a proportionally direct relation between the two. Tepedino *et al.*,[25] evaluated the cortical bone thickness in the interradicular area, concluding that the best area for inserting a microscrew in the maxilla is in the space between the first molar and the second premolar. Lee *et al.*,[20] Felicita *et al.*,[18] and Kang *et al.*,[19] positioned the mini-implants in the region of greatest stability; however, Scheffler *et al.*,[16] positioned the mini-implants in a region with less bone availability. Although the treatments performed in the selected studies are long-term, none of them assess the loss of mini-implants or the protocol followed in cases of loss of stability. This information could be fundamental when choosing the most suitable mechanics to perform the intrusion and could also be related to the final stability of the treatment and outcomes achieved.

Another important parameter for selecting the position of an anchor device is the mechanics to be performed. A study of finite elements by Jeong *et al.*,[26] analyzes the position of the center of resistance of the maxilla in different clinical situations, locating the center of resistance for block movements approximately at the level of the cervical third of the root of the second premolar.

Kang *et al.*,[19] used two microscrews per side, one mesial and another distal to the center of resistance, at a relatively similar distance. In contrast, all the other authors used a single device placed distally from the center of resistance at a greater or lesser distance from it. The results obtained by Kang *et al.*,[19] show similar intrusion values in molars and incisors, whereas the values obtained by Scheffler *et al.*,[16] Marzouk *et al.*,[17] Felicita *et* *al.,*[18] had wider variability. Scheffler *et al.,*[16] and Marzouk *et al.,*[17] achieved intrusion of the molars and extrusion of the incisors; Felicita *et al.,*[18] obtained greater in-trusion values in molars and lower in incisors. This confirms the results by Jeong *et al.,*[26] re-garding the center of resistance, noting that, for full arch intrusions, the application of force is needed close to the center of resistance, while for intrusion of the posterior region and extrusion or maintenance of the anterior re-gion, the use of a force distal to the center of resistance of the maxilla is preferable.

Kawamura *et al.,*[27] analyzed intrusion move-ment using the finite element method and observed a strong tendency for molars and premolars to tilt vestibularly during move-ment and the need for accessory mechanics to avoid this effect. In the selected studies, various methods were used to this end.

Felicita *et al.,*[18] used a transpalatal bar; Kang *et al.,*[19] used a 0.016x0.022 arch in a 0.018 slot; Marzouk *et al.,*[17] used a double transpalatal bar in molars and premolars; Scheffler *et al.,*[16] used a transpalatal bar with an acrylic shank in molars and a rectangular arch; and finally, Lee *et al.,*[20] did not use any extra method, but, subsequent to the intrusion used 0.019x0.025 rectangular steel arches to correct the torque. With the exception of the study by Lee *et al.,*[20] none of the selected studies presented an as-sessment of this undesirable effect or how it might relate to the total amount of intrusion and final stability of the treatment.

The amount of intrusion movement is a pa-rameter that depends on the individual objec-tives of each treatment, where it can be complemented by rotational and/or inclina-tion movements. In our study, only the vertical movement performed was analyzed, regard-less of any complementary movements.

However, it is interesting to assess the corre-lation between the amount of intrusion and the recurrence rate.

Of the analyzed studies, the only one with this assessment is by Marzouk *et al.,*[17] who observed a significant positive correlation between the severity of the initial condition of the molars and the open bite with the recurrence rate. In addition, they observed that greater movements were strongly associated with higher recurrence rates.

Due to the shape of the maxilla and its sagittal visualization on lateral cephalometric radio-graphy, the distance between the palatal plane and a tooth can be modified by both intrusion and mesialization/distalization. The previous studies do not evaluate this parame-ter to contrast it with the amount of effective intrusion. Another important parameter that should be analyzed in intrusion studies that include extraction treatments is the amount of mesialization and other measurements that explain how this movement influences the final amount of intrusion. Tooth inclination (tip back/forward) can influence the millimeters of intrusion in the posterior region. In the studies by Marzouk *et al.,*[17] and Felicita *et al.,*[18] the angle between the tooth and the palatal plane was used as a reference to analyze this parameter.

Lee *et al.,*[20] examined intrusion at each molar cusp for the same purpose. However, Kang *et al.,*[19] and Scheffler *et al.,*[16] did not include any values to measure this parameter, making it impossible to determine the actual degree of intrusion/inclination. In this regard, Felicita *et al.,*[18] used the distance between the center of resistance of molars, premolars, and/or incisors and the palatal plane as a me-asurement parameter. However, this does not take into account that the location of a tooth's center of resistance is influenced by the size of its root.

The literature mentions that various degrees of complications in the root tissues may be associated with the applied force and the type of intrusion movement when performed in isolation or in combination with other movements.[28,29] This study endeavors to verify the stability of the intrusion movement, and as such, we consider it important to establish which mechanisms were used to maintain the outcomes achieved clinically by each of the authors. From this point of view, it would be interesting to analyze the impact of this phase of treatment on the final stability and recurrence. Although all the studies performed some follow-up, only two studies defined the method of containment used. Marzouk *et al.*,[17] used a Hawley plate, and Scheffler *et al.*,[16] used immediate acetate containment and then a Hawley plate at night while maintaining the use of elastics from the plate to the microscrews bilaterally for 6 months. This is consistent with previous studies, which show that a large percentage of the recurrence occurs during the first few months post-treatment.

The selected studies performed an analysis at different moments and times, which makes them difficult to compare. In the study by Lee *et al.*,[20] restorations were made on the antagonist tooth at the end of the intrusion to restore the contact points, which provided correct stability with minor recurrence. Marzouk *et al.*,[17] had the greatest containment/control time, obtaining recurrence values of approximately 0.5 mm for intrusion movements of molars, similar to the values obtained by Kang *et al.*,[19] in the molar area.
However, the latter obtained considerably higher recurrence values in incisors (approximately 0.9 mm), which can be attributed to the greater tooth contact surface in molars. Although Scheffler *et al.*,[16] had the strictest containment protocol, they also reported the greatest recurrence (from 0.5 to 1.5 mm) as well as the greatest magnitude of force in the movement.

Although the intrusion movement shows an acceptable level of stability, these results must be analyzed carefully due to the short post-treatment control time of most of the studies and the lack of analysis of the containment type/time used. Since some of the analyzed studies use 2D studies or plaster models, it is necessary to conduct future studies with 3D analysis of the effects of intrusion in CBCT related to stability in order to obtain more precise information on the characteristics of the movement and its long-term effects.

CONCLUSION

In conclusion, greater vertical position changes can be achieved in the maxilla in a shorter time compared to the mandible. Meanwhile, when evaluating the stability of vertical movements at 6, 12, 24, and 36 months after the retention phase, no clinical changes are observed. Studies with greater methodological rigor are needed, which follow up with three-dimensional imaging of tooth movement and evaluate the amount of force and its association with the amount of recurrence in vertical movement.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

ETHICS APPROVAL

Does not apply

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AUTHORS' CONTRIBUTIONS

Víctor Ravelo: Methodology, Validation, Investigation, Resources, Data curation, Writing, Original draft preparation.
Gonzalo Muñoz: Validation, Investigation, Resources, Writing, Review and editing, Visualization.
Leonardo Brito: Validation, Investigation, Resources, Data curation, Writing, Review and editing, Visualization.
Sergio Olate: Conceptualization, Validation, Investigation, Resources, Writing, Original draft preparation, Visualization.
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REFERENCES

1. Leung MT, Lee TC, Rabie AB, Wong RW. Use of miniscrews and miniplates in orthodontics. J Oral Maxillofac Surg. 2008;66(7):1461-6. https://doi.org/10.1016/j.joms.2007.12.029. PMID: 18571031.
2. Manea A, Dinu C, Băciuţ M, Buduru S, Almășan O. Intrusion of Maxillary Posterior Teeth by Skeletal Anchorage: A Systematic Review and Case Report with Thin Alveolar Biotype. J Clin Med. 2022;11(13):3787. https://doi.org/10.3390/jcm11133787. PMID: 35807072; PMCID: PMC9267289.
3. Grec RH, Janson G, Branco NC, Moura-Grec PG, Patel MP, Castanha Henriques JF. Intraoral distalizer effects with conventional and skeletal anchorage: a meta-analysis. Am J Orthod Dentofacial Orthop. 2013;143(5):602-15. https://doi.org/10.1016/j.ajodo.2012.11.024. PMID: 23631962.
4. Antoszewska-Smith J, Sarul M, Łyczek J, Konopka T, Kawala B. Effectiveness of orthodontic miniscrew implants in anchorage reinforcement during en-masse retraction: A systematic review and meta-analysis. Am J Orthod Dentofacial Orthop. 2017;151(3):440-455. https://doi.org/10.1016/j.ajodo.2016.08.029. PMID: 28257728.
5. Alshammery D, Alqhtani N, Alajmi A, Dagriri L, Alrukban N, Alshahrani R, et al. Non-surgical correction of gummy smile using temporary skeletal mini-screw anchorage devices: A systematic review. J Clin Exp Dent. 2021;13(7):717-23. https://doi.org/10.4317/jced.58242.
6. Bayome M, Park JH, Bay C, Kook YA. Distalization of maxillary molars using temporary skeletal anchorage devices: A systematic review and meta-analysis. Orthod Craniofac Res. 2021;24(1):103-12. https://doi.org/10.1111/ocr.12470
7. Park HM, Kim BH, Yang IH, Baek SH. Preliminary three-dimensional analysis of tooth movement and arch dimension change of the maxillary dentition in Class II division 1 malocclusion treated with first premolar extraction: conventional anchorage vs. mini-implant anchorage. Korean J Orthod. 2012 ;42(6):280-90. https://doi.org/10.4041/kjod.2012.42.6.280.
8. Chang HP, Tseng YC. Miniscrew implant applications in contemporary orthodontics. Kaohsiung J Med Sci. 2014;30(3):111-5. https://doi.org/10.1016/j.kjms.2013.11.002.
9. Hodges RJ, Atchison KA, White SC. Impact of cone-beam computed tomography on orthodontic diagnosis and treatment planning. Am J Orthod Dentofacial Orthop. 2013;143(5):665-74. https://doi.org/10.1016/j.ajodo.2012.12.011.
10. .Deguchi T, Murakami T, Kuroda S, Yabuuchi T, Kamioka H, Takano-Yamamoto T. Comparison of the intrusion effects on the maxillary incisors between implant anchorage and J-hook headgear. Am J Orthod Dentofacial Orthop. 2008;133(5):654-60. https://doi.org/10.1016/j.ajodo.2006.04.047
11. Aras I, Tuncer AV. Comparison of anterior and posterior mini-implant-assisted maxillary incisor intrusion: Root resorption and treatment efficiency. Angle Orthod. 2016; 86(5): 746-52. https://doi.org/10.2319/085015-571.1
12. Baek MS, Choi YJ, Yu HS, Lee KJ, Kwak J, Park YC. Long-term stability of anterior open-bite treatment by intrusion of maxillary posterior teeth. Am J Orthod Dentofacial Orthop. 2010;138(4):396-9. https://doi.org/10.1016/j.ajodo.2010.04.023
13. Kang DO, Yu HS, Choi SH, Kim ST, Jung HD, Lee KJ. Stability of vertical dimension following total arch intrusion. BMC Oral Health. 2023;23(1):164. https://doi.org/10.1186/s12903-023-02842-1
14. Page M J, McKenzie J E, Bossuyt P M, Boutron I, Hoffmann T C, Mulrow C D et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021; 372:71. https://doi.org/10.1136/bmj.n71
15. Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ. 2016; 355 :4919. https://doi.org/10.1136/bmj.i4919.
16. Scheffler NR, Proffit WR, Phillips C. Outcomes and stability in patients with anterior open bite and long anterior face height treated with temporary anchorage devices and a maxillary intrusion splint. Am J Orthod Dentofacial Orthop. 2014;146(5):594-602. https://doi.org/10.1016/j.ajodo.2014.07.020.
17. Marzouk ES, Kassem HE. Evaluation of long-term stability of skeletal anterior open bite correction in adults treated with maxillary posterior segment intrusion using zygomatic miniplates. Am J Orthod Dentofacial Orthop. 2016;150(1):78-88. https://doi.org/10.1016/j.ajodo.2015.12.014
18. Felicita AS, Wahab TU. Intrusion of the maxillary posterior teeth with a single buccal mini-implant positioned bilaterally in young adults with a tendency towards hyperdivergence: A clinical study. J Orthod. 2022;49(3):338-346. https://doi.org/10.1177/14653125211071094.

19. Kang DO, Yu HS, Choi SH, Kim ST, Jung HD, Lee KJ. Stability of vertical dimension following total arch intrusion. BMC Oral Health. 2023;23(1):164. https://doi.org/10.1186/s12903-023-02842-1
20. Lee SJ, Jang SY, Chun YS, Lim WH. Three-dimensional analysis of tooth movement after intrusion of a supraerupted molar using a mini-implant with partial-fixed orthodontic appliances. Angle Orthod. 2013;83(2):274-9. https://doi.org/10.2319/060912-480.1
21. Mattos PM, Gonçalves FM, Basso IB, Zeigelboim BS, Niwa MF, Stechman-Neto J, et al. Risk factors associated with the stability of mini-implants and mini-plates: systematic review and meta-analysis. Clin Oral Investig. 2022;26(1):65-82. https://doi.org/10.1007/s00784-021-04212-z
22. Somaskandhan A, Kumar NMV, Vijayalakshmi RD. Stress distribution and displacement in the maxillofacial complex during intrusion and distalization of the maxillary arch using miniplates versus mini-implants: a 3-dimensional finite element study. Prog Orthod. 2023;24(1):8. https://doi.org/10.1186/s40510-023-00455-6
23. Pan CY, Liu PH, Tseng YC, Chou ST, Wu CY, Chang HP. Effects of cortical bone thickness and trabecular bone density on primary stability of orthodontic mini-implants. J Dent Sci. 2019;14(4):383-388. https://doi.org/10.1016/j.jds.2019.06.002
24. Erbay Elibol FK, Oflaz E, Buğra E, Orhan M, Demir T. Effect of cortical bone thickness and density on pullout strength of mini-implants: An experimental study. Am J Orthod Dentofacial Orthop. 2020;157(2):178-85. https://doi.org/10.1016/j.ajodo.2019.02.020.
25. Tepedino M, Cattaneo PM, Niu X, Cornelis MA. Interradicular sites and cortical bone thickness for miniscrew insertion: A systematic review with meta-analysis. Am J Orthod Dentofacial Orthop. 2020; 158(6): 783-98. https://doi.org/10.1016/j.ajodo.2020.05.011
26. Jeong GM, Sung SJ, Lee KJ, Chun YS, Mo SS. Finite-element investigation of the center of resistance of the maxillary dentition. Korean Journal of Orthodontics. 2009; 39(2):83-94. https://doi.org/10.4041/kjod.2009.39.2.83
27. Kawamura J, Park JH, Tamaya N, Oh JH, Chae JM. Biomechanical analysis of the maxillary molar intrusion: A finite element study. Am J Orthod Dentofacial Orthop. 2022;161(6):775-82. https://doi.org/10.1016/j.ajodo.2020.12.028.
28. Akl HE, El-Beialy AR, El-Ghafour MA, Abouelezz AM, El Sharaby FA. Root resorption associated with maxillary buccal segment intrusion using variable force magnitudes. Angle Orthod. 2021; 91(6):733-42. https://doi.org/10.2319/012121-62.1
29. Bellini-Pereira SA, Almeida J, Aliaga-Del Castillo A, Dos Santos CCO, Henriques JFC, Janson G. Evaluation of root resorption following orthodontic intrusion: a systematic review and meta-analysis. Eur J Orthod. 2021;43(4):432-41. https://doi.org/10.1093/ejo/cjaa054