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Tooth movement with dental anchorage vs. skeletal anchorage: A systematic review of clinical trials

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Abstract

The aim of this study is to compare the time and movement of orthodontic treatment using dental anchorage and skeletal anchorage in adolescent and adult patients with dental malocclusions. A systematic search was conducted in the Embase, PubMed, Lilacs, Cochrane, Trip, and Scopus databases up to October 2022. All the articles were selected using title and abstract, applying the inclusion and exclusion criteria. Disagreements were resolved with a third author. Finally, a full-text selection took place. The data extraction was conducted by two authors who independently evaluated the risk of bias. The methodological quality of the randomized clinical trials was evaluated using the Cochrane tool for the evaluation of the randomized clinical trials. Six articles were included in the data analysis. There were four clinical trials and two randomized clinical trials. A total of 176 patients was obtained with an age range between 14 and 46 years. Four studies showed significant differences when comparing the two anchorages in retraction or distalization of tooth groups, and two showed no differences when using dental and skeletal anchorage for vertical movements; only the articles with vertical movements showed relapse. We can conclude that skeletal anchorage generates precise and stable horizontal movements without overloading or changing the position of the molar. Future studies must incorporate three-dimensional technology for greater clinical accuracy.

Keywords:
Dental anchorage, dental movement, skeletal anchorage

Introduction

Orthodontics movements combine physiological adaptation and mechanical stresses through coordinated and efficient bone remodeling.[1] In this sense, the trend is to find methods to increase dental movement in a lower time of treatment; however, most of the techniques have some doubts about the technique and results.[2]

The arch and braces could not be related to dental root conditions during orthodontic treatment, with the main disadvantage being the excess of force in the tooth movement over a long time, which could create problems as root resorptions.[3] Hence, it is necessary to take pauses in the movement to reduce the risk of root resorption and to take time for the root cement repair.[4]

Skeletal anchorages are temporary and auxiliary fixation systems used to put specific and efficient force on alignments, intrusions or extrusions, molar distalizations, and protractions without generating undesired movements in other teeth.[5,6] This device anchored to bone tissue requires adequate depth and thickness of bone tissue to achieve primary stability[7]; hence, 80% of the stability problems with skeletal anchorages can be observed within the first 4 months.[8] Skeletal anchorage is considered

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a failure when it presents mobility, inflammation, or infection at the installation site.[9]

Both dental anchorage and skeletal anchorage are considered effective in performing teeth alignment.[10] Skeletal anchorage does not use teeth to move another group of teeth and is associated with a decrease in dentoalveolar inclinations.[11]

The aim of this research is to compare the time and movement of orthodontic treatment using dental anchorage and skeletal anchorage in adolescent and adult patients with dental malocclusions.

Materials and Methods

Design

A systematic review was performed according to the Cochrane Handbook for Systematic Reviews of Interventions. It was reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)[11] to respond to the following research question: Are there any differences in time and tooth movement when using orthodontics with dental anchorage versus orthodontics with skeletal anchorage in patients with malocclusion?

PICOS

The sample was composed of patients with malocclusion to which a tooth movement was performed using fixed orthodontics with dental and skeletal anchorage. Horizontal and vertical tooth movements as well as the time required to complete the movement, were assessed.

Search strategy

A systematic search was performed in the Embase, PubMed, Lilacs, Cochrane, Trip, and Scopus databases from 1945 (since the first article that refers to performing a tooth movement with bone anchorage was published in that year) to October 2022.

The following search strategy was used: (((((malocclusion[MeSH Terms]) OR (malocclusion, angle class i[MeSH Terms]) OR (malocclusion, angle class iii[MeSH Terms])) OR (malocclusion, angle class ii[MeSH Terms])) AND (((((tooth movements[MeSH Terms]) OR (tooth mobilities[MeSH Terms])) OR (dental movement)) OR (orthodontic dental movement)) OR (dental movement orthodontics))) AND ((conventional orthodontics) OR (orthodontics brackets))) AND ((((((((orthodontic anchorage) OR (implants orthodontic anchorage)) OR (orthodontic anchorage procedures)) OR (orthodontic miniscrew)) OR (orthodontic mini-screw)) OR (orthodontic mini implants)) OR (orthodontic mini-implants)) OR (orthodontic implant site))

Study selection

The titles and abstracts were selected independently by two investigators (V.R. and L.B.) to verify their eligibility. In case of discrepancy, consensus was reached by discussion or consultation with a third reviewer (S.O.). The references that seemed to fulfill the inclusion criteria were reviewed in full text by the same reviewers (V.R. and L.B.).

Studies were included based on adolescent or adult patients with the presence of a dental malocclusion that compared the time and tooth movement in orthodontic treatment using fixed braces with dental anchorage and skeletal anchorage. Publications in English, Spanish, and Portuguese were included.

Studies on animals, subjects with periodontal disease, or who had orthodontic treatment with aligners or lingual orthodontics were excluded.

Data extraction

Two reviewers extracted the data and evaluated the methodological quality of the studies by means of a predefined and standardized data form. A pilot test was used to ensure the homogeneity of the criteria between the reviewers. The reviewers were not blinded to the authors or journals.

a. Study group data (number of patients, sex, age, and type of malocclusion)
b. Study data (follow-up period, prospective or retrospective nature of the study, level of evidence, and method of analysis);
c. Orthodontic treatment data (type of technique used, tooth movement, complementary procedure, required time to achieve the movement).
d. Type of data analyzed in the consultation (use of software and references used in the studies);
e. Type of capture of the tooth movement (lateral teleradiography, computed tomography (CT), cone-beam computed tomography (CBTC), intraoral scanner, and the software used in the analysis).

The methodological quality of the randomized clinical trials was evaluated with the Cochrane tool for assessing the risk of bias with the following criteria: (1) random sequence generation; (2) concealed allocation; (3) blinding of participants and personnel; (4) blinding of the evaluators; (5) data on incomplete results, selective reporting of results, and other potential sources of bias. The extracted information is classified as “high risk,” “moderate risk,” or “low risk.”

Results

Selection of articles

Using a systematic search, 259 articles were identified, of which 81 duplicates were excluded. One hundred seventy-eight articles were selected for review of title and abstract, of which 172 articles were excluded for not fulfilling the inclusion criteria. Six potentially relevant articles remained for full-text review [Figure 1]. All the articles included an analysis of the tooth position at the beginning and end of the orthodontic treatment. Several articles evaluated the type of anchorage used to perform the tooth movement and the time in which the orthodontic treatment was achieved.

Characteristics of the studies included

Six articles were included to perform the analysis [Table 1]. There were four clinical trials and two randomized clinical trials. A total of 176 patients was obtained, with an age range between 14 and 46 years. The minimum follow-up time was 5 months and the maximum 24 months.

Table 2 shows the descriptive results of the studies included. In the orthodontic pretreatment diagnosis, there was a greater prevalence of Angle's class II malocclusion,[12-15] followed by patients with an open bite.[13] In three studies, upper first premolars and lower second molars were extracted[12,13,14] and in two studies, only extractions of upper first premolars were carried out.[15,16] In five studies, the first molar was used as a method of dental anchorage to make retractions in the anterior sector, and in one study, dental anchorage was performed in the lower incisors and canines to make the intrusion.[17] In four studies, skeletal anchorage was performed vestibularly between the second premolar and the first molar to generate movement in the anterior sector.[12-15] In one study, a skeletal anchorage was performed by the vestibular canine and mandibular lateral incisor to produce intrusion of the anterior sector, and in another study, palatal anchorage was performed to stabilize the upper first molar, and this did not shift with traction of the anterior sector. All the studies used a 2D image overlay at the beginning and end of the

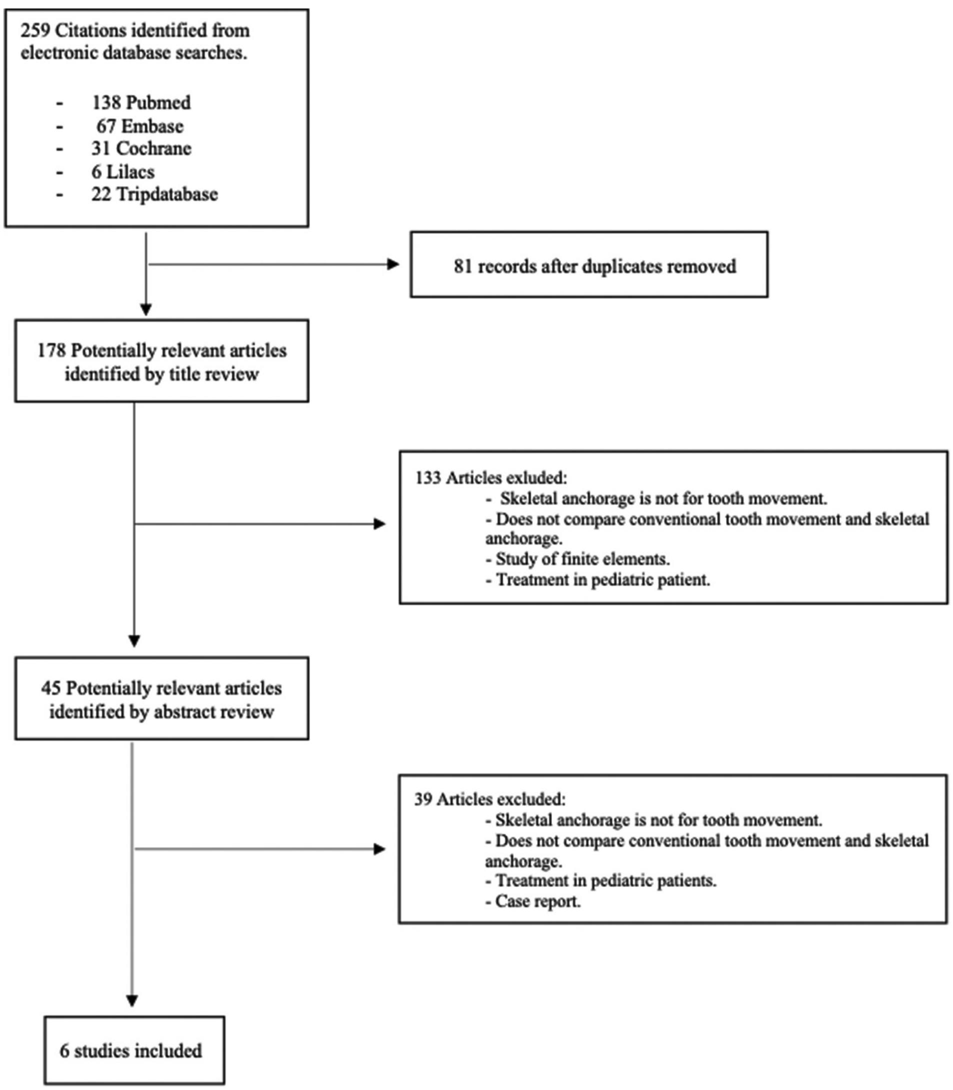

Figure 1: Flowchart of selected studies

Table 1: Characteristics of six potential articles related to the aim of the study and patients included

Author and year	Objective	*N*	Sex (M/F)	Age (years)	Follow-up (months)
Thiruvenkatachari *et al*. 2008[12]	To measure the amount of canine retraction and to compare the retraction using bone anchorage and dental anchorage.	12	4-8	16-22	6
Deguchi *et al*., 2011[13]	To evaluate the skeletal and occlusal features when using anchored orthodontics with microimplants and conventional orthodontics with skeletal open bite.	30	0-30	18 to 46	24
Aydogdu & Ozsoy, 2011[17]	To compare dentofacial effects of intrusion using mini-implants and conventional orthodontics.	26	6-20	16.3	5
Borsos *et al*., 2012[16]	To compare the skeletal anchorage at palatal level with a conventional dental anchorage in the maxilla.	30	13-17	14.4	33
Park *et al*., 2012[14]	To compare the effect of dental movement by means of dental anchorage and tooth movement with mini-implants in the maxilla.	22	ND	>14	9,8
Al-Sibaie & Hajeer, 2014[15]	To compare results of tooth retraction treatments of anterior teeth using mini-implants and conventional dental anchorage	56	21-35	22.34	16,9

N: Number; F: Female; M: Male; ND: Not described

treatment. Park *et al*.[14] incorporated an overlay of digital models to evaluate the change in tooth position, whereas Borsos *et al*.[16] compared the study models in plaster at the beginning and end of the tooth movement.

Presentation and analysis of results

Table 3 shows the analysis, the methodology, and the results obtained. Thiruvenkatachari *et al*.[12] used a microscrew in the mandible and maxilla to carry out the retraction of canines and incisors. The tooth movement using the skeletal anchorage was 0.6 mm greater in the maxilla and 0.35 mm in the mandible, with a time of 0.12 mm per month in the maxilla and 0.07 mm per month in the mandible; a significant correlation was found when the two were compared and complete space closure at 5 months. Park *et al*.[14] and Al-Sibaie and Hajeer[15] compared molar anchorage and skeletal anchorage between the first molar and the second premolar of the maxilla to create a distalization of the anterior sector; in both, they found significant changes when the stability of the position of the first molar was assessed during retraction of the anterior sector. In both studies, the dental anchorage produced a mesialization between 1.4 and 1.5 mm of the first molar, whereas for the skeletal anchorage, the first molar movement was between 0.4 and 0.8 mm. The study by Thiruvenkatachari *et al*.,[12] Park *et al*.[14] and Al-Sibaie and Hajeer,[15] the skeletal anchorage occurred in less time than the dental anchorage, but in both treatments, space closure was achieved. Borsos *et al*.[16] compared the position stability of the upper first molar when performing the canine retraction, observing that the palatal anchorage reduced the time and side effects of the position of the first molar when retracting the canines and incisors.

Deguchi *et al*.[13] evaluated bite closure using dental anchorage and skeletal anchorage. No significant differences were noted in either treatment since similar results were obtained; furthermore, both treatments presented subjects with relapse within a period of 24 months.

Of all the studies, only the one by Park *et al*.[14] used an overlay of 3D models to assess the change in tooth position using both treatments, observing that the use of skeletal anchorage allows for greater retraction (Central incisor 1.6 mm; Lateral incisor 0.9 mm) and greater intrusion (Central incisor: 1.3 mm; Canine: 0.6 mm) in the upper anterior sector, as well as less mesialization of the second premolar (0.5 mm) and upper first molar (0.4) in a range of 8.6 months.

Risk of bias

The evaluation of the risk of bias in the studies included is reported in Figure 2. Of the six trials, four used probability sampling by convenience to form the intervention groups, presenting a selection risk since the initial sample and the treatment sample were not randomized, nor was the allocation concealed, and they were therefore classified as weak. Only one study was classified as strong because it was a randomized clinical trial that randomized its sample to generate the intervention groups and concealed the allocation and the intervention from those performing the procedure, which is why the only information that is managed for all the investigators were the results obtained when finalizing the clinical treatment. Most of the studies used objective measures based on the overlay of anatomical points to evaluate tooth movements, being classified as strong in the measurements. In terms of information bias, only two studies used 2D imaging to evaluate the shifts, which is why they were classified as moderate; they did not use study models or three-dimensional images to evaluate the movement in every direction. In general, one study was classified as strong, one as moderate, and four studies as weak because they had at least two domains classified as weak due to the high risk they presented.

Discussion

The mechanics used in dental anchorage are safe and accurate in tooth movements that require a slight to moderate anchorage, but when a strong anchorage

Table 2: Characteristics of the articles included (6 articles) that reported tooth movement with dental and skeletal anchorage

Author and year	Study design	Quality of study	Diagnosis	Premolar extractions	Anchorage used (case/control)	Location of the anchorage (case/control)	Tooth movement dental anchorage	Tooth movement skeletal anchorage	Time to make tooth movement (case/control)	Measurement
Thiruvenkatachari *et al.*, 2008[12]	Clinical trial	Low	CI and CII malocclusion	Upper and lower first premolar	Tube and springs in maxillary and mandibular molar/titanium micro-implant 1.2 mm in diameter and 9 mm long	Anchorage maxillary and mandibular first molar/vestibular microscrew between the roots of the first molar and second premolar of the upper and lower arches	Distal movement of canine 3.79 mm maxillary/3.75 mm mandibular	Distal movement of canine 4.29 mm maxillary/4.10 mm mandibular	Molar anchorage was 0.81 mm per month in maxilla, and 0.76 mm in mandible/skeletal anchorage was 0.93 mm per month in maxilla and 0.83 mm in mandible	2D x-ray overlay
Deguchi *et al.*, 2011[13]	Clinical trial	Low	CI and CII malocclusion with open bite	Upper and lower first premolar	Metal braces, elastics, and traction harness/microscrew 1.3 mm in diameter and 6-8 mm long	Dental anchorage in molars and anterior sector/microscrew between the roots of the second premolar and the first molar	1.5 extrusion in upper molars/3.5 extrusion in upper incisors and 1.8 in lower incisors.	2.3 intrusion in upper molars and 0.8 in lower molars/1 mm extrusion in upper incisors and 0.3 in lower incisors.	Does not describe the specific duration for each treatment, only an average value of 7 to 9 months.	2D radiography overlay
Aydogdu & Ozsoy, 2011[17]	Randomized clinical trial	moderate	Deep bite of 5 mm or more	ND	Metal braces and utilitarian arch/microscrews 1.2 mm in diameter and 6 mm long	Dental anchorage in mandibular incisors/vestibular microscrew between mandibular lateral canines and incisors	1 mm intrusion in mandibular incisors	2 mm intrusion in mandibular incisors	Average of 5 months for the intrusion with skeletal anchorage, with changes of 0.4 mm per month/average of 5 months for the dental anchorage group, with changes of 0.25 mm per month	2D radiography overlay
Borsos *et al.*, 2012[16]	Clinical trial	Low	ND	Upper first premolar	Metal braces with springs and transpalatal bar/microscrew 4.2 mm in diameter and 1.8 mm in length with transpalatal bar	Dental anchorage in upper molars/microscrew in palate	Dental anchorage: when the canine retraction began, the molar shifted 4.28 mm	Skeletal anchorage: Dental anchorage: when the canine retraction began, the molar shifted 4.19 mm	The retraction with palatal anchorage took 5 months, and the dental anchorage took 9 months	2D x-ray overlay and study models
Park *et al.*, 2012[14]	Clinical trial	Low	CII malocclusion	Upper first premolar and lower second premolar	Metal braces/microscrew 1.6 mm in diameter and 6 mm long	Anchorage of upper first molar/Vestibular microscrew between the second premolar and the first molar on both sides	Maxillary: Retraction of 5.3 mm in central incisor; 5.0 mm lateral incisor; 5.4 mm canine. Intrusion of central incisor and canine of 0.5 mm. mesialization of	Maxillary: Retraction of 6.9 mm central incisor; 5.9 mm lateral incisor; 6.4 mm canine. 1.8 mm intrusion in central incisor and 1.1 mm canine. mesialization of	Conventional anchorage was performed in 9.8 months, and skeletal anchorage was performed in 8.6 months	Overlay of 3D models and 2D radiography

Contd...

Table 2: Contd...

Author and year	Study design	Quality of study	Diagnosis	Premolar extractions	Anchorage used (case/control)	Location of the anchorage (case/control)	Tooth movement dental anchorage	Tooth movement skeletal anchorage	Time to make tooth movement (case/control)	Measurement
							1.5 mm premolar; 1.4 mm first molar	0.5 mm premolar; 0.4 mm first molar		
Al-Sibaie & Hajeer, 2014[15]	Randomized clinical trial	High	CII malocclusion	Upper first premolar	Transpalatal bar with bands welded in molars/microscrew 1.6 mm in diameter and 7 mm long	Band welded in upper first molars/microscrew between the upper second premolar and first molar	Maxillary: the incisors retracted 4.79 mm and extruded 0.92 mm. The molars mesialized 1.5 mm	Maxillary: 5.93mm the retraction incisor and 1.53 mm the intrusion. The molars distalized 0.89 mm	Skeletal anchorage was performed in 12.9 months and molar anchorage in 16.9 months	2D radiography overlay

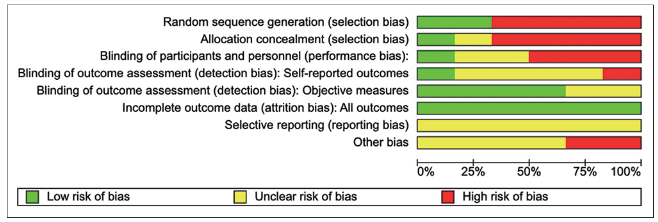

Figure 2: Summary of the risk of bias of the included studies (green: strong; yellow: moderate; red: weak)

is required, precise control of the tooth movement is needed.[18] Thus, multiple resources have been used to avoid undesired movements of the anchorage unit to avoid movement of the posterior teeth before closing the spaces.[19]

In our study, we observed that the transverse movements with skeletal anchorage make it possible to generate movements in less time than with dental anchorage. In addition, the skeletal anchorage does not generate significant changes in the vestibular/palatal or lingual inclination, as either movement in the posterior sector during the retractions of the anterior sector or space closing after premolar extraction. These results allow greater control in the orthodontic treatment.

Thiruvenkatachari *et al*.[12]; Borsos *et al*.[16]; Park *et al*.,[14] and Al-Sibaie and Hajeer[15] reached the conclusion that skeletal anchorage allows retractions of the anterior sector in less time than dental anchorage. In addition, Park *et al*.[14] and Al-Sibaie and Hajeer[15] compared the position of the first molar when dental anchorage and skeletal anchorage were used, reporting that skeletal anchorage does not exceed 0.9 mm of movement, whereas dental anchorage moved it in the anterior direction between 1.4 and 1.5 mm.

De Assis Claro *et al*.[20] indicated that dental anchorage generates greater force in the cervicodistal region, whereas skeletal anchorage generates greater stress in the apical third, which increases the control of the inclination and extrusion. Several authors[15,21,22] indicate that skeletal anchorage provides stable horizontal movements because it avoids movement toward the anterior of the molars. In the same way, it allows posterior movement of molars when the premolars, canines, and incisors are retracted.

Our study shows statistically significant results with horizontal movements but not significant results with vertical tooth movements. Deguchi *et al*.[13] and Aydoğdu and Özsoy[17] found no significant changes in intrusion movements or relapse using either anchorage. Despite the intrusions occurring more quickly and effectively with the skeletal anchorage, the extrusions can be obtained with both types of anchorage.[23] The main

Table 3: Features of the articles that compared the tooth movement with dental anchorage and skeletal anchorage, the method of measurement, and the results

Author and year	Method of measurement	Main results
Thiruvenkatachari *et al*., 2008[12]	The distal movement of the upper and lower canine anchored to the molar and anchored to a microscrew in the same patient was measured by overlay of lateral teleradiography and clinical evaluation.	There was a correlation between the lateral movement of canine and the treatment time using skeletal anchorage. Where the tooth movement with skeletal anchorage was 0.6 mm in the maxilla and 0.35 mm in the mandible, with a time of 0.12 mm per month in the maxilla and 0.07 mm per month in the mandible, achieving the complete movement in approximately 5 months.
Deguchi *et al*., 2011[13]	The bite closing in the anterior sector was evaluated using dental anchorage and skeletal anchorage by means of lateral cephalometry and plaster models.	There was no correlation when using dental anchorage and skeletal anchorage, since both presented patients with relapse within 24 months. Patients with dental anchorage and skeletal anchorage both presented relapses.
Aydogdu & Ozsoy, 2011[17]	The movement of intrusion of mandibular incisors with dental anchorage and utilitarian arch as compared to the skeletal anchorage using lateral teleradiography.	There was no correlation between the intrusions of mandibular incisors using both orthodontic techniques. It was only observed that the skeletal anchorage presented 0.15 mm more movement than the dental anchorage.
Borso *et al*., 2012[14]	The change in position of the upper first molar was compared by doing canine retraction. Dental anchorage was used with the support of a transpalatal bar and palatal skeletal anchorage with a transpalatal bar.	The palatal anchorage reduced the time and side effects of the position of the upper first molar at the time of performing the distalization of the canines and incisors, but there was no significant difference between doing it with skeletal anchorage or dental anchorage.
Park *et al*., 2012[14]	The distalization and intrusion of the anterior teeth and stability of the position of the first molar in the upper arch.	There were significant changes in time and amount of movement when performing intrusions and distalizations in the anterior teeth. In the molars, there was a correlation in both treatments, where there was less dimensional change in the position of the molar (0.4 mm) in the skeletal anchorage compared to the dental anchorage (1.4 mm).
Al-Sibaie & Hajeer, 2013[15]	Distalization of the anterosuperior sector and the shift of the first molar were compared using dental and skeletal anchorage.	When using skeletal anchorage to distalize the anterosuperior teeth, the first molar was only distalized 0.89 mm, whereas in the dental anchorage, the first was mesialized 1.5 mm to perform a retraction of the anterosuperior teeth.

limitation of dental intrusions is the magnitude of the force and the duration of the intrusion, since they can produce root shortening in the incisors between 0.8 and 0.85 mm in a range of 6.6 months.[24,25]

Skeletal anchorage presents clinical advantages such as the low technical requirements and the short time of use to generate movements and close spaces.[26] However, complications have been reported, such as screw loosening, fractures, infections, and damage to adjacent tissues related to the soft tissues of the tooth and periodontium.[27] Another important factor is the proximity of the screw to the tooth root, as this can cause the anchorage to fail and induce pain, infection, and root resorption.[28,29] For these reasons, it is necessary to perform a three-dimensional evaluation to install the skeletal anchorage correctly.

The main disadvantage of this study was that several articles[12,13,15-17] presented 2D overlay or evaluation of the changes in plaster models, whereas only one study[14] used the overlay of digital models to assess tooth movements. Although some randomized clinical trials were analyzed, three-dimensional imaging and digital models are needed to obtain precise and predictable results. Some authors[30,31] concluded that 3D images allow more precision in the analysis of orofacial structures, and reducing time in the record of data for the diagnosis and treatments. The regular study dental cast only shows some differences in measurements in the cast model to be compared; 3D analysis will show comparison by superimposition and the analysis in millimeters of the movement and spatial position of the anatomical landmarks.Jedlinski *et al*.[32] realized a comparison between three intraoral scanners and study models, observing that the scanners present a small optical distortion during the scanning of the second molar, but that this does not generate a significant impact during the diagnosis and treatment, showing advantages over printing models. In terms of the type of scanner, all of them show no differences in the optical characteristics with no significant clinical differences, making it feasible to make superimposed arches.[32]

We can conclude that skeletal anchorage generates precise and stable horizontal movements without overloading or changing the position of the first molar. It is necessary to integrate three-dimensional methodology in future clinical trials.

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Conflicts of interest

There are no conflicts of interest.

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