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Evaluation of the effect of using micro-implant in vertical control in angle class ii malocclusion patients: a systematic review and meta-analysis

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Background and Aim: It is acknowledged that controlling the vertical dimension is a crucial and frequently challenging aspect of orthodontic treatment. The present study evaluated the micro-implant effect in angle class II malocclusion patients. **Methods:** All articles published in international databases such as PubMed, Scopus, Science Direct, ISI Web of Knowledge, and Embase between 2012 and July 2022 are included. Meta-analysis data collected from selected studies were performed using Stata/MP.V17 software. **Results:** The abstracts of 718 studies were reviewed, and finally, 12 studies were selected. The mean differences of vertical change of lower and upper molar between micro-implants were -0.88 (MD, 95% CI -1.15, -0.60; p=0.00). **Conclusion:** Based on the present study's findings, using a Micro-implant compared to conventional anchorage has better vertical control. It is suggested that future studies be conducted with a similar cognitive methodology of higher quality and get help from methodological guidelines.

Keywords: Malocclusion, Angle Class II. Dental arch. Orthodontic anchorage procedures.

Introduction

Class II malocclusion is one of the most common problems in orthodontic treatment, characterized by protrusion of the upper jaw and retrognathia of the mandible[1]. Its frequency in children is reported to be 37%[2]. In people of non-growing ages, teeth displacement is generally used to compensate for jaw disharmony[3]. One of the most critical concerns of orthodontic treatment is minimizing side effects and maximizing tooth movement[4].

A type of maximum anchorage that is widely used is micro-implant (MI)[5]. Many advantages have been reported for MI, including minimal anatomic constraints, relatively low cost, ability to load forces immediately, ease of insertion and removal, and rapid recovery. However, the use of MI may be associated with the risk of damage to the roots of the teeth during implantation, especially when placed between teeth[6]. Vertical control is important in treating hyper-divergent malocclusion characterized by a high mandibular plane angle and a long face. According to multiple studies, vertical control is crucial for treating skeletal class II malocclusion with orthodontics. Using the vertical growth potential of adolescent patients to direct their facial development in the desired direction is frequently the most successful course of action[6].

Long face syndrome is formed by excessive vertical growth of the face with a backwardly rotated mandible, an increased lower face height, and a tendency for open bite in severe cases. Studies have shown that MI is more effective in sagittal control than conventional anchorage (CA)[7-9]. There are many debates regarding the effectiveness of MI in vertical control, and this issue is very challenging. Studies have shown that MI can help mandibular clockwise rotation and have provided favorable results[10,11].

Moreover, some studies comparing MI with CA have found more molar extrusion[12,13]. Therefore, the study evaluated micro-implant effects in angle Class II malocclusion patients.

Materials and Methods

Search strategy

Based on PRISMA guidelines[14], the present study conducts a systematic review and meta-analysis of all articles published between January 2012 and July 2022 in international databases, including PubMed, Scopus, Science Direct, Embase, and ISI Web of Knowledge. The Google Scholar search engine employed the PICO strategy to answer the research questions (Table 1).

Table 1. PICO strategy.

PICO strategy	Description
P	Population: Class II malocclusion patients
I	Intervention: Micro-implant
C	Comparison: Conventional anchorage
O	Outcome: vertical change of upper and lower molar, change of occlusal plane, and chin position.

The following keywords were used to search:

((((“Orthodontic Anchorage Procedures”[Mesh]) AND “Malocclusion, Angle Class II”[Mesh]) OR “Malocclusion, Angle Class II/therapy”[Mesh]) AND “Dental Arch”[Mesh]) OR “Extraoral Traction Appliances”[Mesh] OR “ Micro-implant “[Mesh].

Eligibility criteria

Inclusion criteria

1. Randomized controlled trials, controlled clinical trials.
2. The article’s full text was accessible.
3. No language restrictions.
4. Comparison of the intervention group with the control group.
5. Compared micro-implant with other types of anchorage.
6. Human samples.

Exclusion criteria

1. Cohort, cross-sectional, retrospective, in-vitro, and in-vivo studies, review, case reports, letters to the editor, and animal studies.
2. Sample size less than 10.

Selection process and Data collection process

Two reviewers blindly and independently extracted data from the included papers’ full texts and abstracts for data extraction, and then data checklists were checked by a third independent and blind author. Duplicate items were removed, and each approved the final checklist of the three income authors. Kappa statistics were used to check the amount of agreement between the reviewers. The values of kappa were higher than 0.80. Studies data were reported by the first author’s name, years, study design, number of patients, intervention and control group, and outcome.

Risk of bias assessment

The quality of the randomized control trial studies was assessed using the Cochrane Collaboration tool[15]. Low risk received a scale score of 1, while high and unclear risk received a score of 0. The scale scores range from 0 to 6. High quality means a higher score. The quality of the controlled clinical trial studies was assessed using the MINORS scale[16].

Data analysis

Effect Measures and Synthesis Methods

Stata/MP. v17 software was used to analyze the data. Mean differences (95% confidence interval) were used with a fixed effect model and inverse-variance method to examine the outcome. The level of heterogeneity was assessed using the I^2 index test (I^2 50% = low levels, 50-I^2 75% = moderate, and I^2>75% = high levels).

Results

After the initial search for them in databases, 718 articles were identified. Duplicate articles were deleted (n=60) after importing all articles into the EndNote. X9 software. Six hundred fifty-eight articles were entered and examined in the second stage (abstract). At this stage, 554 unrelated articles were excluded from the study while reviewing the titles and abstract articles. The full texts of 104 articles were reviewed in the third step. Twelve articles that met the inclusion criteria and were published between January 2012 and July 2022 eventually entered the analysis. (Figure 1).

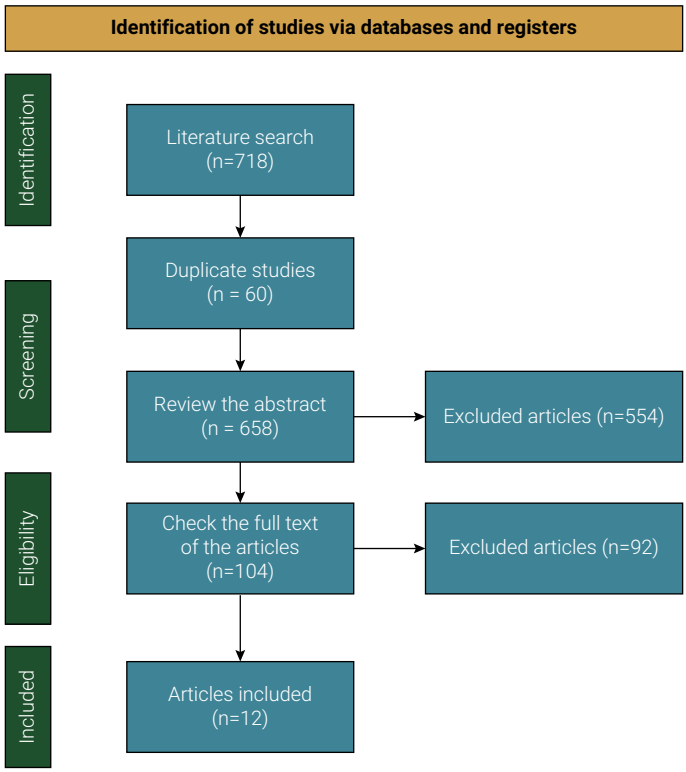

Figure 1. PRISMA flowcharts.

Characteristics

The total number of patients in the Micro-implant and control groups were 105 and 91, respectively. Data extracted from the studies are summarized in Table 2.

Risk assessment

According to the Cochrane Collaboration tool, four randomized clinical trial studies were of high quality (low risk of bias), two had a moderately low risk of bias, and one was of low quality (Table 3). Total MINORS scores of 15-22 showed moderate quality; in the present study, all studies assessed with MINORS scores had moderate quality (Table 4).

Table 2. Data extracted from selected studies.

No.	Study. Years	Outcome	Number of patients				Site and Type		Micro-implant		Range of age	Intrusion of Molars	Occlusal Plane Change
			Micro-implant group		Control group		Micro-implant group	Control group	Diameter (mm)	Length (mm)			
			Male	Female	Male	Female							
1	Ding et al.[17], 2019	Dental, Skeletal	10		10		TPA+ MI	Headgear	2.0	10	15-26	mandibular plane	−0.31 ± 1.26
2	Tan and Wenli[18], 2018	Dental, Skeletal	20		20		U5, U6	J hook	1.6	9	19-26	mandibular plane	0.51 ± 0.64
3	Meng et al.[19], 2017	Dental, Skeletal	5	10	7	8	U5, U6 L5/L6	tpa	1.6	11	18-37	mandibular plane	0.8 ± 0.3
4	Ma et al.[20], 2016	Skeletal, Profile	15		15		U5, U6	TPA	1.6	11	NR	mandibular plane	0.35 ± 0.94
5	Wu et al.[21], 2015	Dental, Skeletal	7	10	5	9	U5, U6	J hook	1.6	11	18-39	mandibular plane	0.18 ± 0.27
6	Liang et al.[22], 2014	Skeletal	5	5	5	5	U5, U6	TPA	1.5	10	18-29	mandibular plane	−0.77 ± 2.3
7	Si et al.[23], 2014	Dental, Skeletal, Profile	0	16	0	16	U5, U6	J hook	1.6	11	16-30	mandibular plane	0.8 ± 3.81
8	Chen et al.[24], 2015	Dental, Skeletal, Profile	6	9	7	9	U5, U6	Headgear	1.6	9	22-30	mandibular plane	−0.27 ± 0.59
9	Ouyang and Du[25], 2013	Dental, Skeletal	0	10	0	10	U5, U6	Headgear	1.6	9	18-35	mandibular plane	−1.51 ± 2.6
10	Al-sibaie and Hajeer[12], 2014	Dental, Skeletal	9	19	12	16	U5-U6	TPA	1.6	7	16-29	mandibular plane	−0.41 ± 1.4
11	Liao et al.[26], 2012	Dental, Skeletal, Profile	7	7	4	10	U5-U6	Headgear	1.4	8	18-37	mandibular plane	−1.2 ± 2
12	Yu et al.[27], 2012	Dental, Skeletal	15	19	5	8	U1-U2, U5- U6	J hook	1.6	11	22-39	mandibular plane	−0.41 ± 0.48

U5: upper second premolar; U6: upper first molar; U1: upper incisor; U2: upper lateral incisor; L5: lower second molar; L6: lower first molar.

Table 3. Risk of bias assessment (Cochrane Collaboration's tool).

Study	Random sequence generation	Allocation concealment	Blinding of participants and personnel	Blinding of outcome assessment	Incomplete outcome data	Selective reporting	Total score
Ding et al.[17], 2019	+	+	?	+	+	+	5
Meng et al.[19], 2017	+	+	?	+	+	+	5
Ma et al.[20], 2016	+	+	?	+	+	+	5
Liang et al.[22], 2014	+	?	?	+	+	+	5
Si et al.[23], 2014	?	?	?	?	+	+	2
Al-sibaie and Hajeer[12], 2014	?	?	+	?	+	+	3
Liao et al.[26], 2012	?	?	+	+	+	+	4

Table 4. MINORS score

Study	Clearly stated aim	Inclusion of consecutive patients	Prospective data collection	Endpoints appropriate to study aim	Unbiased assessment of study endpoint	The follow-up period appropriate to the study's aim	<5% lost to follow-up	Prospective calculation of study size	Adequate control group	Contemporary groups	Baseline equivalence of groups	Adequate statistical analyses	Total
Tan and Wenli[18], 2018	2	2	2	2	2	0	0	0	2	2	0	2	16/24
Wu et al.[21], 2015	2	2	2	2	2	0	0	0	2	2	0	2	16/24
Chen et al.[24], 2015	2	2	2	2	2	0	0	0	2	2	2	2	18/24
Ouyang and Du[25], 2013	2	2	2	2	2	0	0	0	2	2	0	2	16/24
Yu et al.[27], 2012	2	2	2	2	1	0	0	0	2	2	0	2	15/24

Vertical change of upper and lower molar

The mean difference of vertical change of lower molar between MI and CA was -0.88 (MD, 95% CI -1.15, -0.60; p=0.00) (I^2=57.73%; P=0.12; moderate heterogeneity). A significant Vertical change was observed between the two groups, showing lower molar intrusion in the Micro-implant group (Figure 2).

The mean difference of vertical change of upper molar between MI and CA was -0.53 (MD, 95% CI -0.62, -0.44; p=0.00) (I^2=98.13%; P=0.00; high heterogeneity). A significant vertical change was observed between the two groups, showing that the micro-implant group performed significantly better in the upper molar intrusion (Figure 3).

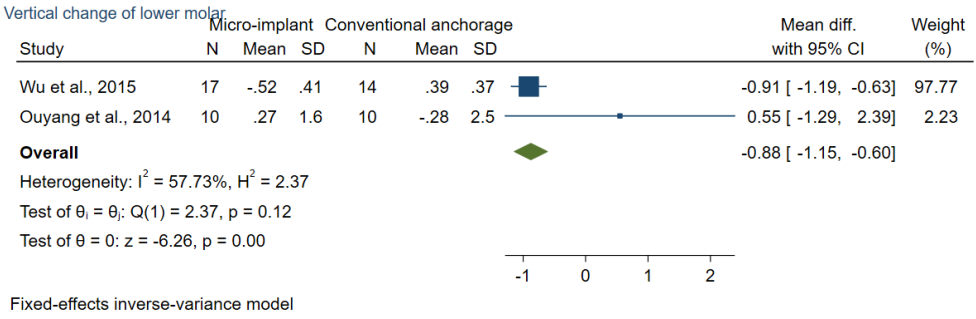

Figure 2. The forest plot showed a vertical change of lower molar between Micro-implant and conventional anchorage.

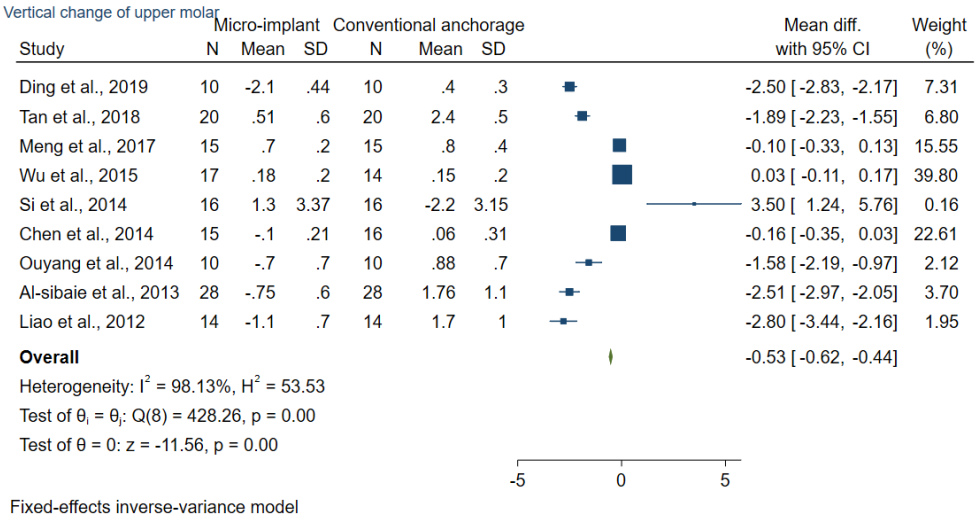

Figure 3. The forest plot showed a vertical change of upper molar between Micro-implant and conventional anchorage.

Occlusal plane

The mean difference of change of occlusal plane between MI and CA was -1.39 (MD, 95% CI -1.82, -0.96; p=0.00) (I^2=93.49%; P=0.00; high heterogeneity). The difference in the change of occlusal plane between the two groups resulted in a decrease in the occlusal plane in the micro-implant group (Figure 4).

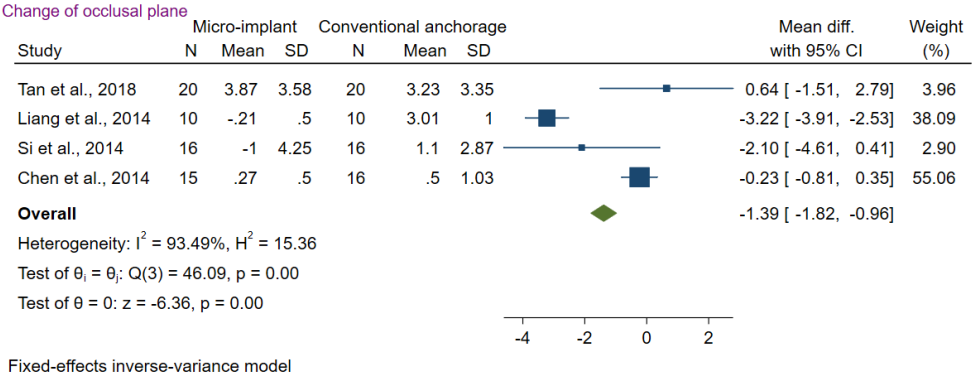

Figure 4. Change of occlusal plane between Micro-implant and conventional anchorage.

Chin position

The mean change of chin position change between MI and CA was 0.16 (MD, 95% CI 0.12, 0.20; p=0.00) (I^2=99.24%; P=0.00; high heterogeneity). According to the difference in change of chin position between the two groups, the forward moving of the chin in the Micro-implant group was observed (Figure 5).

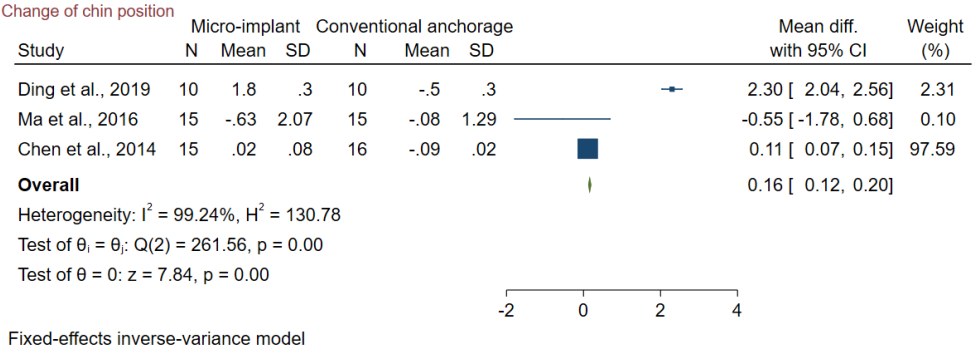

Figure 5. Change of chin position between Micro-implant and conventional anchorage.

Discussion

The present study was conducted to investigate the effectiveness of MI in vertical control of orthodontic treatment. The current meta-analysis observed that MI reduced

the mandibular plane angle and intruding upper molars better than CA. It should be noted that vertical control during orthodontic treatment is important both theoretically and clinically. If correct vertical control is performed in patients with class II malocclusion, it leads to clockwise rotation of the mandible, which affects treatment. For the best orthodontic care, well-vertical control is crucial and may help lessen the jaws' anteroposterior discrepancy.

On the other hand, for every 1 mm that the molars were extruded, there was an approximate 3° increase in the mandibular plane angle. For class II patients, molar intrusion or preventing molar extrusion is necessary for successful treatment; however, from an aesthetic perspective, class III patients may not be appropriate candidates for MI treatment.

Based on the study of molars and whole teeth, it penetrates with receding anterior teeth[10,11]. Some studies have shown that using MI from the beginning of treatment effectively improves treatment in patients with class II malocclusion[11]. In addition, the force used during retraction was focused on the MI rather than the molars, reducing friction and consistent with the original favoring thin wire and light force. As a result, the movement of teeth is close to the physiological movement[21].

The present study showed that MI performed significantly better in the upper molar intrusion. Peng et al.[28], 2023 reported findings similar to the present study and showed that MI significantly decreased mandibular plane angle and intruded upper molars. According to the present meta-analysis, MI reduced the occlusal surface occlusal plane and changed the chin position observed in the MI group. Based on the findings of the present meta-analysis, MI can reduce the occlusal plate and improve the profile. Studies have reported that MI and CA improve the profile[28].

Studies have shown that class II elastic traction can negate vertical control and lead to the extrusion of lower molars[20,21,27]. Such studies have shown that vertical control reduces anteroposterior jaw discrepancy, which is particularly important during orthodontic treatment[25,29]. The present meta-analyses showed the forward movement of the chin in the Micro-implant group. In the orthodontic treatment of class II patients, molar intrusion is essential for the success of the treatment. In class II patients, MI is not recommended due to aesthetics. Clinically, the anticorruption effect of anchorage in MI has been reported to be appropriate in treating class II malocclusions. However, evidence from RCTs needs to be more consistent. More clinical trial studies are needed to confirm the evidence[6]. When using MI on the bed, it is better to choose the location individually, and the infrazygomatic crown is suitable. It is essential to assess adjacent anatomic structures and bone density before MI placement to assess the success of MI.

In conclusion, based on the present study's findings, micro-implant use has better vertical control than conventional anchorage. Most of the studies selected in the present study were of moderate quality, and heterogeneity between studies was high, so the results should be interpreted carefully. It is suggested that future studies be conducted with a similar cognitive methodology of higher quality and get help from methodological guidelines.

Conflict of interest

The authors have no conflict of interest to disclose.

Data availability

Datasets related to this article will be available upon request to the corresponding author.

Author Contribution

Sareh Keshavarz Meshkinfam: Methodology, Writing - Original Draft and Writing - Review and Editing. **Fatemeh Teimoori:** Methodology, Writing - Original Draft and Writing - Review and Editing. **Ali Amiri:** Conceptualization, Methodology, Formal Analysis, Investigation, Writing - Original Draft, Writing - Review and Editing and Visualization. **Fereshte Keikha:** Validation and Writing - Review and Editing. We declare that all authors actively participated in two distinct criteria related to authorship. All authors have revised and approved the final version of the manuscript.

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