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Superior effect of mini-implant anchorage in the treatment of skeletal class II malocclusion

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Abstract

OBJECTIVES: To evaluate the effectiveness of mini-implant (MI) anchorage versus conventional anchorage for the treatment of skeletal class II malocclusion.

MATERIALS AND METHODS: The study was conducted on 64 patients with skeletal class II malocclusion. The patients were divided into two groups: 1) 32 patients underwent conventional anchorage, and 2) 32 patients underwent MI anchorage. Cephalometric radiographs were taken pre-treatment, and the data were compared with post-treatment measurements.

RESULTS: The age and gender distribution between the conventional and MI anchorage groups was similar, and the differences were statistically significant. The SNA and SNB angles post-treatment were reduced compared to pre-treatment measurements in both groups. The MI anchorage demonstrated a superior subsidence effect, reducing the level of forward displacement of the first molars in the maxilla. The MI group also exhibited less extrusion of the molars compared to the conventional group. In skeletal class II cases, especially in patients with a high mandibular angle using MI anchorage helped prevent the mandible from rotating counterclockwise, thus improving aesthetics rather than worsening them after treatment. In 75% of the cases in the MI anchorage group, the outcome was assessed as "greatly improved" based on the PAR index.

CONCLUSIONS: MI anchorage was more effective than conventional anchorage. It allows for greater posterior movement and intrusion of the maxillary incisors while maintaining or rotating the mandibular plane counterclockwise.

Keywords:

Orthodontic anchorage, orthodontic conventional device, orthodontic mini-implant, skeletal class II malocclusion, teeth extraction

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Introduction

Skeletal class II malocclusion has a significant impact on facial aesthetics. Generally, the treatment for this type of deformity in adult patients is often indicated with the extraction of the premolars and retraction of the anterior segments under anchorage. Orthodontists have used conventional devices including the Nance appliance or trans palatal arch (TPA) augmented with anchoring Headgear to prevent the posterior teeth from moving forward during the closure of the extraction site while pulling the upper anterior teeth backward. The conventional methods have the disadvantage of using teeth to form the anchorages, which often fail. Furthermore, anchorage enhancers are uncomfortable and usually require patient compliance. Recently, the use of an orthodontic mini implant (MI), which is screwed into the jaw to allow maximum anchorage has overcome the disadvantages of conventional instruments.[1-4]

Moreover, most studies evaluating the outcomes of orthodontics frequently use

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cephalometry to analyze the variation between pre- and post-treatment.[5-7] On cephalometry, the peer assessment rating (PAR) index is the occlusal index to assess the orthodontic outcome. The changes in PAR index between pre- and post-treatment on plaster casts can be divided into three categories: worse or no different (PAR index change <30%), improved (PAR index change ≥30%), greatly improved (PAR index change ≥30% combined with a reduction of 22 or more weighted PAR points).[8]

The objective of this study was both to evaluate the effectiveness of MI as the maximum anchorage versus that of conventional anchorage in the treatment of skeletal class II malocclusion and to analyze the changes in cephalometric radiographs. In addition, the differences in outcomes, based on the landmarks shown on cephalometric radiographs pre as well as post-treatment and via an assessment of the plaster casts within the PAR index between the two methods of anchorage, were assessed.

Materials and Methods

The study was conducted between June 2014 and December 2022 at the Orthodontic Department of the National Hospital of Odonto-Stomatology in Hanoi, Vietnam. The study involved 64 patients (age range: 12–45 years old) and all those exhibited a Class II skeletal pattern, upper lip proclination, a sharp nasolabial angle, and a convex facial profile. They were diagnosed with skeletal class II malocclusion, characterized by an ANB angle greater than 3.6° and a Wits index exceeding 2.1 mm. These patients required tooth extraction and maximum anchorage.

The subjects were divided into two groups (n = 32/group).

- The conventional group: Those undergoing conventional anchorage using Nance or TPA devices enhanced by headgear [Figure 1]
- The MI group: Those undergoing the MI anchorage [Figure 2].

Each patient underwent premolar extractions followed by absolute anchorage to retract the upper anterior teeth. Cephalometric radiographs were taken before and after treatment to visualize and assess changes in dento-skeletal structures [Figures 3 and 4].

Figure 1: Conventional anchorage devices. TPA and Nance's devices enhanced by Headgear for anchorage

In the MI anchorage group, not all patients required the placement of three implants. Additional implants were indicated only in cases with deep bites. For patients with deep bites, the MI anchorage group often required the insertion of one or two additional screws in the upper molar region to intrude the upper molars, and one or two screws in the lower molar region to intrude the lower molars.

The closing force was measured using a force measurement device from Ormco, with a closing spring or elastic chain employed to close the gap.

- The conventional group
  - A force of 100 grams was used to retract the third molar.
  - A force of 200 grams was applied to retract the four premolars.
  - For headgear anchorage, a force of 300–350 grams was utilized. The type of headgear depended on the patient's mandibular angle: Patients with a large lower jaw angle were prescribed high-pull headgear, while those with small to moderate lower jaw angles were indicated to use straight-pull headgear.
- The MI group: A force of 250 grams was applied to retract the entire anterior teeth using a micro-implant stop screw, with immediate effect upon insertion.
- Force for deep bite correction: An elastic chain exerting a force of 150 grams was used to correct the occlusion of all six premolars and canines.

Visualization and measurements

Landmarks and lines on cephalometric radiographs were manually traced and then measured by orthodontists using 0.5 mm mechanical pencils and acetate tracing papers (Ormco, USA). The planes used were the SN, Frankfort, NPepr, functional occlusion plane, ANS-PNS, Go-Gn, E-plane, and PTV plane. The measurements used are the SNA, A-NPerp, Co-A, SNB, Pog-NPerp, Co-Gn, ANB, Wits, Diffe Max-Md, NBa- PtG, NPogPOr, GoGn-SN, Md-FH, PP-Md, ANS-Me, U1-SN,

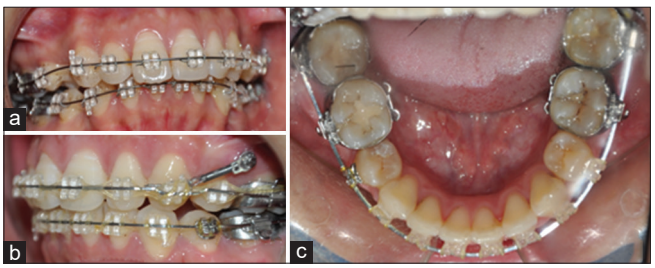

Figure 2: The mini-implant procedure. Self-drilling mini-implants (Jeil, Korea) with a diameter of 1.6 mm for the posterior area and 1.4 mm for the anterior area, the length of each instrument was 8 mm. Cephalometric radiograph Orthorali × 9200, (Carestream, USA). a. Stage of evenly arranging and straightening teeth. b. Stage of MI fixation with traction spring. c. Final stage of detailed adjustment and treatment

U1-ANSPNS, U1-APo, 1L-APo, 1L-Md, 1U-1L, 6U-PTV, 1U-Avert, 1U-FH, 6M-FH, UU, MM, Ls-E, Li-E, and nasolabial angle [Figure 3].

Using the plaster casts to measure the components of occlusion with a PAR ruler pre- and post-treatment [Figure 5].

Statistical analysis

Statistical analysis with the Chi-Square test was performed to assess differences between the MI and the conventional group. The software used was Microsoft Excel and SPSS 23.0 (IBM, USA).

Results

The mean ages of patients in the conventional and MI groups were 18.9 ± 5.8 years (range: 12–29 years old) and 21.6 ± 6.4 years (range: 12–32 years old). Before treatment, the dental indices on the cephalometric films in both groups were significantly higher than the normal values for Europeans. There was no statistically significant difference between the control and intervention groups [Table 1].

The indications for tooth extraction were similar between the control and intervention groups. A large proportion of patients (81.3%) required the extraction of four premolars, while 18.7% had only two upper premolars extracted without the need for lower premolar extraction [Table 2].

All patients with an overbite greater than 7 mm (100%) were indicated for the extraction of two upper premolars without lower premolar extraction. In 75% of cases, two upper premolars were extracted when the overbite exceeded 9 mm. Among patients with an overbite between 7.1 mm and 9 mm, 15.4% required the extraction of four premolars. However, for cases with an overbite greater than 9 mm, there were no indications for extracting four premolars [Table 3].

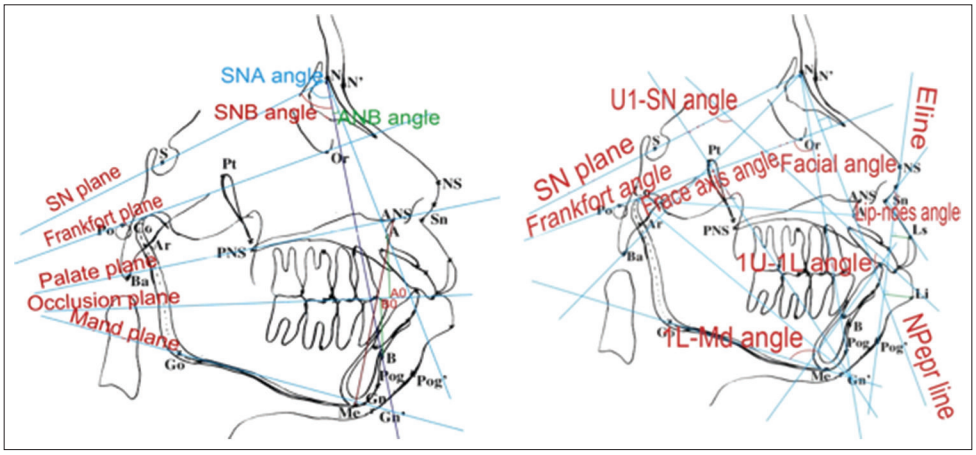

Figure 3: Angles and planes used in this research

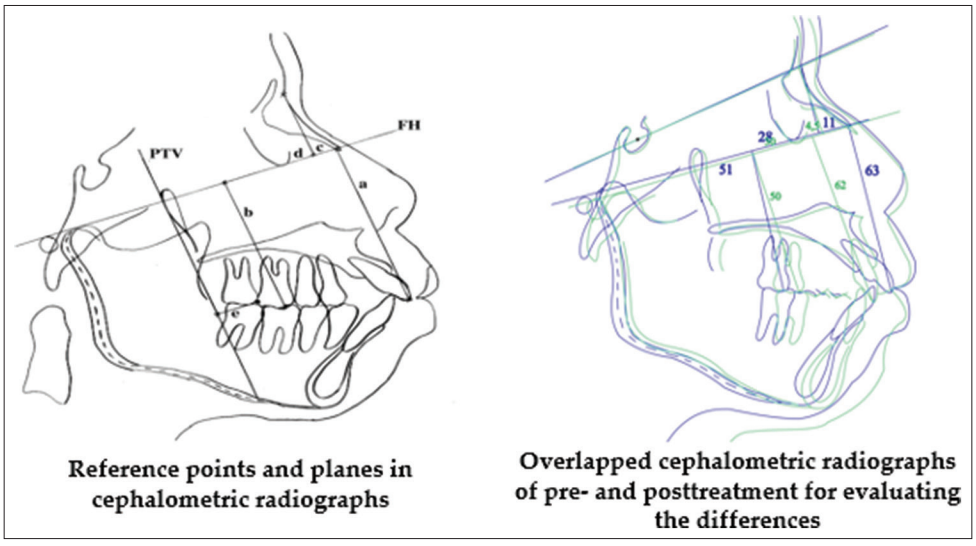

Figure 4: Measurements determining the movements of incisors and molars in the anteroposterior and vertical axes: a. 1U-FH index. b. 6M-FH index. c. UU index. d. MM index. e. 6U-PTV index (*Blue shape: Pre-treatment, Green shape: Post-treatment*)

Discussion

The study showed that MI anchorage was more effective than conventional anchorage. It allows for greater posterior movement and intrusion of the maxillary incisors while maintaining or rotating the mandibular plane counterclockwise.

The statistically significant similarity in terms of age and gender ensured a high reliability level of other comparisons between the 2 groups. Comparison with other studies performed by Deguchi[9] (the male ratio was 11.1% and the female ratio was 88.9%) and Yao's[10] (the male ratio was 8.5%, the female ratio was 91.5%). So females' requirement of esthetic was higher than males.

The postoperative SNA angle was decreased when compared to the pre-treatment in the conventional and MI groups, measuring 0.6 ± 1.30 degrees and 0.7 ± 1.2 degrees, respectively ($P < 0.05$) [Table 4]. Therefore, the extraction of teeth and pulling back of the upper incisors in the patients with Skeletal class II malocclusion reduced the SNA angle when compared to pre-treatment. The SNB angle post-treatment decreased in both groups of patients, the difference was statistically significant. The degree of reduction in both groups was similar, measuring 0.4 ± 1.2 and 0.5 ± 1.2 in the conventional anchorage group and MI anchorage group, respectively [Table 4]. The angle was similar pre- and post-treatment, suggesting that both SNA and SNB angles post-treatment were reduced as compared to those pre-treatment. Our study findings were similar to those of Kuroda and Deguchi.[9,11]

The MI group had a 6U/PTV index that changed less than that of the conventional group (−0.6 ± 2.1 mm compared to −2.0 ± 1.4 mm), suggesting that the first upper molars in the MI group moved forward (when compared to the PTV plane) less than they had in the conventional group. The MI group had fewer changes in MM when compared to those of the conventional group (1.4 ± 2.3 mm versus 3.2 ± 2.2 mm), indicating that the first upper molar in the MI group moved forward (when compared to the Frankfort plane) less than it had in the conventional group [Table 5]. The change of both 6U/PTV and MM indices has contributed to the affirmation that using the MI as anchorage reduces the level of forwarding displacement of the first molars in the maxilla compared to that of the conventional anchorage. Our study expresses the same opinion as that of Kuroda (2009), Lai (2008), and Yao (2008).[10-12]

The change in the distance from the biting edge of the upper incisors to the Frankfort plane (1U-FH) shows that the maxillary incisors post-treatment in the MI group were intruded by 0.2 ± 2.7 mm. In the conventional group, the maxillary incisors were extruded to −3.0 ± 3.4 mm below the Frankfort plane [Table 5]. Similarly, the distance from the proximal knob of the first maxillary molar to the Frankfort plane (6M-FH) in the MI group changed less than it had in the conventional group (0.2 ± 2.7 mm in the MI group and − 2.9 ± 4.0 mm in the conventional group). Thus, the first maxillary molar was intruded 0.2 ± 2.7 mm in the MI group and extruded 2.9 ± 4.0 mm in the conventional group when referenced with the Frankfort plane [Table 5]. The use of an MI as an anchorage in our study showed that MI effectively intruded the upper incisors and molars.[13,14] Our study

Table 1: Pre-treatment dental indices on cephalometry film

Group Index	Normal (Europe)	Conventional	Mini-implant	*P*
U1-SN (degree)	103±1	113.5±8.6	112.3±6.5	0.534
U1-ANSPNS (degree)	110±5	122.4±8.1	122±5.5	0.805
U1-Apo (mm)	3±2	11.8±2.5	10.8±2.1	0.094
1L-Apo (mm)	1±2	5.3±3.5	4.6±3.1	0.416
1L-Md (degree)	95±5	102.9±9.6	99.2±7.0	0.083
1U-1L (degree)	125-130	108.1±11.9	110.6±7.6	0.331

Data was presented as mean±standard deviation

Table 2: Indication for tooth extraction in two groups

Indication for tooth extraction	Conventional *n* (%)	Mini-implant *n* (%)	Total *n* (%)
Only the two first premolars in the upper jaw were extracted, while no premolars were extracted in the lower jaw	6 (18.7)	6 (18.7)	12 (18.7)
Extraction 4 premolars	26 (81.3)	26 (81.3)	52 (81.3)

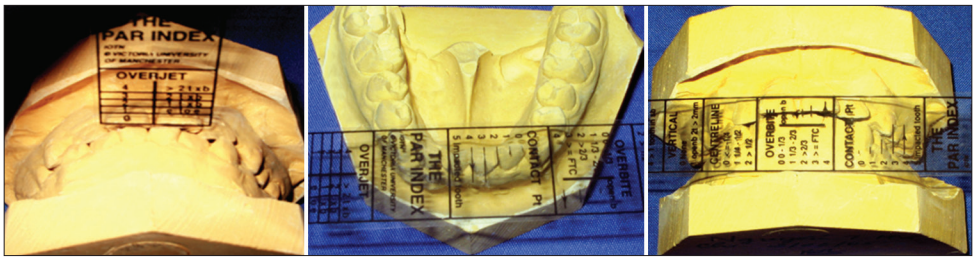

Figure 5: Measurement of occlusion components using a par ruler on a plaster cast

Table 3: Classification of tooth extraction

Bite depth Extraction	3.1–5 mm *n* (%)	5.1–7 mm *n* (%)	7.1–9 mm *n* (%)	>9 mm *n* (%)	Total *n* (%)
Only the two first premolars in the upper jaw were extracted, while no premolars were extracted in the lower jaw	0	0	3 (25)	9 (75)	12 (100)
Extraction 4 premolars	25 (48,1)	19 (36,5)	8 (15,4)	0	52 (100)
Total	25 (39,0)	19 (29,7)	11 (17,2)	9 (14,1)	64 (100)

Table 4: Indicators pre- and post-treatment of conventional and mini-implant groups

Indicator	Conventional			Mini-implant		
	Pre-treatment	Post-treatment	*P*	Pre-treatment	Post-treatment	*P*
SNA (degree)	83.1±4.0	82.6±4.0	0.022	84.3±3.5	83.6±3.8	0.003
SNB (degree)	76.5±4.0	76.0±3.9	0.044	77.5±3.2	76.9±3.8	0.017
ANB (degree)	6.7±1.5	6.6±1.6	0.588	6.8±1.9	6.7±1.7	0.148
Wits (mm)	3.7±1.8	2.2±2.2	0.000	4.1±2.2	3.4±2.3	0.047

Data was presented as mean±standard deviation

Table 5: Differences of anchorage indicators between pre and post-treatment

Indicator	Conventional	Mini-implant	*P*
6U/PTV (mm)	−2.0±1.4	−0.6±2.1	0.004
1U-Avert (mm)	5.0±1.9	5.6±2.4	0.332
1U-FH (mm)	−3.0±3.4	0.2±2.7	0.000
6M-FH (mm)	−2.9±4.0	0.2±2.7	0.014
UU (mm)	4.2±3.8	6.6±3.1	0.006
MM (mm)	3.2±2.2	1.4±2.3	0.002

Data was presented as mean±standard deviation

Table 6: Differences controlling the vertical dimension between pre- and post-treatment

Indicator	GoGnSN >37°		GoGnSN ≤37°	
	Conventional (*n*=22)	Mini-implant (*n*=17)	Conventional (*n*=10)	Mini-implant (*n*=15)
GoGnSN				
Pre	39.5±5.0	37.3±1.3	28.8±4.8	29.5±1.5
Post	39.7±5.0	38.9±1.8	30.6±4.9	30.2±1.4
P	0.691	0.072	0.05	0.242
NBaPtG				
Pre	81.6±0.9	81.9±0.9	84.4±1.3	85.1±3.4
Post	80.4±1.0	81.9±1.2	83.4±1.2	84.4±3.5
P	0.002	0.932	0.087	0.014
ANS-Me				
Pre	64.6±5.2	65.8±6.4	62.5±5.0	65.1±5.1
Post	67.2±6.0	67.4±3.8	64.5±4.8	65.5±4.7
P	0.001	0.160	0.023	0.396

Data was presented as mean±standard deviation

drew the same conclusion as that of Deguchi (2008) and Yao (2008) positing that the MI has a better subsidence effect than that of the conventional method [Figure 6].[9,10]

To control the vertical dimension, when using the MI for the anchorage of the mandibular plane, no change or marginal change was evident in the high-angle group (having GoGn SN >37 degrees) when comparing measurements taken before and after treatment [Table 6]. But in this high-angle group and when treated with the

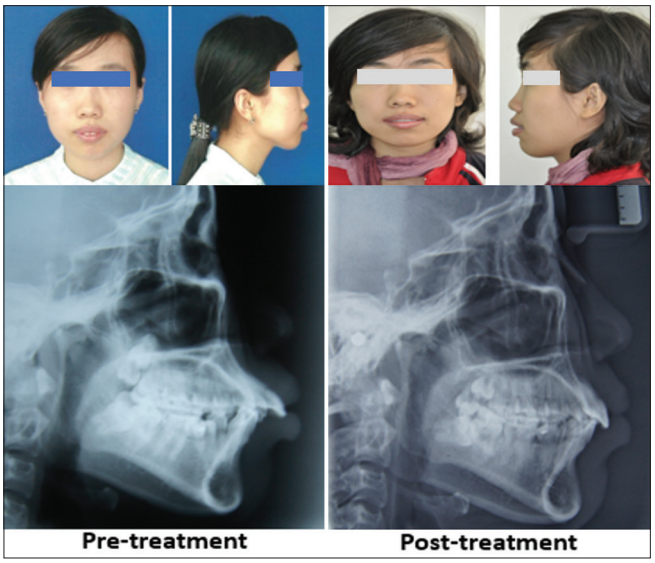

Figure 6: Comparison of clinical and cephalometric radiographs pre- and post-treatment in the mi group

conventional anchorage, the NBa-PtG angle decreased significantly. The low face height within the ANS-Me index was increased significantly in the group with the higher angle, resulting in the mandibular rotating both downward and backward. Such rotation resulted in an unfavorable aesthetic appearance as if the patient had a skeletal class II classification with its long face and high angle, possibly showing that when MI is used for anchorage in extraction cases with the high angle, the vertical dimension would require more control than that of the conventional anchorage group. The maxillary incisors were pulled in a more retrusive fashion when using MI for anchorage in low or normal-angle cases (the UU index decreased by 6.1 ± 3.3 mm vs 2.3 ± 4.1 mm) [Table 7]. Our study came to the same conclusion as Yao (2008) (the UU index decreased by 6.0 ± 1.7 mm in the conventional anchorage group and 8.6 ± 1.6 mm in the MI group). In the high-angle group, the index of 6U-PTV (0.2 ± 1.9 mm vs 2.1 ± 1.6 mm) and the MM index (0.8 ± 2.1 mm vs 3.1 ± 2.6 mm) in the MI group

Table 7: The differences pre and post-treatment between two anchorage groups with high-angle cases

Indicator	GoGnSN >37°			GoGnSN ≤37°		
	Conventional (*n*=22)	Mini-implant (*n*=17)	*P*	Conventional (*n*=10)	Mini-implant (*n*=15)	*P*
6U-PTV	−2.1±1.6	−0.2±1.9	0.000	−1.6±0.7	−1.4±2.2	0.752
1U-Avert	5.5±1.7	5.8±1.9	0.581	4.0±2.0	2.9±0.8	0.244
1U-FH	−3.3±3.7	0.4±2.6	0.001	−2.3±2.5	0.0±3.0	0.055
6M-FH	−3.7±3.8	−0.6±3.5	0.006	−1.3±4.1	-1.1±2.5	0.880
UU	5.0±3.4	7.1±2.9	0.056	2.3±4.1	6.1±3.3	0.017
MM	3.1±2.6	0.8±2.1	0.005	3.6±1.2	2.1±2.5	0.089

Table 8: The movement forward of the first molar on superimposition on the SN plane between the two anchorage groups

Superimposition	Conventional *n* (%)	Mini-implant *n* (%)	*P*
U6 not moving forward	4 (12.5)	18 (56.3)	0.000
U6 moving forward	28 (87.5)	14 (43.7)	

Table 9: The rotation of the mandibular between the two anchorage groups on superimposition

Mandibular	Conventional *n* (%)	Mini-implant *n* (%)	*P*
Not rotate	5 (15.6)	13 (40.6)	0.031
Rotate uncounter clockwise	6 (18.8)	8 (25)	
Rotate counter clockwise	21 (65.6)	11 (34.4)	

Table 10: The percentage change PAR index between pre- and post-treatment

PAR index change	Conventional *n* (%)	Mini-implant *n* (%)	*P*
Worse or no different	0	0	0.068
Improved	15 (46.9)	8 (25)	
Greatly improved	17 (53.1)	24 (75)	

changed less than those within the conventional group, showing that the first molars of maxillary in the MI group moved forward less than those in the conventional group in the high-angle cases. The index 1U-FH and 6M-FH showed the intrusion or extrusion of incisors or molars. 1U-FH index was 0,4 ± 2,6 mm meaning that the incisors were intruded in the MI group [Table 7]. The 6M-FH index in the MI group showed that the molars were minorly extruded as compared to those within the conventional group (−0,6 ± 3,5 mm vs −3.7 ± 3.8 mm). Our findings regarding high-angle cases were similar to those within Yao (2008).[10]

The superimposition on the SN plane showed that the conventional anchorage group had a rate of maintaining the first molar position that was lower than that within the MI anchorage group (12.6% versus 56.3%) [Table 8]. When superimposed, the rate of mandibular, which was maintained in position or rotated counterclockwise in the MI group, was higher than that of the conventional group (65.6% versus 34.4%) [Table 9]. In skeletal class II, especially with the mandibular retrusive patients, using MI could help refrain the mandibular from rotating counterclockwise so that the aesthetic could improve and not worsen after treatment. Our study had 75% cases within the MI anchorage group and had the outcome of "greatly improved" when assessed by the PAR index [Table 10]. This result was higher than that of the conventional group (53.1%) and higher than that of Stalpers (2007) (73%).[15]

Conclusions

The findings, obtained through cephalometric radiographs and the PAR index in skeletal class II malocclusion, revealed that mini-implant (MI) anchorage is more effective than conventional anchorage. The use of MI anchorage allowed for greater posterior retraction and intrusion of the maxillary incisors while maintaining or rotating the mandibular plane counterclockwise. According to the PAR index, the quality of the outcomes was significantly improved and superior with MI anchorage compared to conventional methods.

Proof of consent

Ethics approval was obtained from the institutional review board of the National Hospital of Odonto-Stomatology. Informed consents were obtained from the subjects included in the study. All procedures performed in studies involving human participants were by the ethical standards of the 1964 Helsinki Declaration and its later amends or comparable ethical standards.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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