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Original Article

A Cephalometric Evaluation of Dentoskeletal and Soft Tissue Changes with Mini-Implants versus Conventional Methods of Anchorage Reinforcement for En-masse Retraction of Anterior Teeth in Bialveolar Dental Protrusion Cases

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Abstract

Aims: The purpose of this study was to investigate and compare the dentoskeletal and soft-tissue treatment effects with mini-implants as anchor units in bialveolar dental protrusion patients requiring extraction of four first premolars and maximum retraction of anterior teeth with patients treated by conventional methods of anchorage reinforcement. In addition, the anchorage loss and the time taken for space closure were recorded.

Materials and Methods: A total of 20 patients were assigned to two groups each containing 10 patients - group 1 (G1) - anterior space closure was done with mini-implants as anchorage and group 2 (G2) - anterior space closure was done with conventional methods of anchorage. Skeletal, dental, and soft-tissue changes were analyzed in both groups on lateral cephalograms taken before retraction (T1) and after space closure (T2).

Statistical Analysis Used: Student *t*-test was done to analyze the treatment changes in the 2 groups.

Results: For the skeletal parameters, a statistically significant decrease in the facial vertical dimensions was seen in G1 ($P < 0.01$), but the variables in G2 showed a significant increase ($P < 0.01$). Anchorage loss, in both the horizontal and vertical directions, was noted in G2, whereas G1 showed distalization (anchorage gain) and intrusion of molars. Although the soft-tissue response was variable, facial convexity angle, nasolabial angle, and lower lip protrusion had greater changes in G1.

Conclusion: Mini-implants are more efficient for intra-oral anchorage reinforcement for en-masse retraction than conventional methods of anchorage reinforcement. The skeletal, dental, and soft tissue treatment changes were favorable. However, no differences in the mean retraction time were noted between the two groups.

Key words: Anchorage, Mini-implant, Space closure

INTRODUCTION

Bialveolar dental protrusion is one of the most common problems seen today around the globe. Dentoalveolar flaring of the anterior teeth with resultant protrusion of lips and convexity of the face are unique features of bimaxillary protrusion. Protrusive lips and a convex facial profile usually result in poor facial esthetics.[1]

The current treatment modality followed by most orthodontists to treat bialveolar protrusion is the extraction of the four first premolars. It was also observed that retraction of maxillary incisors causes upper lip retraction, increases the length of the lower lip and the nasolabial angle, whereas mandibular incisor position determines lower lip position

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and shape. The magnitude of anterior dental reduction and the resulting change in lip position is determined not merely by the extraction of teeth but by how anchorage is managed. Anchorage loss is the reciprocal reaction of the anchor unit that can obstruct the success of orthodontic treatment by complicating anteroposterior correction.[2]

Minimizing anchorage loss during the treatment of such cases is of paramount importance. To address this problem, many appliances and techniques have been devised; Nance holding arch, transpalatal bars, extraoral traction, multiple teeth at the anchorage segment, and differential moments are the commonly used ones.[3]

The advent of temporary skeletal anchorage devices (TSADs) such as mini-implants and mini-screws has, however, significantly simplified orthodontic biomechanics by providing independent absolute anchorage.[4] With its help, it is now possible to obtain absolute anchorage of the posterior teeth and close the extraction spaces completely by anterior teeth retraction. Their primary advantages are easy placement and removal, immediate loading, placement at various anatomic locations including the alveolar bone between the roots of teeth, and low cost.[3] Consequently, TSADs are quickly becoming the preferred method of skeletal anchorage. Despite all the above advantages, what is of primary importance is to know whether the TSAD's are efficient enough to hold the anchorage units intact during en-masse retraction.

The aims and objectives of this study were:
1. To compare the dentoskeletal changes in bialveolar dental protrusion patients requiring extraction of four first premolars with mini implants as anchor units when compared with conventional methods of anchorage reinforcement for en-masse retraction of anterior teeth
2. To compare soft tissue changes between the two groups
3. To compare the amount of anchorage loss between the two groups
4. To compare the time taken for space closure in both the groups.

Thus, the null hypothesis in the study is that mini-implants are more efficient for intra-oral anchorage reinforcement for en-masse retraction than conventional methods of anchorage reinforcement.

MATERIALS AND METHODS

The study included 20 Class I bialveolar protrusion patients between the age group of 15–25 years in the permanent dentition. The sample was randomly divided into two groups of 10 each: the study group (G1) [Figure 1] and the control group (G2). For all the 20 patients, consent was taken regarding the extraction of four first premolars. In the study group G1, consent was also taken from the patients regarding the placement and removal of implants under local anesthesia.

The inclusion criteria were:
1. Minimum age of 14 years at the beginning of treatment, to minimize confounding results due to growth
2. Class I molar relationship (±1 mm) and overjet not exceeding 5 mm (measured on the study models with a digital caliper)
3. Well-aligned maxillary and mandibular incisors with minimum crowding (<3.5 mm).

The exclusion criteria were:
1. Previous history of mouth breathing, thumb sucking, tongue thrusting, or orthodontic treatment
2. Congenitally missing teeth except for third molars.

In both the groups, only the first molars were banded and all the remaining teeth mesial to the first molars were bonded. All patients were treated with the pre-adjusted edgewise appliance system (MBT prescription, slot size 0.022 × 0.028 in). After the initial leveling and aligning 0.017 × 0.025-in stainless steel archwires with crimpable hooks were placed distal to the lateral incisors in both arches. To ensure that the wires remained passive, they were left in place for at least 4 weeks before starting the en-masse retraction procedure.

In G1 subjects, titanium mini-implants (1.3 mm in diameter, 5–9 mm in length, self-drilling, S.K. Surgicals, Pune) [Figure 2] were used as anchorage units in both the arches. Implants were placed in the alveolar bone between the roots of the first molar and second premolar at the mucogingival junction. The implants were then immediately loaded with pre-calibrated nickel-titanium closed-coil springs (150 g, Dentos India Pvt. Ltd., Mumbai) extending from the implant head to the crimpable hooks for en-masse retraction of maxillary and mandibular anterior teeth [Figures 3 and 4].

In G2 subjects, conventional methods of anchorage reinforcement were used according to the need of space closure, such as transpalatal arches, banding of the second molars, and application of differential moments. After initial leveling and aligning, 0.017 × 0.025-in stainless steel archwires with hooks were placed in a passive state for 4 weeks, and then conventional sliding mechanics were employed for en-masse anterior retraction.

To estimate treatment changes primarily due to retraction of anterior teeth, lateral cephalograms were taken at the end of alignment (T1) and after space closure (T2) in both the

Figure 1: Pretreatment intraoral photos of G1 subject

Figure 2: Titanium mini-implants (1.3 mm in diameter, 5-9 mm in length, self drilling, S.K. Surgicals, Pune)

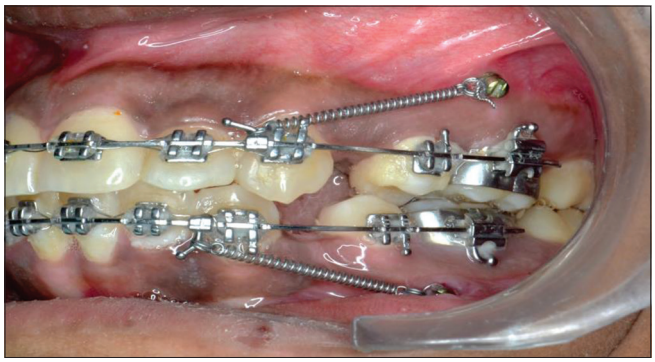

Figure 3: Nickel titanium closed coil springs extending from the implant head to the crimpable hooks in G1 subject

Figure 4: End of space closure intraoral photos of G1 subject

groups. All the 40 cephalograms were traced and analyzed to assess the skeletal, dental, and soft tissue changes.

The cephalometric parameters used in this study were as follows:

Landmarks

Hard tissue [Figure 5]

(1) Nasion (N), (2) Sella (S), (3) Pogonion (Pog), (4) Gnathion (Gn), (5) Gonion (Go), (6) Point A, (7) Point B, (8) Mesial cusp tip of maxillary first molar (U6), (9) Mesial cusp tip of mandibular first molar (L6), (10) Incisal tip of maxillary central incisor (U1), (11) Incisal tip of mandibular central incisor (L1).

Soft tissue [Figure 5]

(12) Nasal tip (Nt), (13) Subnasale (Sn), (14) Sulcus superior (Ss), (15) Labrale superior (Ls), (16) Labrale

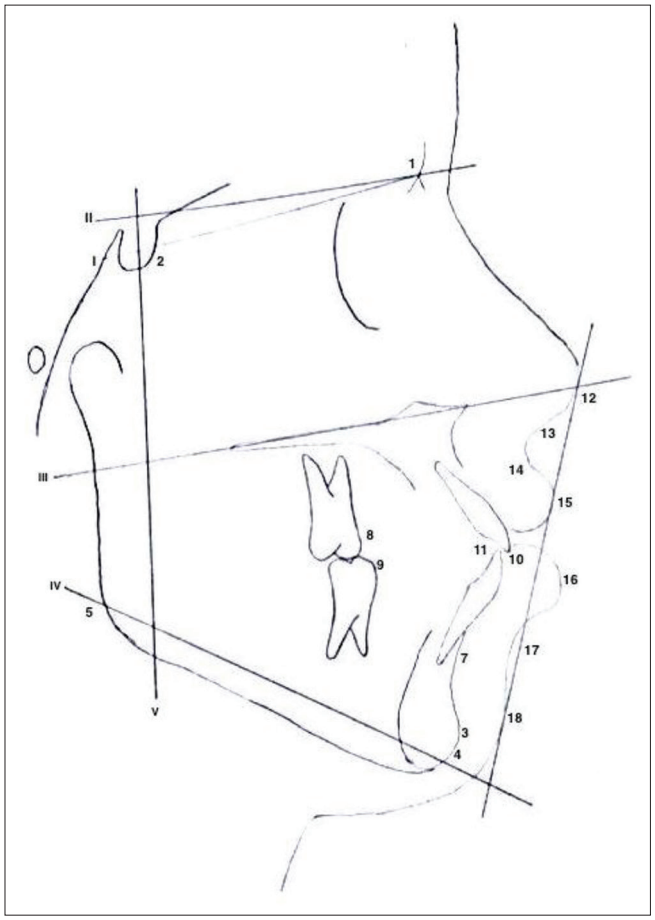

Figure 5: Cephalometric landmarks (hard tissue, soft tissue) and cephalometric planes (Cephalometric landmarks [hard tissue]: (1) nasion [N]; (2) sella [S]; (3) pogonion [Pog]; (4) gnathion [Gn]; (5) gonion [Go]; (6) Point A; (7) Point B; (8) U6; (9) L6; (10) U1; (11) L1. Cephalometric landmarks [soft tissue]: (12) Nt; (13) Sn; (14) Ss; (15) Ls; (16) Li; (17) Si; (18) Pg. Cephalometric planes: (I) S-N plane; (II) constructed Frankfort horizontal plane [x-axis]; (III) palatal plane [anterior nasal spine [ANS]-posterior nasal spine [PNS]); (IV) mandibular plane [Go-Gn); (V) sella vertical [Sv or y-axis); (VI) Ricketts' E-plane [Nt-Pg])

inferior (Li), (17) Sulcus inferior (Si), (18) Soft-tissue Pog (Pg).

Cephalometric planes [Figure 5]

(I) S-N plane, (II) Constructed Frankfort horizontal plane (X-axis), (III) Palatal plane (anterior nasal spine [ANS] - posterior nasal spine [PNS]) (IV) Mandibular plane (Go-Gn), (V) Sella vertical (Sv or Y-axis), (VI) Ricketts' E-plane (Nt-Pg).

Skeletal angular measurements [Figure 6]

(1) SNA angle, (2) SNB angle, (3) ANB angle, (4) SN-Go-Gn.

Skeletal linear measurements [Figure 6]

(5) Upper facial height (UFH) (N-ANS), (6) lower facial height (LFH) (ANS-Me), (7) posterior facial height (PFH) (S-Go), (8) total anterior facial height (TAFH) (N-Me), (9) Sv-Pog.

Dental angular measurements [Figure 7]

(1) U1-SN Plane, (2) IMPA, (3) Interincisal angle (U1-L1).

Dental linear measurements [Figure 7]

(4) Vertical position of maxillary first molar (U6-PP), (5) Sagittal position of maxillary first molar (U6-Sv), (6) Sagittal position of mandibular first molar (L6-Sv), (7) Vertical position of mandibular first molar (L6-MP), (8) Sagittal position of maxillary incisor edge (U1-Sv), (9) Sagittal position of mandibular incisal edge (L1-Sv).

Soft tissue angular measurements [Figure 8]

(1) Facial convexity angle (G-Sn-Pg), (2) Nasolabial angle (Sn tangent and Sn-Ls), (3) Labiomental angle (Li-Si and Si-Pg).

Soft tissue linear measurements [Figure 8]

(4) Sv-Nt; (5) E-line – Ss; (6) E-line – Ls; (7) E-line – Li; (8) E-line – Si.

RESULTS

The data obtained from this study was evaluated and comparisons were made within the group and between the study group (G1) and the control group (G2). Means, standard deviations, correlation coefficients, and level of

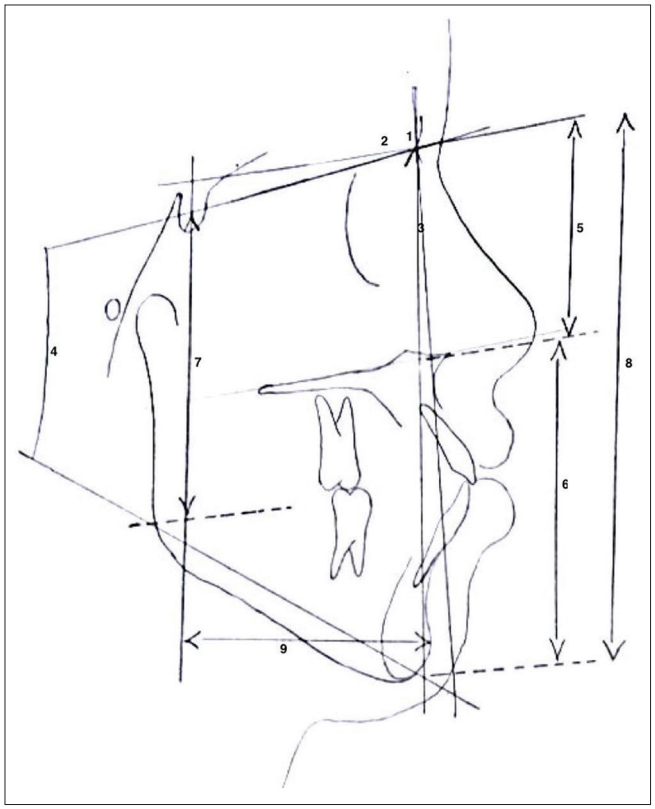

Figure 6: Skeletal angular and linear measurements (Skeletal angular measurements: (1) SNA angle; (2) SNB angle; (3) ANB angle; (4) SN-Go-Gn. Skeletal linear measurements: (5) Upper facial height [N-ANS]; (6) Lower facial height [ANS- Me]; (7) Posterior facial height [S-Go]; (8) Total anterior facial height [N-Me]; (9) Sella vertical-Pogonion)

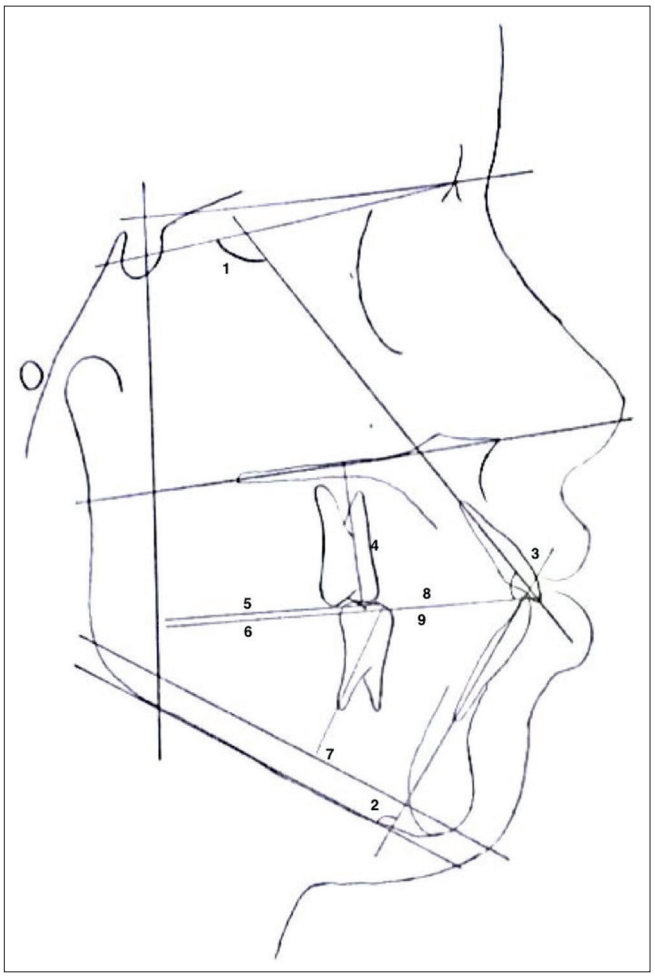

Figure 7: Dental angular and linear measurements (Dental angular measurements: (1) U1-SN plane; (2) IMPA; (3) U1-L1 [interincisal angle]. Dental linear measurements: (4) U6-PP; (5) U6-Sv; (6) L6-Sv; (7) L6-MP; (8) U1-Sv; (9) L1-Sv)

significance were determined. Student t-test was done to find the significance of study parameters within each group. $P < 0.01$ indicated strong significance. *P*-value between 0.01 and 0.05 ($0.01<P<0.05$) indicated moderate significance.

(* Moderately significant [*P*-value: $0.01<P\leq0.05$], ** Strongly significant [*P*-value: $P \leq 0.01$]).

Age and duration of time taken for retraction:
Although mean retraction time for G1 (8.55 ± 0.55 months) was less than that of G2 (9.05 ± 0.72 months), the differences were not significant ($P > 0.01$) [Table 1].

Skeletal Changes

Both the implant group and conventional group had a significant reduction in the SNA angle ($P \leq 0.01$), moderate reduction in the ANB angle ($0.01<P\leq0.05$), and no significant change in SNB. Forward displacement of the chin (Sv-Pg) was noted for the implant group. The implant group showed significant increase in the UFH, PFH, and reduction in the SN-MP angle ($P \leq 0.01$). In the conventional group, there was only a moderate increase in the UFH ($0.01<P\leq0.05$) and significant increase in the LFH ($P \leq 0.01$). However, there was a significant increase in the SN-MP angle ($P \leq 0.01$). The differences between G1 and G2 were statistically significant ($P < 0.05$) [Tables 2 and 3].

Dental Changes

No anchor loss was observed in the horizontal direction in the implant group. Instead a net distal movement was recorded, which was clinically and statistically significant ($P \leq 0.001$). On the other hand, in the control group the molars showed clinically and statistically significant levels of molar mesialization ($P \leq 0.001$). Significant vertical changes were also observed in both the groups. In the implant group, there was significant intrusion of the molars whereas in the conventional group there was extrusion of the molars ($P \leq 0.001$). The incisors in both the groups showed significant intrusion but more so in the implant group ($P < 0.05$) [Tables 4 and 5].

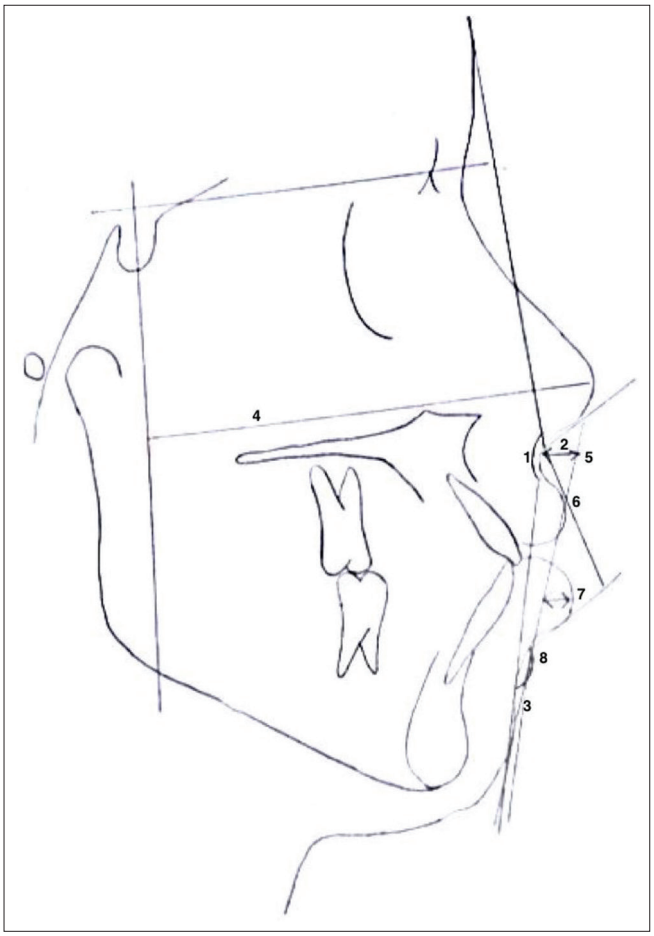

Figure 8: Soft-tissue angular and linear measurements (Soft-tissue angular measurements: (1) G-Sn-Pg; (2) nasolabial angle; (3) labiomental angle. Soft-tissue linear measurements: (4) Sv-Nt; (5) E-line–Ss: distance from sulcus superior to E-line; (6) E-line–Ls; (7) E-line–Li; (8) E-line– Si)`

Table 1: Age and duration of retraction

	Group G1	Group G2	*P*-value
Age in years	20.50±3.78	24.30±4.24	0.049*
Duration of retraction	8.55±0.55	9.05±0.72	0.099+

Table 2: A comparison of skeletal effects in G1 group AT T1 and T2

Skeletal effects in G1	T1	T2	*P*-value
SNA Angle (degree)	82.70±1.49	81.30±1.42	0.003**
SNB Angle (degree)	79.10±1.73	79.30±1.49	0.555
ANB Angle (degree)	3.20±1.14	2.20±0.92	0.042*
SN-GO-GN	31.50±1.96	30.00±2.11	0.009**
UFH (N-ANS) (mm)	50.60±7.12	52.30±7.17	0.001**
LFH (ANS-Me)(mm)	68.00±2.94	67.40±2.50	0.217
PFH (S-Go)(mm)	78.10±6.31	78.80±6.27	0.010**
TAFH (N-Me)(mm)	116.90±9.02	117.20±8.94	0.627
SV-Pog(mm)	58.40±4.53	59.80±5.27	0.013*

UFH: Upper facial height, LFH: Lower facial height, PFH: Posterior facial height, TAFH: Total anterior facial height, SV-Pog: Sella vertical-Pogonion

Table 3: A comparison of skeletal effects in G2 group at T1 and T2

Skeletal effects in G2	T1	T2	*P*-value
SNA Angle (degree)	83.30±1.83	82.10±2.08	<0.001**
SNB Angle (degree)	78.80±1.62	78.70±1.83	0.811
ANB Angle (degree)	4.50±1.58	3.40±1.26	0.024*
SN-GO-GN	32.70±3.09	34.50±2.32	0.001**
UFH (N-ANS) (mm)	51.10±3.81	51.80±3.43	0.025*
LFH (ANS-Me)(mm)	70.00±5.81	71.90±5.26	0.001**
PFH (S-Go)(mm)	80.50±6.72	81.00±6.86	0.096+
TAFH (N-Me)(mm)	119.80±8.77	123.10±8.84	<0.001**
SV-Pog(mm)	58.30±4.08	57.70±3.71	0.111

UFH: Upper facial height, LFH: Lower facial height, PFH: Posterior facial height, TAFH: Total anterior facial height, SV-Pog: Sella vertical-Pogonion

Soft Tissue Changes

Profile changes (labiomental angle, nasiolabial angle, and facial convexity angle) showed significant changes in both the groups ($P \leq 0.01$), but changes were more pronounced in the implant group ($P < 0.05$). There were statistically significant levels of lip retraction seen in both groups ($P \leq 0.01$) but the intergroup difference was not statistically significant ($P > 0.05$) [Tables 6 and 7].

DISCUSSION

Preserving anchorage has always been a humongous task for the orthodontist. Conventional methods of anchorage control included both intraoral and extraoral means. With the advent of preadjusted edge-wise appliance systems, sliding mechanics has become a commonly practiced technique. During the past 5 years, anchorage control with self-tapping screws or mini-implants has gained enormous credibility in the clinical management of space closure.

Upadhyay *et al.* conducted a study to determine the efficiency of mini-implants as intraoral anchorage units for en-masse retraction of the 6 maxillary anterior teeth when the first premolars were extracted compared with conventional methods of anchorage reinforcement. Thirty patients requiring high anchorage after extraction of the maxillary first premolars were selected for this study. They were divided into two groups of 15 each. In the first group (G1), mini-implants were used for en-masse retraction; in the second group (G2), conventional methods of anchorage preservation were followed. Horizontal, vertical, and angular positions of the maxillary first molar and central incisor were evaluated cephalometrically before and after orthodontic retraction. The maxillary first molars in the G1 patients showed net distal movement of 0.55 mm, and mesial movement of 1.95 mm was found in G2. The differences were statistically significant In G1 patients; net intrusive

Table 4: A comparison of dental effects In G1 group at T1 and T2

Dental Effects in G1	T1	T2	*P*-value
U1-SN Plane (Degree)	112.00±2.67	99.90±1.66	<0.001**
IMPA (Degree)	99.00±4.59	88.30±3.09	<0.001**
Interincisal angle (U1-L1) (Degree)	114.20±5.22	134.20±4.61	<0.001**
Vertical position of maxillary first molar (U6-PP) (mm)	24.20±1.99	22.90±1.91	0.001**
Sagittal position of maxillary first molar (U6-Sv) (mm)	42.70±2.31	41.60±3.06	0.048*
Sagittal position of mandibular first molar (L6-Sv) (mm)	45.70±2.11	44.40±2.80	0.004**
Vertical position of mandibular first molar (L6-MP) (mm)	31.70±3.23	30.10±3.11	<0.001**
Sagittal position of maxillary incisor edge (U1-Sv) (mm)	70.80±3.91	64.20±3.88	<0.001**
Sagittal position of mandibular incisal edge (L1-Sv) (mm)	67.50±3.84	62.50±3.44	<0.001**

Table 5: A comparison of dental effects in G2 group at T1 and T2

Dental Effects in G2	T1	T2	*P*-value
U1-SN Plane (Degree)	112.50±2.12	105.80±7.16	0.008**
IMPA (Degree)	99.10±2.73	92.20±1.99	<0.001**
Interincisal angle (U1-L1)(Degree)	115.00±4.06	128.60±2.72	<0.001**
Vertical position of maxillary first molar (U6-PP) (mm)	24.80±2.25	27.00±2.31	<0.001**
Sagittal position of maxillary first molar (U6-Sv) (mm)	42.80±4.87	45.00±4.78	<0.001**
Sagittal position of mandibular first molar (L6-Sv) (mm)	46.00±5.60	48.40±6.15	<0.001**
Vertical position of mandibular first molar (L6-MP) (mm)	34.90±3.21	36.90±3.35	<0.001**
Sagittal position of maxillary incisor edge (U1-Sv) (mm)	71.70±6.46	67.50±6.24	<0.001**
Sagittal position of mandibular incisal edge (L1-Sv) (mm)	68.70±5.98	65.30±5.64	<0.001**

Table 6: A comparison of soft tissue changes in G1 group at T1 and T2

Soft tissue changes in G1	T1	T2	*P*-value
Facial convexity angle (G-Sn-Pg) (Degree)	162.70±9.27	159.70±8.91	<0.001**
Nasolabial angle (Sn tangent and Sn-Ls) (Degree)	94.20±4.83	106.30±3.92	<0.001**
Labiomental angle (Li-Si and Si-Pg) (Degree)	122.80±5.69	127.60±5.82	<0.001**
SV-Nt (mm)	93.00±5.52	94.10±5.28	<0.001**
E-line–Ss (mm)	–4.30±3.92	–6.60±2.87	0.001**
E-line–Ls (mm)	2.30±1.95	1.30±1.89	<0.001**
E-line–Li (mm)	4.60±1.43	0.90±0.88	<0.001**
E-line–Si (mm)	–3.00±0.94	–5.70±0.95	<0.001**

Table 7: A comparison of soft tissue changes in G2 group at T1 and T2

Soft tissue changes in G2	T1	T2	*P*-value
Facial convexity angle (G-Sn-Pg) (Degree)	160.90±3.48	159.40±3.92	0.048*
Nasolabial angle (Sn tangent and Sn-Ls) (Degree)	96.60±2.63	103.00±3.02	<0.001**
Labiomental angle (Li-Si and Si-Pg) (Degree)	122.30±13.47	127.20±13.64	<0.001**
SV-Nt (mm)	95.50±7.09	95.50±6.50	1.000
E-line–Ss (mm)	–5.60±1.96	–7.15±1.67	<0.001**
E-line–Ls (mm)	1.40±1.43	0.60±1.07	<0.001**
E-line–Li (mm)	4.30±1.77	1.00±1.49	<0.001**
E-line–Si (mm)	–3.70±1.30	–5.65±1.38	<0.001**

effect on the molars was recorded though not statistically significant. No significant differences were found in the rates of incisor retraction between the two groups. However, G1 showed more than 2 mm of incisor intrusion, which was statistically significant. The average time required for space closure was 9.2 months in G1 and 10.6 months in G2.[2]

The findings in our study corroborated the above study. It was seen that time required for space closure was less in G1 (8.55 ± 0.55 months) than G2 (9.05 ± 0.72 months) subjects, the differences were however not significant. G1 patients showed distal movement of the maxillary first molars along with intrusion of the same whereas G2 subjects showed mesial movement and extrusion of the maxillary first molars. There was significant incisor retraction in both the groups, however greater retraction was found in G1 subjects ($P \leq 0.01$). Thus, the above study supports our study.

Thiruvenkatachari *et al.*, conducted a study to compare and measure the amount of anchorage loss with titanium microimplants and conventional molar anchorage during canine retraction. Subjects for this study comprised ten orthodontic patients (seven women, three men) with a mean age of 19.6 years (range, 18–25 years), who had therapeutic extraction of all first premolars. After leveling and aligning, titanium microimplants 1.3 mm in diameter and 9 mm in length were placed between the roots of the second premolars and the first molars. Implants were placed in the maxillary and mandibular arches on 1 side in 8 patients and in the maxilla only in two patients. A brass wire guide and an intraoral periapical radiograph were used to determine the implant positions. After 15 days, the implants and the molars were loaded with closed-coil springs for canine retraction. Lateral cephalograms were taken before and after retraction, and the tracings were superimposed to assess anchorage loss. The amount of molar anchorage loss was measured from the pterygoid vertical in the maxilla and sella-nasion perpendicular in the mandible. The superimpositions showed that anchorage loss occurred on the nonimplant side, which was evident with the mesial migration of that molar; anchorage loss did not occur on the implant side, and no mesial movement was noted there. Anchorage loss was <20% on the molar-anchored side which was acceptable for the subjects selected. Anchorage loss in this study ranged from 1 to 2 mm with means of 1.6 mm in the maxilla and 1.7 mm in the mandible. Statistical analyses showed a significant anchorage loss in both the maxilla and the mandible.[5]

In our study too, we saw that there was significant anchor loss of the first molars in both maxilla and mandible in the conventional anchorage group. There was mesial migration of the maxillary and mandibular first molars in the sagittal plane and the differences were statistically significant ($P \leq 0.01$), when compared with the implant group. Thus, the above study affirms our study.

Rajni *et al.* did a study where three sets of profile cephalograms- pre-treatment, pre retraction and post retraction cephalograms of 20 skeletal Class I dentoalveolar bimaxillary protrusion patients, half of which were treated with conventional enmasse sliding mechanics and other half by enmasse sliding mechanics using micro-implants were obtained. Seven parameters were used to evaluate anchorage loss, quality of retraction, and treatment duration. It was seen that the control group showed an anchorage loss of 1.72 mm whereas implant-supported group showed an anchorage loss of only 0.09 mm. The quality of retraction of upper incisors obtained by retracting with help of implants was superior to that obtained by conventional enmasse sliding mechanics. Control group showed mean retraction of upper incisors by 2.5 mm during space closure and experimental group showed mean retraction of 3.79 mm. Both were highly significant. There was no significant difference in the treatment duration between the two groups.[6]

When compared with the above study, our study too showed similar findings. There was anchor loss in the sagittal and vertical direction of the maxillary first molars in the conventional group whereas there was little or no anchor loss in the mini-implant group. There was significant retraction of the upper incisors in both the groups but more so in the mini-implant group ($P \leq 0.01$). Although treatment time was slightly shorter in the mini-implant group, it was not significant. Thus, the above study supports our study.

CONCLUSION

The quality of retraction obtained by retracting with the help of implants was superior to that obtained by conventional enmasse sliding mechanics.

Thus, the following conclusions were made:

1. Mini implants were efficient sources of intraoral anchorage and remained stable all throughout the retraction phase. The advantages of the treatment approach were - elimination of compliance-depended intraoral and extraoral anchorage aids, favorable esthetics, immediate force application, and relatively predictable outcomes
2. The screw insertion and retrieval procedures were quick, simple, and painless
3. Although mean retraction time for implant group was less than that of the conventional one, the differences were not significant ($P > 0.01$)

4. Both the implant group and conventional group had a significant reduction in the SNA angle ($P \leq 0.01$), moderate reduction in the ANB angle ($0.01<P\leq0.05$), and no significant change in SNB. Forward displacement of the chin (Sv-Pg) was noted for the implant group
5. The implant group showed significant increase in the UFH, PFH and reduction in the SN-MP angle ($P \leq 0.01$). In the conventional group, there was only a moderate increase in the UFH ($0.01<P\leq0.05$) and significant increase in the LFH ($P \leq 0.01$). However, there was a significant increase in the SN-MP angle ($P \leq 0.01$). The differences between G1 and G2 were statistically significant ($P < 0.05$)
6. No anchor loss was observed in the horizontal direction in the implant group. Instead, a net distal movement was recorded, which was clinically and statistically significant ($P \leq 0.001$). On the other hand, in the control group the molars showed clinically and statistically significant levels of molar mesialization ($P \leq 0.001$)
7. Significant vertical changes were also observed in both the groups. In the implant group, there was significant intrusion of the molars whereas in the conventional group there was extrusion of the molars ($P \leq 0.001$)
8. The incisors in both the groups showed significant intrusion but more so in the implant group ($P < 0.05$)
9. Profile changes (labiomental angle, nasiolabial angle, and facial convexity angle) showed significant changes in both the groups ($P \leq 0.01$) but changes were more pronounced in the implant group ($P < 0.05$)
10. There was statistically significant levels of lip retraction seen in both groups ($P \leq 0.01$) but the intergroup differences were not statistically significant ($P > 0.05$).

Thus, the null hypothesis in the study that mini-implants are efficient for intra-oral anchorage reinforcement for en-masse retraction than conventional methods of anchorage reinforcement is acceptable.

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