A clinical comparative study using anchorage from mini-implants and conventional anchorage methods to retract anterior teeth

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ABSTRACT

Background: Proclined teeth has been one of the main reasons for compromised esthetics. In a patient with proclined anteriors, retraction is done after 1st premolar extraction. Absolute/maximum anchorage is required to achieve the best esthetics.

Objective: We conducted this study with the aim of retracting the proclined maxillary anterior teeth and to check for efficient retraction, type of tooth movement during retraction, and amount of anchorage loss.

Methods: Patients with proclined anterior teeth where therapeutic extraction of first premolars is required were included in the study, where anchorage was taken with mini-implants in one group, and in the second group, conventional anchorage method of 1st and 2nd molar banding with TPA was chosen. Each group consisted of 8 subjects. Lateral cephalogram was taken both preretraction and 4 months after starting retraction to compare anchor loss, rate of retraction, and type of tooth movement of retracted anteriors, in both groups.

Results: The retraction in the implant group was more than in the conventional group and the difference was statistically significant (P < 0.05). Anchorage loss was seen to be greater in conventional group than in the implant group and was also significant statistically. The type of tooth movement of the anterior teeth on retraction was also compared, with the implant group showing predominantly controlled tipping and the conventional group showing uncontrolled tipping movement.

Keywords: Anchorage loss, anterior teeth, mini-implants, proclination

Introduction

One of the major concerns in orthodontic patients is facial esthetics. Also, patients demand fast treatment time, that does not stretch to years, and does not require constant oral hygiene care. This would improve oral health, and overall well-being, without causing any burnout from long treatment times. Better esthetics also provide increased confidence in young adults.

Protrusive upper lip is seen in cases with protrusion of maxillary teeth in Angle’s Class II Div I malocclusion and Class I bimaxillary protrusion. Such cases require therapeutic first premolar extraction, and ideally, the anterior teeth are retracted completely without any inadvertent reactionary mesial molar movement.

According to Newton’s Third law, for every action, there is an equal and opposite reaction. Thus, anchorage control has...
been one of the major concerns for orthodontists. It was only in 1923, that Louis Ottofy described it as “the base against which orthodontic force or reaction of orthodontic force is applied.”

Williams and Hosila found that only 66.5% of extraction space is used while retracting anterior teeth in first premolar extraction cases. Creekmore noted that space available for retraction of anterior segment and relief of crowding is only two-thirds of the extraction space as the posterior segment moves mesially when retraction is attempted.

In a traditional approach, extraoral appliances (headgear, facemask) or intraoral aids (transpalatal arch, nance holding arch, multiple teeth as anchor segments) have been used, but not without disadvantages such as, unfavourable reactionary tooth movements and patient compliance. To overcome these limitations, Temporary Anchorage Devices (TADs) that get anchored in bone, came into being. They can be used for direct anchorage or can help support posterior teeth that form anchorage unit (indirect anchorage).

In 1983, Creekmore and Ekland first used vitallium implant for anchorage, to intrude maxillary incisors in a 25-year-old female. Fourteen years later, in 1997, Konami used anchorage from mini-implant for orthodontic purposes. Consequently, multiple screws with varied designs were developed.

In this study, comparison in treatment effects of retraction using two methods of anchorage i.e., mini-implant and conventional methods, in cases where anterior retraction is needed in the first premolar extraction space (Angles Class II div I or Angles Class I with bialveolar protrusion), using sliding mechanics. Amount of retraction and anchor loss with type of tooth movement seen in a 4-month interval was recorded.

Materials and Methods

A prospective clinical trial was done in the department of Orthodontics and Dentofacial Orthopedics, after getting ethical approval from Institutional Ethical committee and informed consent was taken from each participant 10/05/2013.

The patient selection criteria was as follows: (1) comprehensive medical and dental history showing absence of any systemic disease (2) absence of congenitally missing teeth except third molars (3) Minimal or complete absence of anterior crowding (4) cases requiring therapeutic first premolar extraction. (5) Angles Class I bimaxillary protrusion, or Angles Class II malocclusion with proclined anteriors, requiring maximum anchorage that is 75% to 100% space closure; (6) young patients that is between 16 and 25 years of age, well past their pubertal growth.

Patients with history of periodontal problems or previous orthodontic treatment were excluded from the study.

Sixteen subjects were enrolled and put in two different groups of 8 each. After sampling, implant group (Group 1), consisted of 4 males and 4 females (mean age 19.87 years) and the conventional group (Group 2) consisted of 2 males and 6 females (mean age of 22.25 years).

Preadjusted edgewise appliance 0.022” slot MBT appliance was selected, and banding of molars was done. Retraction was done on a 19 x 25 ss wire engaged passively. At this stage, pre-retraction records including lateral cephalogram, OPG, study models, extraoral, and intraoral photographs were taken and repeated after 4 months of retraction.

The basic mechanism of retraction consisted of three parts [Figure 1]:
1. Anterior segment
2. Posterior segment.
3. Retraction Niti coil spring attached to the anchor source at one end, and power arm at the other end.

For group 1 (implant group) patients, the site between the 2nd premolar and 1st molar was selected for the placement of implants on either side. The SK Surgical (Pune) titanium implants were selected [Figure 2a]. For precise placement, a template made with 17 x 25 ss wire was utilized [Figure 3a and b]. The implants were placed as high as possible in the attached gingiva to prevent bite deepening during space closure. Subsequently IOPAs were taken with the parallex method to check correct template placement. After complete sterilization and asepsis, local anesthesia was given above the site. A bleeding point was made in center of eyelet of the template, to mark the site of implant placement. The jig was removed and a 1.3 x 8 mm self-tapping implant was inserted at the bleeding point site, on both sides. Primary stability of implant was checked and another IOPA was taken to ensure correct placement of implant. Hooks soldered between the lateral incisor and canine on the working archwire served as power arms. Retraction force was applied after a week of implant insertion, as suggested by Park, with closed coil Niti springs,
providing 150–160 grams of force calibrated using dontrix guage [Figure 2b]. Once the retraction mechanics were initiated, the force levels were constantly checked.

For group 2, conventional anchorage methods were utilized. After leveling and alignment, when a passive 19 x 25 ss wire was reached, the posterior teeth were joined together to form the buccal stabilizing segment, which included the second premolar, first molar, second molars. TPA (transpalatal arch) was used to connect the posterior segments on both sides of arch, to prevent anchorage loss. To increase the stability of the posterior segment and also to prevent lingual tipping of the anterior segment while retracting, 0.019 x 0.025 inch ss wire was placed for the retraction phase. A power arms was soldered just as in implant group.

To check for molar anchorage loss and incisal retraction, lateral cephalogram tracings of the pre-retraction and the post-retraction stage were superimposed, and movements of the molar and incisor were measured taking a stable cranial reference that is, along SN plane.

Type of Tooth Movement

To check for changes in position of the central incisors, the quotient of the moved distance of the most apical point (Ia) and the moved distance of the most occlusal point (Io) was calculated. A negative sign was allotted to the amount, if the apical point moved in the opposite direction to the coronal point or vice versa. Classification of tooth movement was done as - (Ia/Io): < 0, uncontrolled tipping; =0, controlled tipping; >0, controlled tipping and bodily movement; 1, bodily movement; and >1, root movement. The numbers and percentages of the 3 types of tooth movement were calculated and assessed [Figure 4].

Statistical Analysis

SPSS software package (version 20.0, Chicago, Ill) was used for the statistical analysis. Mean and standard deviation were calculated for all values obtained from lateral cephalogram. To measure the treatment changes in the implant and conventional group, paired sample t-test was done. Independent-samples t test was utilized to compare mean treatment changes among the two groups. Level of significance was taken as P value <0.05.

Results

Retraction was assessed for 4 months and comparison was done for anchorage loss and incisor retraction. Changes were assessed when pretreatment values were subtracted from the post-treatment. Positive value indicated a large post-treatment value and represented mesial movement, crown anterior, and posterior root movement. A negative value indicates distal movement, crown posterior, and anterior angular root changes.

Molar movements

In the implant group the molar showed, though insignificant, net distal movement of -0.34 ± 0.83 mm on mesial and -0.37 ± 0.82 mm on the distal aspect of the molar. But conventional group showed highly significant mesial movement of 1.0 ± 0.37 mm on mesial and 1.18 ± 0.37 mm on distal. Difference between the groups was statistically significant (p < 0.05) [Table 1].

Vertically, a net intrusion of -0.50 ± 0.67 mm on mesial and -0.67 ± 0.99 mm on distal, but some extrusion was also seen in implant group. However, conventional group showed extrusion. Implant group showed net distal molar tipping of 0.563.07 (anchor gain) but conventional group showed significant mesial tipping of -2.25 ± 1.22 (anchor loss).

Movements of maxillary incisor

Greater incisor retraction was achieved in implant group (-5.0 ± 1.19 mm) than conventional (-3.12 ± 0.44 mm).

The incisal root apex moved distally slightly in implant anchorage (-0.62 ± 0.95 mm) but crown moved distally showing predominantly controlled tipping of incisors. But the conventional group apex moved mesially (+0.5 ± 1.38 mm) and crown moved distally, causing uncontrolled tipping.

Vertically, the maxillary incisor apex in implant group showed significant intrusion of -1.0 ± 0.75 mm, but incisal edge intruded to a lesser extent (-0.53 ± 1.05 mm). The conventional group showed significant incisal extrusion. Therefore, intergroup difference was significant.

The incisal proclination (I Angle) decreased by -11.25 ± 3.44° in implant group and by -7.56 ± 3.81° in the conventional group. [Table 1]
Rate of Retraction - Retraction achieved with implants in 4-month duration was 5.0 mm (1.25 mm/month) and 3.125 mm (0.78 mm/month) in the conventional group.

Type of Tooth Movement - The implant anchorage brought about controlled tipping with some translation (Ia/Io = 0.11 ± 0.16). The conventional group mostly showed uncontrolled tipping (Ia/Io = -0.13 ± 0.42). The intergroup differences were statistically insignificant [Table 2].

There was 62.5% of controlled tipping in the implant group. Some controlled tipping with bodily movement was also seen. This movement was higher in percentage than the conventional group (25%). The conventional group mostly showed uncontrolled tipping (75%). Uncontrolled tipping was not seen in the implant group (0%). [Table 3]

Discussion

Patients seek orthodontic treatment, to improve their esthetics which leads to greater psychological well-being. Anchorage preservation while retracting protruded teeth, provides best treatment results, and for this several techniques have been introduced. If sufficient control is maintained, shorter appointment time and overall shorter treatment duration can be provided to the patient. Conventional anchorage requirements are more critical, and various means such as banding of both first and second molars, transpalatal arch, headgear are utilized.

Miniscrews/microimplants or self-tapping screws have been introduced to augment anchorage while attempting space closure. They are screwed within the alveolar bone and can be used to derive direct anchorage without unwanted anchor tooth movements. Studies suggest that they decrease retraction period, without patient compliance.[1,8]

No implant failure was encountered in our study; hence, the success rate was 100%. To avoid uncontrolled tipping and have incisor intrusion, the retraction force was applied close to center of resistance of the anterior six teeth.[9] The horizontal component of force was more than the vertical component.

In the conventional group, the retraction force was applied from power arm on the first molar tube to the soldered hook anteriorly, making the line of force pass further away from the center of resistance of anterior teeth, and was predominantly horizontal. This caused uncontrolled tipping and extrusion.

Anchorage preservation

In our study, implant group (Group 1), showed net distal movement of 0.35 mm and distal tipping of 0.56° (anchor gain) of maxillary molar, though insignificant [Table 1]. When molar distalization occurs, the concurrent extrusion of molars leads to wedging effect and mandibular plane opens up.[10] But, we achieved molar intrusion even though it was insignificant (-0.51 mm on the mesial and -0.67 mm on the distal aspect) [Table 1]. As explained by Nanda,[11] while doing enmasse retraction of anterior teeth using implants, the continuous archwire might have displaced the posterior segment causing distal tipping and intrusion. This could be the reason for the distal tip and intrusion of the molars. As recommended by Nanda, the forces were not excessive and frequent activation was not done, hence, distal tipping and intrusion was not excessive enough to cause anterior open bite.

The conventional group (anchorage with TPA and 2nd molar banding), showed significant anchor loss of 1.09 mm and mesial tipping of the molar of -2.25° [Table 1]. Story and Smith had noticed that when the canines were retracted, 5–50% of anchor loss occurred, when the anchor unit consisted of second premolar and first molar only.[12] A study showed 1.6–4 mm of

| Parameter | n | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
|-----------|---|------|----|------|----|------|----|------|----|------|----|------|----|------|----|
| U6M-SV (mm) | 8 | -0.343 | 0.834 | 1.00 | 0.378 | -2.038 | -0.649 | -4.151 | 0.002 | S |
| U6D-SV (mm) | 8 | -0.375 | 0.824 | 1.188 | 0.372 | -2.169 | -0.831 | -4.989 | 0.001 | S |
| U6M-PP (mm) | 8 | -0.518 | 0.672 | 0.187 | 0.530 | -1.347 | -0.043 | -2.297 | 0.038 | S |
| U6D-PP (mm) | 8 | -0.671 | 0.993 | 0.563 | 0.177 | -2.067 | -0.401 | -3.46 | 0.010 | S |
| U6 Angle (°) | 8 | 0.563 | 3.076 | 2.250 | 1.225 | 0.172 | 5.453 | 2.642 | 0.039 | S |
| Ia-SV (mm) | 8 | -0.625 | 0.954 | 0.50 | 1.389 | -2.418 | 0.168 | -1.888 | 0.083 | NS |
| Io-SV (mm) | 8 | -5.00 | 1.195 | -3.125 | 0.443 | -2.896 | -0.854 | -4.160 | 0.003 | S |
| Ia-PP (mm) | 8 | -1.00 | 0.756 | 0.563 | 0.320 | -2.215 | -0.910 | -5.383 | 0.000 | HS |
| Io-PP (mm) | 8 | -0.531 | 1.055 | 0.750 | 0.535 | -2.209 | -0.353 | -3.062 | 0.012 | S |
| I Angle (°) | 8 | -11.25 | 3.443 | -7.563 | 3.812 | -7.586 | 0.212 | -2.03 | 0.062 | NS |

| Parameter | n | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
|-----------|---|------|----|------|----|------|----|------|----|------|----|------|----|------|----|
| Ia/Io | 8 | 0.115 | 0.166 | -0.138 | 0.425 | -0.112 | 0.617 | 1.563 | 0.152 | NS |
mesial molar movement with traditional mechanics. Some anchorage is achieved with intraoral transpalatal arch. However, studies such as those done by Bobak et al. and Ingervall, have shown that the transpalatal archs do not significantly modify the orthodontic anchorage.

Thiruvenkatachari et al. attempted to retract the canines with conventional molar anchorage, and noted anchorage loss of 1-2 mm with a mean of 1.6 mm in the maxilla. Basha et al. noted 1.73 mm of anchor loss in the conventional group which was statistically significant compared to the implant group. Upadhyay et al. also noted significant mesial movement of 1.95 mm in the conventional methods of anchorage, with mesial tipping of 3.7° of the molars. Thus, it can be said with great certainty, that implants are superior in providing anchorage. More recently, Davis et al. and Khlef et al. noted that implants provided greater anchorage. Becker et al. noticed gain of anchorage with anchorage from mini-implants. Thiruvenkatachari et al. where canine retraction proceeded at a faster rate in the implant (4.29 mm) than in conventional group (3.79 mm).

Vertically, significant mean intrusion at apex (1 mm) was seen in implant group but incisal edge intruded by 0.53 mm only. The net intrusion at the apex and incisal edge in the implant group was because the retraction force vector had some vertical component of force, even though it was mostly horizontal. This vertical component facilitated the intrusion.

In contrast, significant extrusion was seen in the conventional group at both apex (0.56 mm) and incisal edge (0.75 mm) as the force vector was horizontal and further away from center of resistance of anterior teeth. This led to uncontrolled...
tipping and led to undesirable bite deepening. These results can be corroborated with studies of Rajni et al.,[28] Upadhyay et al.[29] etc.

Between both the groups, differences were highly significant at the apex, and significant for the maxillary incisal edge, as intrusion was more apparent at apex in the implant group.

The angular incisal changes in implant group (−11.25°) were more than the conventional (−7.56°), even though a heavy 19 x 25 ss wire was used. This can be reasoned since patient sample in implant group had comparatively, more proclined anteriors preretraction, and in the conventional group, mild curve of spee was given in the wires, to prevent bite deepening.

Type of tooth movement

Controlled tipping was the predominant tooth movement with implants. However, the conventional group showed predominantly uncontrolled tipping. Intergroup difference was insignificant, as the apex in the conventional group moved mesially, to cause uncontrolled tipping, by mean of 0.5 mm only.

According to Horiuchi et al.,[21] width of the alveolar bone and palatal cortical bone could be some of the limiting factors during orthodontic retraction. The width of the alveolar bone was adequate for all the patients. In a study by Edward et al.[22] it was seen that bone remodeled with tooth movement at the level of mid-root and alveolar margins but not at higher levels. He inferreded that alveolar bone in the anteropalatal curve caused greater interference in retraction of teeth. This could be the reason for limited distal apical movement in implant group.

Also, the forces were directed close to center of resistance of anterior segment, causing controlled tipping, which is preferred when teeth are highly proclined.

In the conventional group, mostly uncontrolled tipping was seen as the retraction force vector was predominantly horizontal and away from center of resistance of the anterior teeth. A clockwise moment was generated, causing lingual tipping and extrusion.

In Upadhyay’s study,[10] the implant group showed controlled tipping and partly translation. This was similar to our study. The conventional group in his study, however showed, mostly controlled tipping, with uncontrolled tipping (−0.15 ± 0.56 mm).

The intergroup difference in his study was statistically significant. This was different from our study, where mostly uncontrolled tipping was noted in the conventional group, with only some controlled tipping with bodily movement. Also the intergroup difference of Ia/Io was insignificant [Table 3], as the apex moved in the opposite direction from the incisal edge, to cause uncontrolled tipping, but this movement was very less, with the change being non-significant (Ia-SV $P < 0.05$, Table 1).

Summary and Conclusion

The present study was undertaken to compare rate of retraction and amount of anchor loss using two different modes of anchorage when attempting retraction of the maxillary anterior teeth in cases requiring maximum anchorage. Mini-implants as anchorage were compared with conventional anchorage methods such as first and second molar banding with TPA. The following results were observed:

1. Less anchorage loss was seen with implants, but significant loss was seen in conventional group, clearly indicating that implants provide superior anchorage control.
2. Although insignificant, intrusion and distal molar tipping (anchorage gain) was noticed with implants. But significant mesial molar tipping and extrusion (anchor loss) was noticed in conventional group. This too, indicates that mini-implants provide better anchorage.
3. Greater incisal retraction was achieved with implant anchorage, decreasing treatment time.
4. Implants showed incisal intrusion, thus preventing deep bite, whereas conventional group showed extrusion causing unaesthetic bite deepening.
5. Controlled incisal movements occurred with implant anchorage, whereas uncontrolled tipping was seen in conventional group.
6. Lastly, no implant failure was encountered in our study, indicating that implants are firm bone anchors, provided oral hygiene is maintained.

It can be concluded that mini-implants provide a superior treatment result, be it in terms of efficient tooth movement, or anchorage control. Thus, they reduce the treatment duration, being of benefit to both the patient and orthodontist.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Yao CC, Lai EH, Chang JZ, Chen J, Chen YJ. Comparison of treatment outcomes between skeletal anchorage and extraoral anchorage in adults with maxillary dentoalveolar protrusion. Am J Orthod Dentofacial Orthop 2008;134:615-24.
2. Cope JB. Temporary anchorage devices in orthodontics: A paradigm shift. Semin Orthod 2005;11:3-9.
3. William R, Hosila RJ. The effect of different extraction sites upon incisor retraction. Am J Orthod 1976;69:388-410.
4. Creekmore TD. Where the teeth should be positioned in the face and the jaws and how to get them there. J Clin Orthod 1997;31:586-608.
5. Creekmore TD, Eklund MK. The possibility of skeletal anchorage. J Clin Orthod 1983;17:266-9.
6. Konami R. Mini-Implant for Orthodontic Anchorage. J Clin Orthod 1997;31:763-7.
7. Paik CH, Park IK, Woo YJ, Kim TW. Orthodontic Miniscrew implants, Clinical applications. St. Louis Mosby; 2009.
8. Kuroda S, Yamada K, Deguchi T, Kyung HM, Takano-Yamamoto T. Class II malocclusion treated with miniscrew anchorage: Comparison with traditional orthodontic mechanics outcomes. Am J Orthod Dentofacial Orthop 2009;135:302-9.
9. Park HS, Bae SM, Kyung HM, Sung JH. Micro-implant anchorage for treatment of skeletal Class I bialveolar protrusion. J Clin Orthod 2001;35:417-22.
10. Upadhyay M, Yadav S, Patil S. Mini implant anchorage for en masse retraction of maxillary anterior teeth: A clinical cephalometric study. Am J Orthod Dentofacial Orthop 2008;134:803 10.
11. Nanda R. Temporary Anchorage Devices in Orthodontics. St. Louis Mosby. 2008.
12. Storey E, Smith R. Force in orthodontics and its relation to tooth movement. Aust J Dent 1952;56:11-8.
13. Ziegler P, Ingervall B. A clinical study of maxillary canine retraction with a retraction spring and with sliding mechanics. Am J Orthod Dentofacial Orthop 1989;95:99-106.
14. Bobak V, Christiansen RL, Hollister SJ, Kohn DH. Stress related molar responses to the transpalatal arch: A finite element analysis. Am J Orthod Dentofacial Orthop 1997;112:512-51.
15. Thiruvenkatachari B, Ammayappan P, Kandaswamy R. Comparison of rate of canine retraction with conventional molar anchorage and titanium implant anchorage. Am J Orthod Dentofacial Orthop 2008;134:30-5.
16. Basha AG, Shantaraj R, Mogegowda SB. Comparative study between conventional en-masse retraction (sliding mechanics) and en-masse retraction using orthodontic microimplant. Implant Dent 2010;19:128-36.
17. Davis D, Krishnaraj R, Duraisamy S, Ravi K, Dilip S, Charles A, et al. Comparison of rate of canine retraction and anchorage potential between mini-implant and conventional molar anchorage: An in vivo study. Contemp Clin Dent 2018;9:337-42.
18. Khlef H, Hajeer M, Ajaj M, Heshmeh O. En-masse retraction of upper anterior teeth in adult patients with maxillary or bimaxillary dentoalveolar protrusion: A systematic review and meta-analysis. J Contemp Dent Pract 2019;20:113-27.
19. Becker K, Pliska A, Busch C, WilmesB, Wolf M, Drescher D. Efficacy of orthodontic mini implants for en masse retraction in the maxilla: A systematic review and meta-analysis. Int J Implant Dent 2018;4:35.
20. Rajni N, Shetty S, Prakash AT. To compare treatment duration, anchor loss, and quality of retraction using conventional en-masse sliding mechanics and en-masse sliding mechanics using micro-implants. J Ind Orthod Soc 2010;44:52-61.
21. Horiuchi A, HotokezakaH, Kobayashi K. Correlation between cortical plate proximity and apical root resorption. Am J Orthod Dentofacial Orthop 1998;114:311-8.
22. Edwards JG. A study of the anterior portion of the palate as it relates to orthodontic therapy. Am J Orthod 1976;86:43-51.