Comparison of two different implant systems and conventional dental anchorage in enmasse retraction of proclined upper anteriors: A prospective clinical study

Mala Ram Manohara[a], Shanthala K. S[b], DaswaniBadal O[c]

The effectiveness of a single non-osseointegratedmidpalatal mini-implant to provide sagittal and vertical anchorage hasn't been compared with buccal mini-implants and conventional dental anchorage.

Aims: This study aims to compare the effectiveness of a single midpalatal implant in conjunction with a transpalatal arch (TPA), with the anchorage control of buccal inter-radicular mini-implants and the conventional dental anchorage.A prospective clinical study was designed to compare the anchorage control in the sagittal and vertical dimensions, their retraction rate and total treatment durations.

Method and Materials: Thirty patients were treated, ten each with conventional dental anchorage, buccal mini-implant anchorage, and midpalatal mini-implant anchorage with TPA. Each patient had four lateral cephalograms taken at pretreatment T_0, post leveling and aligning T_1, post space closureT_2, and post-treatment T_p, which were used for evaluation of results. Treatment changes were measured on these cephalograms for mesial and vertical changes in molar position, sagittal and vertical changes in incisor positions, retraction rate and total treatment duration.

Statistical analyses used: Arithmetic mean, standard deviation, 'Paired t-test' and One-way Anova were used. All the data were analyzed with SPSS version 11. Post-hoc Tukey's test was used for groupwise comparison.

Results: In the sagittal dimension, themidpalatal mini-implant showed better anchorage control than buccal mini-implants,which in turn fare better than conventional dental anchorage. In the vertical dimension, the buccal mini-implants maintained anchorage better than the midpalatal mini-implant,which in turn did better than conventional dental anchorage. There is no significant difference in the rate of retraction and total treatment time amongst the three anchorage systems.

Conclusions: A singlemidpalatalnon-osseointegratingmini-implant, secured to the transpalatal arch, should be preferred for absolute anchorage for enmasse retraction in maxilla, in view of its better sagittal anchorage, predictability of anatomic location and relative ease of placement, over bilateral buccal mini-implants (except in high mandibular plane angle cases where the bilateral buccal mini-implants may be preferred for their better vertical anchorage control).

Key-words: mini-implants, TADs, anchorage, buccal, palatal

Anchorage loss, with conventional dental anchorage, is a reciprocal reaction that could compromise the results of orthodontic treatment by complicating the sagittal correction of the malocclusion and possibly detracting from lip changes and profile correction. The latest entrant to the list of anchorage control measures are theTemporary Anchorage Devices (TADs) or implants. Temporary Anchorage Devices (TADs) are devices that are temporarily fixed in bone for the purpose of augmenting orthodontic anchorage by supporting the anchor teeth or by removing the need for the anchor teeth altogether, and which are subsequently removed. Osseointegrated dental implants, onplants, miniplates and miniscrews all have been used to provide orthodontic anchorage. Over the last decade this matter has been debated and a consensus has more or less evolved in favor of aminiscrew implant of the smallest possible size in terms of length and diameter. Different sizes and shapes of implants have been studied in various intraoral locations in an attempt to find a non-compliant form of absolute anchorage.[1-8]Also the most popular sites for implant placement have narrowed down to the buccal alveolar (inter-radicular) region between the first molar and second premolar, and the midpalatal region in the maxilla[7.]

The performance of inter-radicular (buccal/lingual) implants versus extraoral headgear has been extensively studied, and the superiority of implant anchorage in controlling molar position is established beyond doubt especially with the added advantage of being a non-compliant method. [9-13,14]

In case of palatal implants, mostly bulky osseointegrated implants have been used[15,16,17] and an attempt to reduce the size of these implants has been attempted.[18] Very little evidence in literature exists for the use of miniscrews in the palatal region, and when used, clinicians have tried to use more than one implant rigidly splinted together.[19]Most palatal miniscrews have been used for either molar intrusion or distalization and not for enmasse retraction.[20-24] Junkil Lee, et.al used two mini-implants in a median palatal position, along with a complex palatal assembly, for enmasse retraction and found anchorage far better than conventional dental anchorage.[25]

[a]Professor, Department of Orthodontics, College of Dental sciences, Davangere, Karnataka, India.
[b] Private practice at Hubli-Dharwad, Karnataka, India.
[c] Private practice at Nagpur, Maharashtra, India.

Why can't a single non-osseointegratingminiscrew, used in conjuction with TPA, be used for enmasse retraction in the labial mechanics? This question led to the formulation of the present study. Such an assembly would have a number of advantages like, no waiting/healing/integration period before loading, minimal invasive surgical procedure, ideal soft tissue conditions for implant survival, sufficient cortical bone thickness, and no risk of damage to tooth roots, periodontium,nerves, or blood vessels.

Buccal Implants offer direct anchorage whereas palatal implants offer indirect anchorage in conjuction with TPA.

The aim of this study was to compare and evaluate the treatment effects of enmasse retraction of proclined upper incisors following first premolar extraction with…

*conventional dental anchorage,
*Bilateral buccal mini-implants, and
*Single midpalatal mini-implant in combination with TPA
…using the following parameters:

1. Anchorage loss in sagittal and vertical dimensions
2. Rate of retraction
3. Total treatment time

Material & Methods:

A total of 30 patients were selected on the basis of the inclusion criteria and were randomly divided into three groups of 10 patients each. 10 patients assigned to group1 were treated using a conventional dental anchorage method. 10 patients assigned to group2 were treated using buccal mini-implants for anchorage. 10 patients assigned to group3 were treated using midpalatal mini-implant in combination with a TPA.

Inclusion Criteria:

· Patients requiring therapeutic extraction of the upper first premolars
· Young adolescent patients.
· Class I or class II molar relation.
· Well aligned upper and lower dental arches.
· Absolute anchorage requirement.
· Age matched to be 16±1 years to ensure the ossification of midpalatal suture and similar skeletal maturity indices.

Group1 patients were treated with conventional dental anchorage (Fig 1).

Fig 1. Conventonal dental anchorage group

Group2 patients were treated with bilateral buccal mini-implants for anchorage (Fig2).

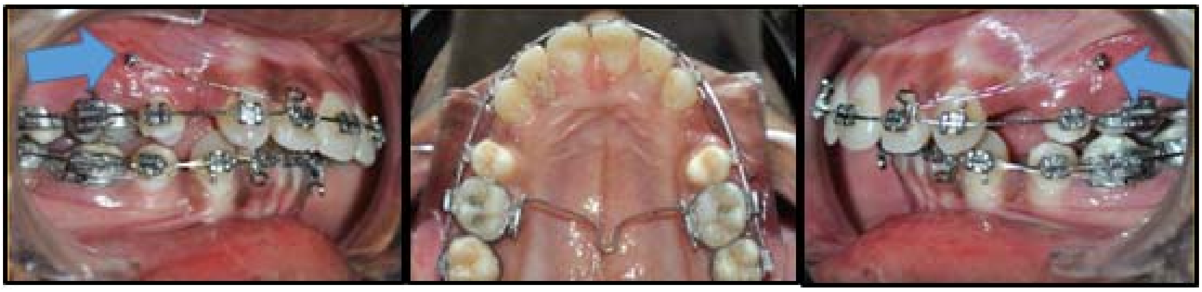


Fig 2. Buccal mini-implant group

Group3 patients were treated with a single midpalatal mini-implant placed in direct contact along the depth ofU-loop of TPA and rigidly tied to it for anchorage (Fig3) with the help of stainless steel ligature wire.

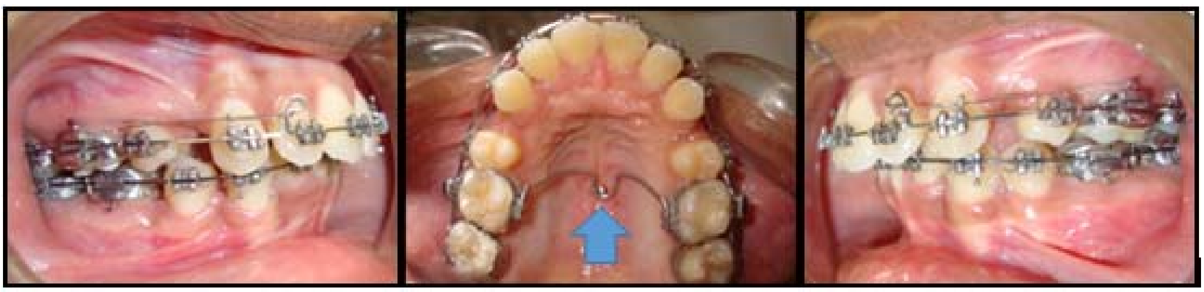


Fig 3. Midpalatal mini-implant group

Adequate measures were taken to ensure matching between the three groups in terms of age and degree of malocclusion.The buccalmini-implants used were Absoanchor™(Dentos)implants of 1.2 mm diameter and 8mm length and placed at a distanceof 8mm apical to the interdental alveolar crest (Fig2) between the second premolar and the first molar on either side of the maxillary arch.[26,27]The midpalatalmini-implants used were Absoanchor™ (Dentos) implants of 1.2 mm diameter and 6 mm length and placed at the midpalatalregion (Fig.3) in close proximity with the U-loop of the TPA.[19,28]

All 30 patients were treated using a 3M Gemini™pre-adjusted edgewise 022 slot appliance with MBT prescription. All second molars were banded and TPA was used in all cases from the onset of treatment. All mini-implants were placed just before starting enmasse retraction with sliding mechanics. For Group2, a stent was placed between the second premolar and first molar and intraoral periapical x-rays were taken to locate the accurate position for mini-implant placement. For Group3, themini-implant was placed in the midpalatal region in close proximity with the depth of U-loop of the TPA, using the palatal implant driver from Dentos™. The mini-implant was firmly secured to the TPA with ligature wire.A standard force of 150 gm was applied with the help of active tieback with stretched elastic modules in all patients for the purpose of uniformity. The buccal mini-implant group received active tiebacks directly from the implants.

After initial leveling and aligning with round and rectangular NiTi, all retractions were performed on a 0.019"x0.025" stainless steel wire with uniform hooks and mild Curve of Spee with sliding mechanics.

Each patient had four lateral cephalograms taken at pretreatment T_0, post leveling and aligning T_1, post space closureT_2, and post-treatment T_p, which were used for evaluation of results. Treatment changes were measured by examining the difference using Cartesian coordinate system[29] (fig.4). At the end of the experimental period, 8 of the best patients were selected in each group. Two patients from each group had to be eliminated due to failed implants, missed appointments or excessive treatment time as a result of lack of patient compliance.

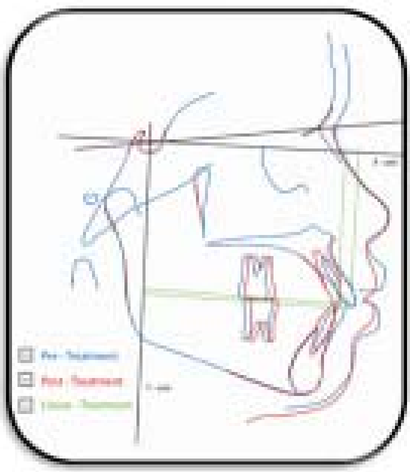


Fig 4. Lateral cephlograph tracing (superimpositions) to measure sagittal and vertical anchorage loss, and amount of retraction.

Cephalograms were traced and landmarks were identified, bilat-eral structures were bisected and then considered mid-sagittal points. Linear measurements of the spatial position of various points were determined by the construction of Cartesian Co-ordinate System.[29] The X-axis of the Cartesian coordinate was a line drawn 7° from the SN line on the pretreatment cephalometric radiograph that was then transferred to the post-treatmentcephalometric radiograph. The Y-axis was generated by dropping a line from Sella perpendicular to the X-axis.

Anchorage loss was recorded as the amount of movement (in mm) that occurred in the direction opposite to the direction of the applied resistance. Sagittal anchor losswas calculated by measuring the difference between Y-axis to the greatest mesial contour of the upper molar by superimposing pre and post space-closure lateral cephalograms; and vertical anchor losswas calculated by measuring the difference between X-axis to the mesiobuccal cusp tip of the upper molar.

The amount of retraction in the sagittal direction was calculated by measuring the difference between Y-axis to the maxillary incisor incisal tip by superimposing the pre and post-space closure lateral cephalograms and vertically the amount of anterior intrusion was calculated by measuring the difference between X-axis to the maxillary incisor incisal tip.

The rate of retraction was calculated by dividing the amount of retraction (distance travelled in millimeters by incisors)with the time in months required to complete the space closure.

The treatment time was calculated by recording the number of months taken from start of orthodontic treatment to the completion of the treatment.

The results thus obtained were subjected to statistical analysis. Arithmetic mean and standard deviation (SD) were used for descriptive statistics. All the data were analyzed with SPSS (version 11.0. SPSS, Chicago, ILL). Results are presented as mean ± SD. 'Paired t-test' was used for intra-group comparisons (i.e. Pre – Post changes). One-way Anova was used for intergroup comparison between the three groups. Post-hoc Tukey's test was used for groupwise comparison. A P-value of 0.05 or less was considered for the results to be statistically significant.

Results

Anchor loss:(Table 1 and Graph I)

A highly significant amount of anchorage loss was seen in the Group1 (Sagittal 1.94±0.81mm, Vertical1.25±0.80mm). The amount of anchorage loss in the Group2was statistically non-significant (Sagittal 0.25±0.85mm , Vertical 0.75±1.10mm). The amount of anchorage loss in Group3 was also non–significant (Sagittal 0.03±0.60mm , Vertical -0.56±1.24mm)

The mean difference in the sagittal anchorage loss between Group1&Group2 was 1.69 mm which was statistically significant (P value 0.001).The mean difference between Group2&Group3 was 0.22mm which was statistically non-significant (P value 0.83). The mean difference between Group1&Group3, 1.91mm, was highly significant (P value 0.00).

The mean difference in the vertical anchorage loss between Group1&Group2 was 2mm which was statistically significant (P = 0.003).The mean differences between Group2 and Group3 was1.31mm which was statistically significant (P=0.05). The mean difference between Group1 and Group3 was 0.69mm which was statistically non-significant (P=0.69).

Incisor retraction and intrusion:

Amount of retraction: (Table 1 and Graph II)

The amount ofincisor retractionwas highly significant in all three groups (Group1:5.94±1.21mm, Group2: 6.56±1.59mm, Group3: 5.75±0.76mm).The intergroup comparison using Oneway ANOVA shows non-significant difference(P=0.40).The mean difference between Group1 and Group2 was 0.62 mm which was statistically non-significant(P=0.58).The mean differences between Group2 and Group3 was 0.81mm which was statistically non-significant (P=0.40). The mean difference between Group1 and Group3 was 0.95mm which was statistically non-significant (P= 0.19).

Amount of incisors intrusion: (Table 1 and Graph III)

The amount of incisors intrusion was statistically significant in Group1 (1.06±0.98mm)&Group2(0.94±1.66mm) but insignificant in Group3 (0.63±1.03mm). The intergroup comparison using oneway ANOVA shows non-significant difference(P= 0.78). The mean difference between Group1 and Group2 was 0.12 mm which was non-significant (P= 0.98).The mean differences between Group2 and Group3 was 0.31mm which was statistically non-significant (P=0.87). The mean difference between Group1 and Group3 was 0.43mm which was statistically non-significant (P=0.77).

Rate of retraction: (Table 2 &Graph IV)

The rate of retraction in maxillary arch of Group1 was 0.89± 0.22 mm per month. In Group2 it was 0.95 ± 0.24 mm per month. In Group3 it was 0.94 ±0.16 per month. The one way Anova between three groups was 0.16 mm which was statistically non-significant (P = 0.85) .

Treatment time

Average treatment time of Group1was 20.5 ± 2.5 months, whereas in Group2 treatment time was 21.6±2.7months. InGroup3treatment time was 21.0±2months.The one way anova in treatment time between the three groups was 0.43months which was statistically non-significant(P= 0.66).

Table 1: Intergroup comparison of anchorage loss and amount of retraction.

Groups		Height(U_1)		Height(U_6)		A-P (U_1)		A-P (U_6)	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD
T^1-T^2 for Group 1		1.06	0.98	-1.25	0.80	5.94	1.21	-1.94	0.81
T^1-T^2 for Group 2		0.94	1.66	0.75	1.10	6.56	1.59	-0.25	0.85
T^1-T^2 for Group 3		0.63	1.03	-0.56	1.24	5.75	0.76	-0.03	0.06
ANOVA F		0.26		7.31		0.95		15.39	
P		0.78 NS		0.004*		0.40 NS		0.00 **	
Group Wise Comparisons (P-Values)	Group1&2	0.98 NS		0.003*		0.58 NS		0.001*	
	Group2&3	0.87 NS		0.05*		0.40 NS		0.83NS	
	Grou1&3	0.77 NS		0.41NS		0.95NS		0.00**	

U_1: upper incisor U_6: Upper first molar
For height, (-) value denotes molar extrusion (loss of vertical anchorage)
For A-P (antero-posterior), (-) value denotes mesial movement of molar (loss of sagittal anchorage)
*P<0.05 Significant
**P<0.001 Highly significant
NS:non-significant

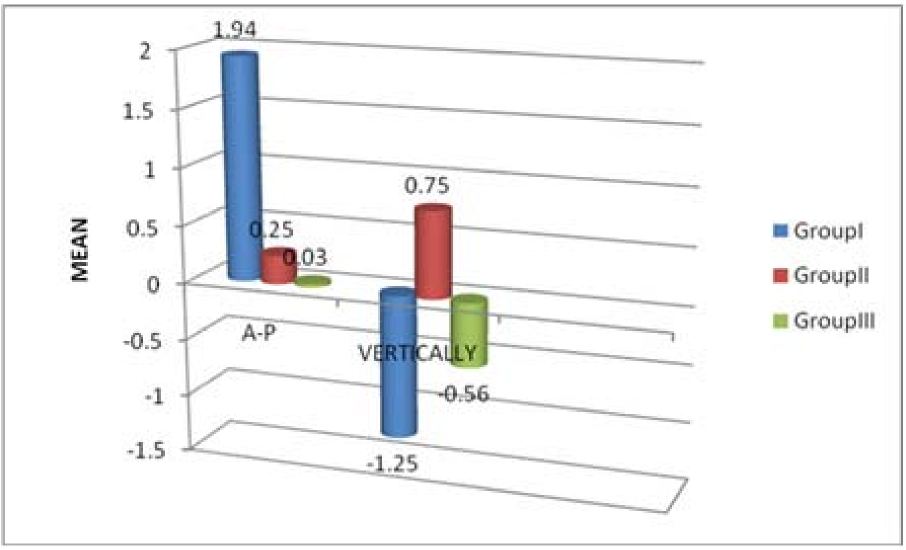
DISCUSSION

The evolution of TADs, in particular buccal inter-radicular mini-implants, has led to a paradigm shift within the speciality of orthodontics. One consideration with the buccal mini-implants, however, is the unpredictable anatomy underlying the superficial soft tissues due to individual anatomical variation. This makes it difficult to consistently place mini-implants without the risk of damaging adjacent interalveolar vital structures.The interalveolar spaces in particular, between the 2nd premolar and the first molar palatal roots are variable in dimension.

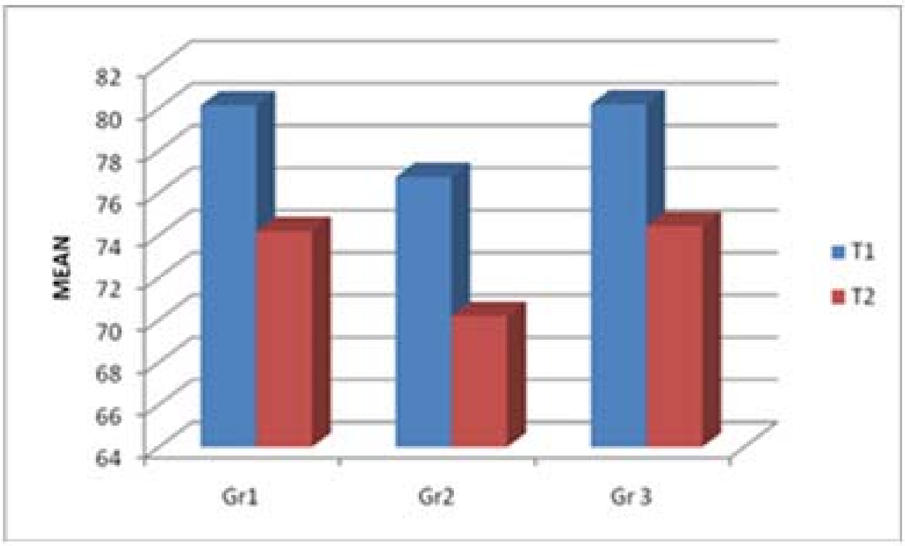
The soft tissue in the paramedian palatal region is just 1mm thick which is ideal for implant survival.[30] It is tempting to think that the palate appears as a thin bone on a lateral cephalogram, and so a wider midpalatal implant or a disc type onplant is required. But if the palatal area is examined three dimensionally, the available bone support is much more than it appears cephalometrically. The nasal crest between the anterior and posterior nasal spine is 2mm thicker than it appears on the lateral cephalogram.[31] The nasal crest has a triangular shape with a base of 5.4mm and a height of 5.6mm in the average adult, large enough for a miniscrew.[32]

Table 2: Intergroup comparison of retraction time, amount of retraction, rate of retraction between three groups

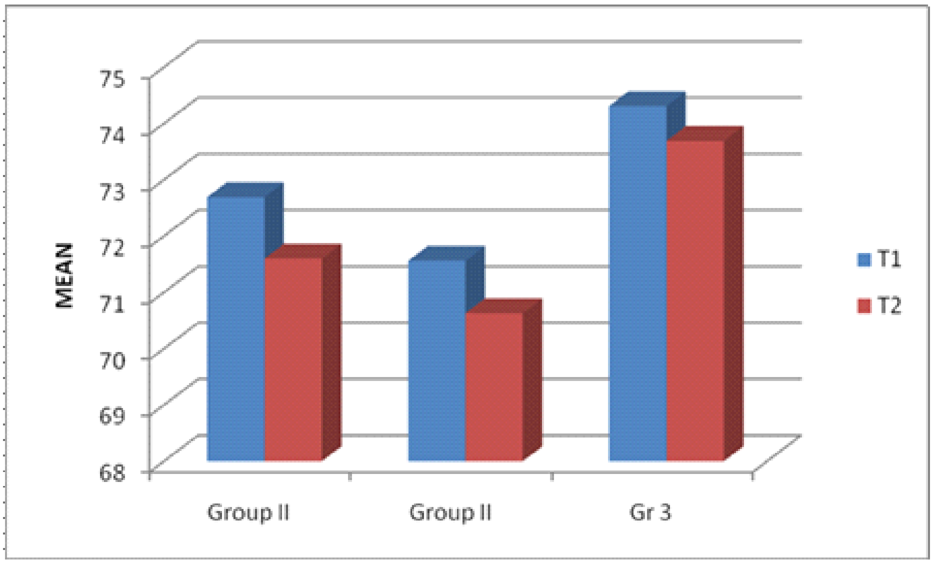
Groups	Retraction time (months)		Amount of Retraction (mm)		Rate of retraction (mm/month)	
	Mean	SD	Mean	SD	Mean	SD
Group 1	6.91	1.78	5.94	1.21	0.89	0.22
Group 2	7.05	1.13	6.56	1.59	0.95	0.24
Group 3	6.04	0.92	5.75	0.95	0.94	0.16
ANOVA F	1.37		1.12		0.16	
P	0.28^{NS}		0.35^{NS}		0.85^{NS}	



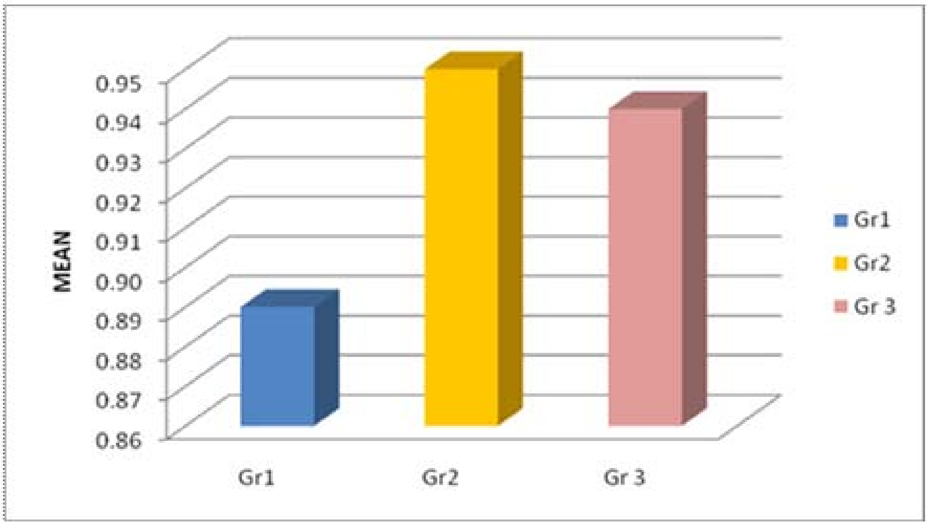
Graph 1: Comparisonof anchorage loss (in MM)



Graph II: Intragroup and Intragroup Comparison of incisor



Graph – III: Intragroup and intergroup comparison of incisor intrusion (in mm)



Graph – IV: Comparison of rate of retraction (in mm)

Miniscrews have been placed in the midpalatal suture area of adults and the paramedian area of adolescents to prevent possible development disturbances of the midpalatal suture.[33] Midpalatalminiscrews have been used for retraction of maxillary anteriors by Park et.al and Hong et.al for retraction with the lingual approach.[14,34]

Kim et.al[19]found a clinical success rate of 90.08% for 210 immediately loaded.mini-implants placed in the midpalatal suture and paramedian region.

In the present study, we have found that a single midpalatal mini-implant is effective for anchorage conservation.Of all the parameters studied, the most significant difference was detected in the amount of anchorage loss between the three modalities.

Conventional mechanics resulted in significant vertical anchorage loss and highly significant sagittal anchor loss, whereas no significant anchorage loss was encountered with either the buccal or midpalatal mini-implant groups. With conventional anchorage, first molar lost 1.25mm vertical and 1.94mm horizontal maxillary molar anchorage. The buccal mini-implant anchorage intruded the maxillary molar by 0.75mm and mesialised it by 0.25mm. The midpalatal mini-implant resulted in a mild molar extrusion of 0.56mm and a mesial movement of only 0.03mm. The midpalatal mini-implant was most effective in conserving anchorage in the anteroposterior direction whereas the buccal mini-implant was the most effective in controlling anchorage in the vertical dimension, even intruding the molars slightly.

Various studies have reported molar mesial movement with buccal mini-implants ranging from 0.2mm – 1.3mm.[7,8,11,14,33] Our sample of buccal mini-implant fared much better with a mesial molar movement of 0.25mm.

The vertical control of the upper molar varied significantly between the three groups with the conventional and midpalatal mini-implant groups being extrusive in nature and the buccal implant being intrusive. The intrusive nature of the buccal implant system can be used effectively in the treatment of patients with vertical maxillary excess. Jae-Won Song, et.alalso observed, through Finite Element Analysis,maxillary intrusion with high position of buccal mini-implant and short retraction hook.[35] Upadhyay et.al[34] demonstrated an average reduction of the mandibular plane angle by 2 degrees with buccal mini-implant anchorage. In the present study, an average intrusion of 0.75mm was achieved with buccal implants. According to Kuhn,[36] 1mm of intrusion at the posterior teeth can produce a 3mm upward movement at gnathion. The present study can expect a closure of the mandibular angle to the tune of 2.25 degrees.[34]

The results of the present study clearly indicate that if absolute anchorage is needed for retraction of the anteriors to utilise the entire extraction space, the midpalatal implant anchorage is the treatment option of choice. The midpalatal indirect implant system works as efficiently as the buccal with the added advantage of:

1. Being away from all vital structures like tooth roots, periodontium, nerves, blood vessels
2. No obstruction to tooth movement.
3. Ideal soft tissue cover for survival of implant.
4. Reduced cost as only one implant is needed instead of two.
5. Need of intra-oral periapical X-rays and stent is obviated.
6. Less technique sensitive

In addition, we found the midpalatal mini-implant to be stable during the course of retraction. Hence there is no need to use osseointegrated implants or implants of larger diameter. A diameter of 1.2mm and 6mm length offered sufficient retention to enmasse retraction of maxillary anteriors. The height of the midpalatal bone depth was found to be 5.81mm and mucosal depth of 3.06mm by Costa et al.[28] A 6mm length miniscew would completely reside in bone without projecting into the nasal cavity. Wehrbein et.al [37] assessed the diagnostic usefulness of the pretreatment lateral cephalograms and suggested that the hard palate in the middle and anterior thirds was at least 2mm higher vertically than seen on the lateral cephalogram.

The upper incisors were intruded significantly in the conventional group, whereas the buccal and the midpalatal implant groups resulted in statistically insignificant intrusion compared to pre-treatment values. All the three groups had an intrusive effect on the upper incisors with no significant difference between the groups.

The amount of incisor retraction achieved in the present study was 5.94mm in the conventional group, 6.56mm in the buccal mini-implant and 5.75mm in the midpalatal mini-implant groups.

The rate of retraction was similar in all three groups with no statistically significant difference between the groups. The buccal and midpalatalmini-implant groups had a retraction rate of 0.95mm and 0.94mm respectively and the conventional anchorage group at 0.89mm.

The difference in total treatment time with conventional dental anchorage and both the mini-implant systems is insignificant. As the extraction space closes from both mesial and distal sides due to mesial movement of molar and distal movement of incisors in conventional anchorage group, the treatment could be expected to be shorter in conventional dental anchorage group. But in this study, we found no significant difference in total treatment durations.

Conclusion:

- Midpalatal mini-implant with TPA conserves sagittal anchorage better while bilateral buccal inter-radicular mini-implants conserve vertical anchorage better.
- 1.2 x 6mm midpalatal mini-implants offer predictability of anatomic location, ease of insertion, stability and immediate loading for enmasse retraction.
- A single midpalatalnon-osseointegratingmini-implant, secured to a TPA, should be preferred over bilateral buccal inter-radicular implants for enmasse retraction in maxilla for absolute anchorage (except in high mandibular plane angle cases, where bilateral buccal mini-implants may be preferred for their better vertical anchorage).

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