BBRC
Bioscience Biotechnology Research Communications

Comparison of Anchor Loss and Rate of Retraction Between Modified Conventional Anchorage with a Power Arm and Titanium Mini-Implant in En-Masse Retraction- A Randomized Control Split Mouth Study

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ABSTRACT
This study was conducted to determine the efficiency of a new modified power arm with conventional intraoral anchorage units compared to a mini-implant for en-masse retraction of the maxillary anterior teeth in maxillary first premolar extraction case. The aim of the study was to compare the anchor loss and rate of retraction between modified conventional anchorage with a power arm and titanium mini-implant in case of en-masse retraction. Materials and methods:- 15 participants requiring high anchorage in maxillary first premolar extraction cases were selected for this study. In each participant, the en-mass retraction was carried out with mini-implants on one side & modified conventional anchorage with a power arm on the other side. The choice of mode of retraction on the right and the left side was done on the basis of the coin flip method. Horizontal (Sagittal) positions of the maxillary first molar and rate of retraction were evaluated on lateral cephalogram & diagnostic cast. Results and observation: - Mean anchor loss was (+1.03 mm) on the conventional anchorage side & (-0.23 mm) distal movement of a maxillary molar on the mini-implant anchorage side. The rate of en-mass retraction was 0.77 mm per month on the mini-implant side and 0.69 mm per month on the conventional anchorage side. Conclusion: - Mini-implant acts as an efficient intraoral anchorage device for en-masse retraction and intrusion of maxillary anterior teeth. No anchorage loss was observed in either the horizontal or the vertical direction on the mini-implant side. Conventional modified anchorage with a power arm can be used in those cases in which anchorage loss of 1 to 1.5 mm is permissible. En-mass retraction is faster with mini-implant anchorage as compared with modified conventional anchorage with a power arm.

KEY WORDS: ANCHORAGE, MINI-IMPLANT, EN-MASS RETRACTION, INTRUSION, RETRACTION, POWER ARM.

Biosc Biotech Res Comm P-ISSN: 0974-6455 E-ISSN: 2321-4007

Identifiers and Pagination
Year: 2021 Vol: 14 No (6) Special Issue
Pages: 05-13

Article Information
Received: 24th March 2021
Accepted after revision: 27th May 2021

DOI: *http://dx.doi.org/10.21786/bbrc/14.6.2*

INTRODUCTION

An orthodontic tooth movement induces force and moment on a tooth or teeth; and this force and moment generate an unwanted tooth movement. This unwanted tooth or teeth movement leads to a movement of anchor teeth in an unfavorable position usually termed as anchor loss. To achieve a success full result, these unwanted forces must be negated or avoided (Thiruvenkatachari et al., 2008). Therapeutic extraction of 1st pre-molar is necessary in many cases of severe proclination of crowding due to a discrepancy in tooth size and arch length. Anterior retraction can be done in two ways: two-step retraction or en masse retraction (Floria et al., 1996).

The two-step retraction approach allows retraction of canine independently, followed by retraction of incisors in the second step. This helps to achieve greater retraction of all anterior teeth by reducing the chances of anchor loss by including more teeth as an anchor unit (Felemban et al., 2013). However; closing spaces in two steps might take a longer treatment time. In addition, when canines are retracted individually they have a tendency to rotate and tip more than when six anterior teeth are retracted as a single unit thus making en-masse retraction more desirable (Proffit et al., 2007; Braun et al., 1997).

Conventional intraoral anchorage techniques have not always been successful for en-masse retraction. Though headgear has proved to be one of the best sources of anchorage patient compliance is questionable. Undesirable side effects on the maxillary complex and the risk of injuries have jeopardized success, 5 still many cases need to get treated by conventional anchorage techniques only. Londhe SM et al. (2010) showed in their study that the inclusion of the 2nd molars in the anchorage preparation, frictionless mechanics, and low retraction forces are advisable to the conventional anchorage. The Vector of Force passing through the center of resistance induces a pure translation of tooth or teeth. This type of translatory tooth movement conserves and generates anchorage.

Mini-screw as a sole source of orthodontic anchorage is widely accepted in orthodontic literature. Orthodontic mini-screws have been inserted in different locations. The development of the mini-screw as a source of anchorage caused a paradigm shift in anchorage preparation. The success rates of mini-implant have been reported to range from 37% to 97% (Proffit et al., 2007; Braun et al., 1997; Londhe LM et al., 2010).Studies have found that the stability of mini-implant is multi-factorial, so the use of mini implants will not be possible in each patient. Loosening of mini-implants, pain, infection and swelling around the implant and iatrogenic contact to the root of the proximal tooth are the most common problems associated with orthodontic mini-implants (Consolaro et al., 2014).

The alternative for implants is to use modifications in conventional anchorage. One of the methods for modifying conventional anchorage is by using a soldered power arm on the 1st molar, although 2nd molar can also be included to augment anchorage. Whenever there is a requirement of high anchorage both these procedures can be combined (Shivanand et al., 2012). There is a need to modify the conventional anchorage in such a way that anchorage loss will be minimized but still, maximum desirable retraction can be achieved. So the study aimed to compare the anchor loss and rate of retraction between modified conventional anchorage with a power arm and titanium mini-implant in en-masse retraction.

Figure 1: Power arch on Maxillary 1st molar

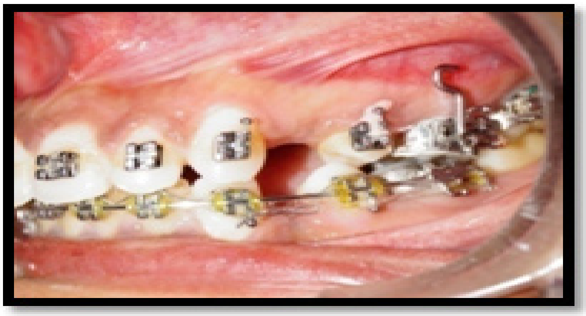
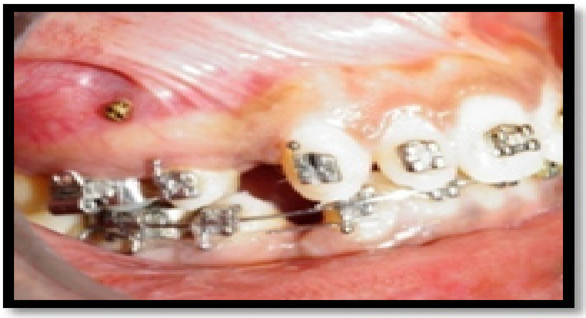


Figure 2: Implant grid

Figure 3: mini implant



METHODOLOGY

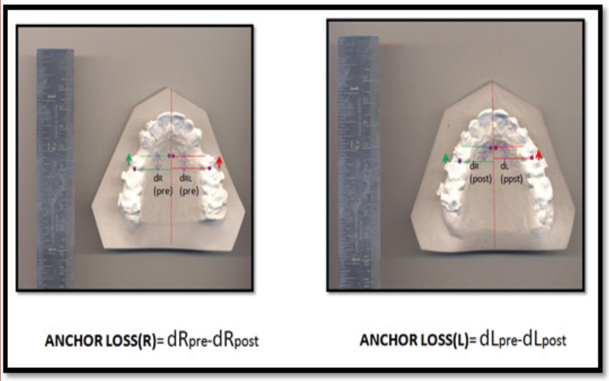
All participants or guardians had been informed about the purpose of the study and signed information & consent form had been obtained. In this study, 15 subjects were chosen as per inclusive & exclusive criteria & treated with 0.022 MBT pre-adjusted edgewise appliance. The mean age of the patient was (mean age, 18.5± 2.3 years; range 8 female, 6 male). The inclusion criteria included participants with 1) Bimaxillary dental protrusion 2) Angle Class II Division I malocclusion with severe overjet 3) full permanent dentition (with or without the third molars) 4) Maximum retraction of the anterior teeth indicated.

The exclusion criteria were

1. developmental anomalies or supernumerary tooth
2. ankylosed molar or anterior teeth 1st maxillary molar and canine
3. Participants with periodontically compromised condition or any missing molar or anterior teeth
4. participant with any kind of bone disorder & systemic conditions.

The selected participants had all the teeth aligned and leveled and ready for the retraction of anterior teeth. The mini implant or modified power arm side was selected using the ‘coin flip’ randomizing method. 2nd molars were included in the conventional anchorage. A power arm was prepared from 19 gauge stainless steel wire and soldered to the headgear tube of maxillary 1st molar on the conventional anchorage side (Fig 1). The implant grid was made from 0.018 round SS wire before placing the mini-implant (Fig.2). A titanium mini-implant was inserted on the opposite side (Fig.3). The point of force application (150 gm) on both sides was similar and the direction of force was made to pass through the center of resistance of 1st molar. A Ni-Ti coil spring of similar length on either side was used to apply retraction force so that the same amount of force could be applied on both the sides. Evaluation of Anchor loss & Rate of retraction was done on both study models and lateral cephalograms. Two sets of records were taken, First after leveling and alignment before retraction and second after all the extraction space were completely closed. The lateral cephalogram was traced by the Dolphin imagine software 11.5. Then evaluation was done based on these records.

Figure 4: Measurement for anchor loss



On study models:– The method given by Ziengler and Ingervall had been followed. The study models were scanned and calibrated. Palatine raphe (or median raphe) was used to construct a median reference line.9 A perpendicular line was drawn from the median reference line to the mesial aspect of the 1st permanent molar on both sides. The distance from the medial aspect of the posterior-most rugae and mesial aspect of the first molar was calculated in reference to median reference line on both sides as shown in Fig.4. Pre-treatment and Post-treatment values were compared to their respective sides.

To measure the rate of retraction, Distance travelled by canine was measured. A median reference line was drawn. A perpendicular line was drawn from the distal aspect of canine to the median reference line as shown. Another perpendicular line from the medial aspect of third rugae was drawn on the median reference line.10,11 (Fig -5) The distance between the two points was measured. The same procedure had been done on the pre-retraction and post-retraction study model. The difference between the two provided the distance travelled by canine. The total distance travelled by canine was divided by a period of time. This provided us the rate of retraction. Pre-treatment and Post-treatment values were compared to their respective sides.

Figure 5: Measurements for distance travelled by maxillary canine

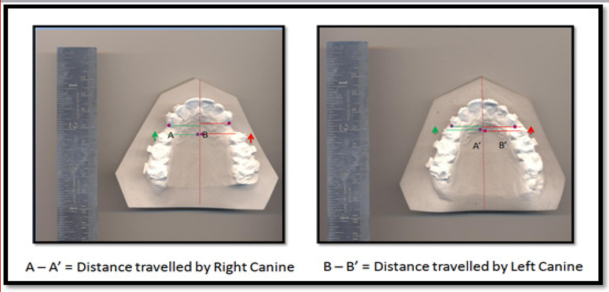
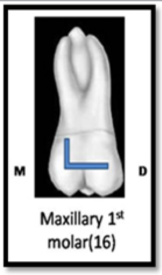


Figure: 6,7,8,9



(Figure6 Right Maxillary 1st molar)

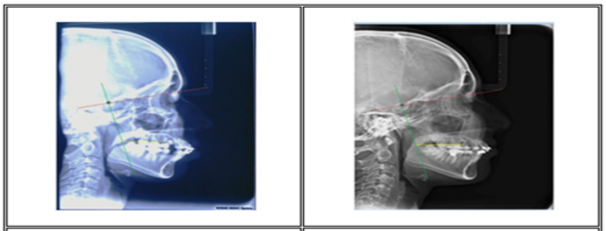
(Figure7Left Maxillary 1st molar)

(Figure 8 Right Maxillary canine)

(Figure9 Left Maxillary canine)

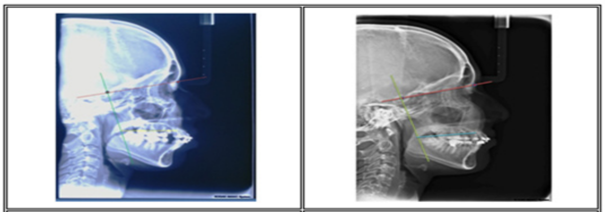
On cephalogram: To differentiate the right and left sides 0.021 ×0.025-in stainless steel L shaped wire of 1 cm vertical length and 1 cm horizontal length was placed in the buccal tube of molars. On the right side, the vertical arm will be pointing gingivally at the mesial end of the molar tube.1 On the left side, the vertical arm will be pointing occlusally at the distal end of the molar tube & curved at the end. (Figure.6,7). A similar wire was placed in the canine bracket also. (Figure.8,9). Then Cephalometric radiographs of pre and post retraction were taken. SN plane was traced on the cephalogram and a perpendicular line was dropped from sella. The perpendicular distance from the dropped line till the respective vertical segment of L shaped wire (terminal point) was measured for right and left molar wire & canine wire. Then the post retraction distance was measured and the difference was calculated for their respective sides. (Fig. 10,11) Pre-treatment and Post-treatment values were compared for the same.

Figure: 10, 11



pre-retraction lat.cephalogram) | (post-retraction lat.cephalogram)

Figure.10 (Position of Maxillary molar)



pre-retraction lat.cephalogram | post-retraction lat.cephalogram

Figure11(Distance travelled by canine)

Observations and Results

Measurement of Anchor Loss

On Mini Implant Side: The mean linear pre-retraction distance measured from 3rd rugae to the mesial side of the first molar was 8.27±0.75mm. The mean linear post-retraction distance was 8.50±0.56mm. The mean pre & post retraction difference in the mini-implant anchorage side was (- 0.23 mm). This negative value indicates the distal movement of a molar. The distal movement of the molar was very small which is not clinically and statistically significant. (P=0.353)

On Modified Conventional Anchorage with Power Arm Side: The mean linear pre-retraction distance measured from 3rd rugae to the mesial side of first molar was 8.40±0.43 mm. The mean linear post-retraction distance was 7.37±0.63 mm. The mean pre & post retraction difference in the mini-implant anchorage side was 1.03 mm. This positive value indicates the mesial movement of a molar. The mesial movement of the molar was clinically and statistically significant. (P=0.0001).

On Mini Implant Side: The mean linear pre-retraction distance measured from the perpendicular line to the SN plane passing through S (sella) point was 48.53±3.04 mm. The mean linear post-retraction distance was 48.27±2.99 mm. The mean pre & post retraction difference in the mini-implant anchorage side was 0.26 mm. Here, this positive value indicates the distal movement of a molar. The distal movement of the molar was very small which is not clinically and statistically significant. (P=0.813)

On modified conventional anchorage with power arm side: The mean of pre-retraction distance measured from the perpendicular line to the SN plane passing through S (sella) point was 48.73±3.65 mm. The mean linear post-retraction distance was 51.433±3.97 mm. The mean pre & post retraction difference on modified conventional anchorage with power arm side was 2.67 mm. Here, this positive value indicates the mesial movement of a molar. The mesial movement of the molar was clinically and statistically significant. (P =0.048).

Table 1. Measurement of anchor loss on study model

Group	Mean	N	Std. Deviation	Std. Error	Mean Difference	P-Value
On mini-implant anchorage side- pre	8.27	15	0.752772653	0.194365063	-0.23	0.353
On mini-implant anchorage side – post	8.50	15	0.56694671	0.146385011		
On modified conventional anchorage side with power arm – pre	8.40	15	0.430945804	0.111269728	1.03	0.0001*
On modified conventional anchorage side with power arm – post	7.37	15	0.639940473	0.16523192		

*The difference is significant if P value is <0.05

The mean anchor loss measured on the mini-implant side was (-0.23±0.23 mm). The mean anchor-loss measured on modified conventional anchorage with power arm side was 1.033±0.35 mm. There is a statistical significant difference present in amount of anchor loss occurred between two groups. (P =0.0001). The mean anchor loss measured on mini-implant side was 0.26±0.26 mm. The mean anchor-loss measured on modified conventional anchorage with power arm side was -2.67±0.75 mm. There is a statistical significant difference present in amount of anchor loss occurred between two groups. (P =0.0001).

Measurement of Rate of Retraction

On Mini-Implant Anchorage Side: Table.5 The mean rate of retraction was obtained by the distance travelled by canine divided by time taken. The distance travelled by canine was measured in linear distance from the horizontal line passing through the medial surface of 3rd rugae to the mesial side of maxillary canine in relation to the mid palatine raphe. The mean rate of retraction was 0.775±0.09 mm/ month.

Table 2. Measurement of anchor loss on lateral cephalogram

Group	Mean	N	Std. Deviation	Std. Error	Mean Difference	P-Value
On mini-implant anchorage side- pre	48.53	15	3.044120015	0.785988408	-0.26	0.813
On mini-implant anchorage side – post	48.27	15	2.999206244	0.774		
On modified conventional anchorage side with power arm – pre	48.73	15	3.654090989	0.943482236	-2.67	0.048*
On modified conventional anchorage side with power arm – post	51.433	15	3.971625	1.025469		

*The difference is significant if P value is <0.05

Table 3: comparison of anchor loss between two groups on study model

Group	Mean	N	Std. Deviation	Std. Error Mean	Mean Difference	P-Value
On mini-implant anchorage side- pre	-0.23	15	0.239692	0.061709535	0.12633	0.0001
On modified conventional anchorage side with power arm	1.03333	15	0.351865775	0.090851352		

*The difference is significant if P value is <0.05

Chart 1: Showing the measurement of anchor loss between Mini-implant anchorage & Modified conventional anchorage with power arm group on study model.

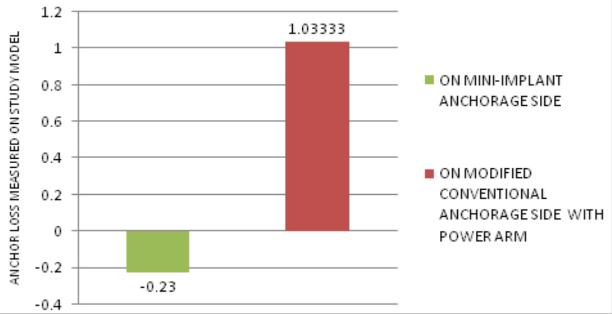
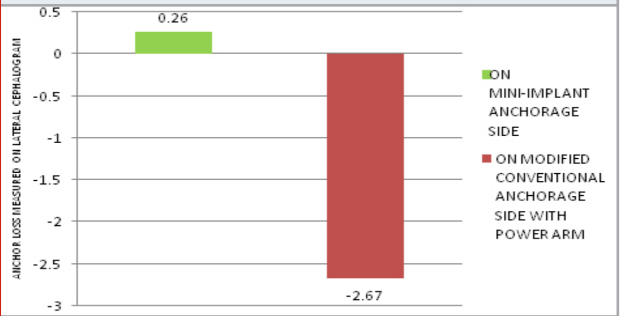


Chart 2: Showing the measurement of anchor loss between Mini-implant anchorage & Modified conventional anchorage with power arm group on Lateral cephalogram.



On Modified Conventional Anchorage Side with Power Arm: The mean rate of retraction on the conventional anchorage side was 0.697 mm/ month. The range of this rate was 0.607 to 0.787 mm/month. There is a statistical significant difference between the rate of retraction among two groups.

On Mini-Implant Anchorage Side: Table.6 The mean rate of retraction was measured by the distance travelled by canine divided by the time required. The mean distance measured from the perpendicular line to the SN plane passing through S (sella) point. The mean rate of retraction was 0.661±0.042mm/ month.

On Modified Conventional Anchorage Side with Power Arm: The mean rate of retraction was 0.581±0.04 mm/ month. The range of this rate was 0.541 to 0.0.621 mm/ month. There is a statistical significant difference in the rate of retraction among the two groups.

Table 4. Comparison of anchor loss between two groups on cephalogram

Group	Mean	N	Std. Deviation	Std. Error Mean	Mean Difference	P-Value
On mini-implant anchorage side	0.26	15	0.268	0.06919	2.93	0.0001*
On modified conventional anchorage side with power arm	-2.67	15	0.7511	0.1939		

*The difference is significant if P value is <0.05

Table 5. Rate of retraction measured on study model

Group	Mean	N	Std. Deviation	Std. Error Mean	Mean Difference	P-Value
On mini-implant anchorage side - rate of retraction	0.77593	15	0.092381559	0.023852816	0.07983	0.0285*
On modified conventional anchorage side with power arm - rate of retraction	0.697	15	0.09	0.024466303		

*The difference is significant if P value is <0.05

Chart 3: Showing the measurement of the rate of retraction between Mini-implant anchorage & Modified conventional anchorage with power arm group on study model.

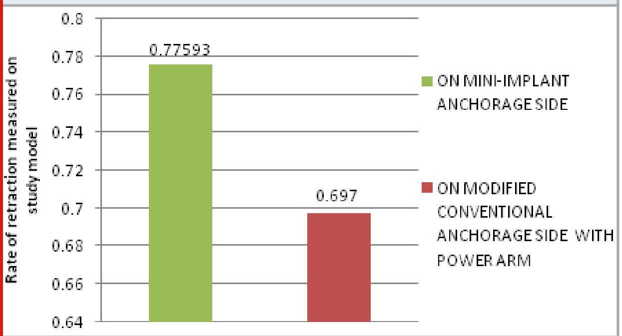


Chart 4: Showing the measurement of the rate of retraction between Mini-implant anchorage & Modified conventional anchorage with power arm group.

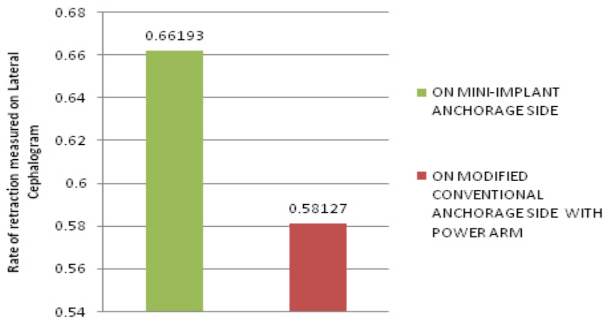


Table 6. Rate of retraction measured on lateral Cephalogram

Group	Mean	N	Std. Deviation	Std. Error Mean	Mean Difference	P-Value
On mini-implant anchorage side - rate of retraction	0.66193	15	0.042390138	0.010945087	0.08	0.0001*
On modified conventional anchorage side with power arm - rate of retraction	0.58127	15	0.040443023	0.010442344		

*The difference is significant if P value is <0.05

DISCUSSION

The titanium mini-implant remained stable through the retraction phase. The Net distal movement for the first permanent molar on the mini implant side is observed to be (0.23 mm) is on study model & 0.26 mm on the lateral cephalogram. Similar results of maxillary molar distalization were reported recently (Xu et al., 2010; Iwasaki et al., 2000). The probable reason for the distal movement of the molar is because of force exerted by a maxillary canine from 2nd premolar after extraction space closure. The retraction force was continued even after the extraction space closure of 1st premolar as in some cases the space closure on the opposite quadrant was still under process. Distal movement of the molar usually leads to an increase in the mandibular plane angle because of a wedging effect & extrusive effect of molars. But in the present study, the distalization of molar was not clinically significant. This result helps to utilize the mini-implant in the vertical growers who have a high risk for anchorage loss.

While in contrast, the conventional anchorage group showed a net mesial movement of 1.03 mm. The maximum anchor loss noted in the study was (2 mm) & the minimum was (0.5mm). The Previous reports in literature noted 1.6 mm to 4 mm of a mesial drift of molars while retracting the canines with traditional anchorage mechanics (Samuels et al., 1998; Rajcich et al., 1997; Kanomi et al., 1997). With additional anchor preparation, anchorage loss can be decreased up to 2.4 mm (Geron et al., 2003; Bae et al., 2002). Other alternatives for avoiding anchor loss are the use of headgear, the inclusion of second molars, and 2nd bicuspid, transpalatal arches, and Nance palatal arch. The minimum anchor loss of 1.03 mm which has occurred in this study is because of the direction of the force vector which was passing through the center of resistance of maxillary 1st molar with the help of a soldered power arm fabricated with 19 gauge stainless steel wire. The power arm itself withstood the reactionary force & dissipated minimal force to the maxillary 1st molar. As reported by Feldmann and Bondemark (2006) anchorage loss measured at the incisors or premolars ranged from 0.2 to 2.2 mm and the anchorage loss/distal molar movement ratio ranged from 0.2 to 0.8 mm.

Rate of En-Mass Retraction: The velocity of tooth movement during orthodontic treatment depends on various factors. For example, the level of cellularity or density of alveolar bone, the formation of hyalinised tissue adjacent to the dental root due to the application of ''excessive'' mechanical force or the discontinuation of force application causing an interruption of the ''initial strain-lag phase undermining resorption'', a cycle of tooth movement as well as the magnitude of force applied (Shpack et al., 2008). During en masse retraction, the anterior and posterior teeth acted as a unit, the segments being linked via retraction force. Although various studies deal with the relationship between optimum force magnitude and rate of canine retraction, very few human studies had been reported. The first such study for comparing this relationship was by Storey and Smith (1952) who reported an optimum force of 150 to 200 g for retraction of the mandibular canines. Iwasaki et al. (2000) reported that forces as low as 18 g could cause effective tooth movement and recommended that optimum pressure should be less than 100 g. Ricketts (1974) advocated 75 g, and Lee20 recommended 150 to 200 g as the optimum pressure value for canine retraction. Boester and Johnston23 reported 140 to 300 g, and Paulsen et al24 used 50 to 75 g for canine retraction. In an experimental study on mini-implants, Buchter et al.. (2005) showed that the immediate loading of implants with a force of 100 cN had a high success rate. It is generally thought that light forces are more biologic and less painful. Because reports have shown effective tooth movement with light forces, a force of 100 g was applied with nickel-titanium closed-coil springs in this study for retraction of the canines into the premolar extraction spaces.

The amount of en-mass retraction of maxillary anterior teeth has been compared between mini-implant anchorage and modified conventional anchorage side in the same environment. However, retraction with implants & power arm was primarily achieved by controlled tipping and followed by translation because the direction of forces applied was closer to the center of resistance of the maxillary anterior teeth. The rate of retraction on the implant side was slightly faster than that of the power-arm group, even though the direction & magnitude of the force and the medium of delivery of force were similar. The expected reason behind it might be the amount of anchor loss occurred on the conventional anchorage side.

Because of this, the distance between the power arm & inter-maxillary hook was decreased which may lead to the force decay. In most participants, the time taken for closure of the complete extraction space was the same on both sides. But on the conventional anchorage side, 1.03 mm of anchor loss was observed. So the net distance travelled by the canine on the modified anchorage side was 1.03 mm less than that travelled by the canine on mini- Implant anchorage side. Even though the distances travelled by canines were different the time taken was the same. With this, it gets confirmed that the retraction was faster on the mini implant side. The other probable reason for a decrease in the rate of canine retraction was the inclusion of the second molar as a result of an increase in frictional force.

A previous study reported almost 7 mm of bodily retraction achieved with the help of micro-implants. 20 The width of alveolar bone and palatal cortical bone could be the limiting factors in maxillary anterior en-mass retraction. A full-size wire is normally not used because such wires do not slide efficiently through the posterior bracket slots. For sliding mechanics to be effective in the present study 0.019 x 0.025 wire in the 0.022 slot was used. The vertical height of the mini-implant plays a crucial role in guiding the forces for intrusion and retraction of maxillary anterior teeth.

Keeping this in view in the present study, the direction of force & magnitude were kept similar on both sides. Another important factor that can alter the direction of force is the vertical height of the intermaxillary crimpable hook. By altering the vertical height of the canine power arm, greater intrusion can be achieved. Keeping this in view, the height of the intermaxillary hook was also kept the same on both sides. The forces exerted by NITI closed coil spring to power arm side & implants for anterior en-masse retraction were physiologic (150-200 g) and similar on both the sides.

- **List Of Abbreviations Used**

SS	:	Stainless steel
MBT	:	McLaughlin, Bennett, Trevisi
NITI	:	Nickel titanium
OPG	:	Orthopantomogram
Fig	:	Figure
mm	:	Millimeter

CONCLUSION

The mini-implants inserted in the interdental bone between the maxillary first molar and second premolar proved to be efficient for intraoral anchorage for the en-masse retraction of the maxillary anterior teeth. The modified conventional anchorage with a power arm placed between the maxillary first molar and second premolar offers the least anchor loss of 1 to 1.5 mm among all reported conventional intra-oral anchorage system. Mini-implant anchorage produced faster maxillary en-mass retraction than modified conventional anchorage with a power arm.

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