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Comparison Of Efficacy Of Infrazygomatic Crest Mini Implant And Interradicular Mini Implant For En Masse Retraction: A Randomised Controlled Split Mouth Study

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Abstract:
Background:
Anchorage control is one of the crucial aspects of orthodontic treatment planning and outcomes. Preservation of anchorage is practically tough in many clinical scenarios especially during en masse retraction. Diverse techniques and devices to reinforce anchorage have been proposed.
Objective:
To evaluate and compare the efficacy of two different types of mini implant types according to insertion site, namely the interradicular mini implant on one side and infrazygomatic crest mini implant on the other side during en masse retraction. The amount of en masse retraction between the interradicular mini implant and infrazygomatic crest mini implant group was assessed. In addition, the anchorage loss was also evaluated.
Materials and methods:
This study is a randomized split mouth study, conducted on 15 patients who required maximum anchorage in upper arch with therapeutic extraction of bilateral upper first premolars. Interradicular mini implants were placed on one side and was considered as GROUP 1 and Infrazygomatic crest mini implants were placed on the other side and considered as GROUP 2. Based on randomization, interradicular and infrazygomatic crest mini implants were allocated either on the right or left sides. Both the mini implants were placed in the first molar region either inter-radicular region between upper second premolar and upper first molar or in the IZC region of upper first molar. The amount of en-masse retraction and anchor loss was assessed at four time-points (T0, T1, T2, T3) in both the groups using study models, orthopantomogram and lateral cephalogram.
Results:
The results showed that the amount of en masse retraction showed statistically significant with higher retraction in Infrazygomatic Crest (IZC) mini implant group compared to Interradicular (IRR) mini implant group. The anchorage loss was statistically higher in IRR mini implant group as compared to IZC mini implant group.
Conclusion:
Although both Interradicular mini implants and Infrazygomatic Crest mini implants can be successfully used as absolute anchorage techniques, Infrazygomatic crest mini implants prove to be more efficacious than Interradicular mini implants during en masse retraction of maximum anchorage cases.

Keywords: *Infra-zygomatic crest mini-implant, Inter-radicular mini-implant, Anchorage, En-masse retraction of anteriors.*

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I. Introduction

Anchorage control is one of the crucial aspects of orthodontic treatment planning and outcomes. Preservation of anchorage is practically tough in many clinical scenarios especially during en masse retraction. In patients with first premolar extractions, only 66.5% of the available extraction space was occupied by retraction of anterior segment[1]. The posterior teeth have move forward approximately one third of the extraction space for relief of crowding and incisor retraction[2]. Therefore, maximum anchorage of the posterior teeth is significant not only for the retraction of anterior teeth to the maximum but also in the achievement of a pleasing profile for the patient by reducing the convexity of the face.

Supplementary use of headgear, facemask, intermaxillary elastics are utilized in complex situations requiring anchorage reinforcement. Factors such as patient compliance[3], unwanted side effects on maxilla, and risk of injuries[4] have jeopardized success rate of headgear anchorage.

Although two staged retraction of canines followed by incisors was accepted as a method to minimize anchor loss, there is no difference between en masse retraction and 2-step retraction, as anchorage loss is seen in both methods[5]. Intraoral trans palatal arches can be used to control anchorage but studies[6,7,8] have shown that even with the use of trans palatal arch anchor loss occurs.

Ever since the advent of skeletal anchorage, temporary anchorage devices certainly appear poised to be one of the remarkable changes in clinical orthodontics. Creekmore and Eklund[9] took the credit of introducing the concept of skeletal anchorage in the field of orthodontics by placing a titanium screw under the nasal spine, which was used for intermaxillary fixation after orthognathic surgery, and had intruded the maxillary incisors.

Temporary anchorage devices are mechanically retained devices which includes mini implants, mini plates and mini screws. Higher success rates have been found with temporary anchorage devices and these have been correlated to several aspects such as factors related to patient, device used, procedure and orthodontic treatment involved[10].

A cone-beam computed tomography study[11] was conducted to suggest safe locations to place mini-implants where the inter- radicular space between the second premolar and first molar root in the upper arch and inter-radicular space between the first molar and the second molar root in the lower arch were considered suitable places. The major issue faced with placing TADs inter-radicularly is the increased risk of root approximation that hinders the tooth movement, before the tooth moved to the desired position and is already in contact with the TAD[12]. Such a difficulty can be prevented by insertion of implants in the extra-alveolar region. The extra-alveolar sites available for placement of TADs include premaxillary region, incisive fossa, midpalate region, canine fossa, IZC, mandibular symphysis, external oblique ridge, buccal shelf area, retromolar area, and sublingual fossa.

Of all extra-alveolar sites, our study of interest is the IZ region. The IZ crest consists of 2 cortical plates—the buccal cortical plate and the floor of maxillary sinus. Hence, with bi cortical fixation, a better primary stability of the mini screw can be accomplished. The mechanical integration between the screw thread and the cortical bone decides the primary stability of the implant. An 8mm screw is sufficient to engage the cortical plate and attain primary stability under most clinical situations[13].

The number of orthodontic retreatment cases have increased due to anchorage loss, and IZC's present to be essential aids as it has become the need of moment for a skilled orthodontist to face such issues and reestablish a stable outcome in such difficult clinical scenarios[14].

Despite the advantages, IZC's also have certain drawbacks such as higher failure rate of about 7% [15], probably due to poor bone quality, immediate loading or excess movable mucosa.

Studies so far have been done to evaluate and compare the efficacy between retraction using conventional molar anchorage and mini implant anchorage, but no studies have been done to compare the efficacy of interradicular mini implants and infrazygomatic mini implants in en masse retraction, hence this study aimed to evaluate and compare the efficacy of both the implants to achieve the desired retraction during orthodontic treatment.

II. Materials and methods:

A total of 15 patients (mean age: 18-30 years) who required maximum anchorage in upper arch with therapeutic extraction of bilateral upper first premolars were selected for the study. This study was approved by The Institutional Ethical Committee of CSI College of Dental Sciences and Research for the procedure of placement of interradicular mini implants on one side and infrazygomatic crest mini implants on other side to compare the efficacy in en masse retraction.

Study Design: Randomized Controlled Split mouth study.
Study Location: CSI College of Dental Science and Research.

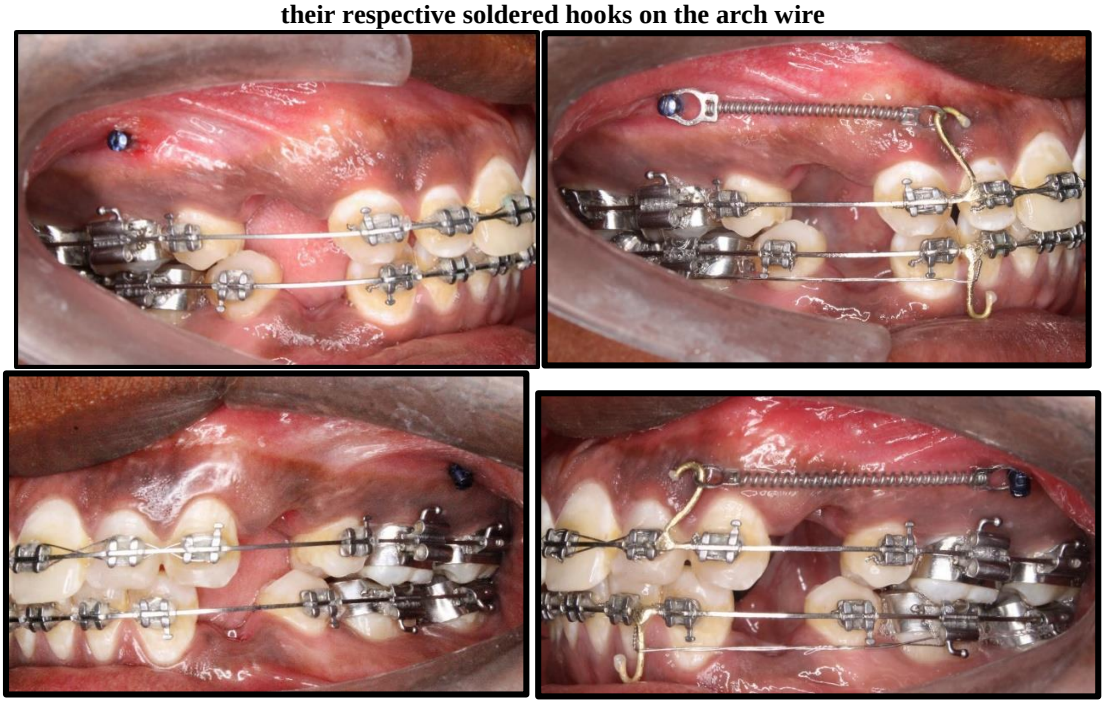
The inclusion criteria are as follows:

- Maximum Anchorage Cases, with 75% to 100% of space closure by retraction of anterior segment in maxillary arch.
- Severe bimaxillary protrusive patients
- Class II Malocclusion with severe overjet.

All patients were treated with preadjusted edgewise appliance system (0.022 ×0.028 in. MBT). After the leveling & alignment of maxillary arch, the 1st premolars were extracted bilaterally and 0.019" × 0.025" SS arch wires were placed with soldered brass hooks between lateral incisor and canines measuring 8mm gingivally from the arch wire. Interradicular mini implants were placed on one side and was considered as GROUP 1 and Infrazygomatic crest mini implants were placed on the other side and considered as GROUP 2. Based on randomization, interradicular and infrazygomatic crest mini implants were allocated either on the right or left sides. Both the mini implants were placed in the first molar region either inter-radicularly between upper second premolar and upper first molar or in the IZC region of upper first molar.

After the placement of the mini implants on the experimental sides, the en masse retraction was started with immediate loading using 9mm NiTi closed coil springs extending from mini implants on both sides to their respective soldered hooks on the arch wire and a force calibrated to 150gms using the tension gauge as shown in Figure 1. The NiTi coil spring was activated every month and en masse retraction was checked.

Figure 1: Placement of mini-implants on the experimental side, the en masse retraction was started with immediate loading using 9mm NiTi closed coil springs extending from mini implants on both sides to their respective soldered hooks on the arch wire



Records were taken at:

- T0- Before Retraction
- T1- After 1 month
- T2- After 2 months
- T3- After 3 months

The following records were taken:

1. Intraoral photographs at T0, T1, T2, T3. [Fig.2(a)]
2. Orthodontic study models at T0, T1, T2, T3. [Fig 2(b)]

The amount and rate of en masse retraction per month and anchor loss per month was measured using these study models.

3. Lateral cephalogram and OPG at T0 and T3. [Fig. 2(c),2(d)]

Standardization jigs in the canine brackets and molar buccal tubes with different configuration on each side (L shaped for right side and zig-zag shaped for left side) were used while taking the digital lateral cephalograms and orthopantomograms before retraction (T0) and after retraction(T3). These jigs were fabricated

for identification of side, for evaluation of position of canine and molar, measurement of amount of retraction and anchor loss.

Figure 2: Pre-treatment and post -treatment records
Figure 2(a): Intra-oral occlusal photographs

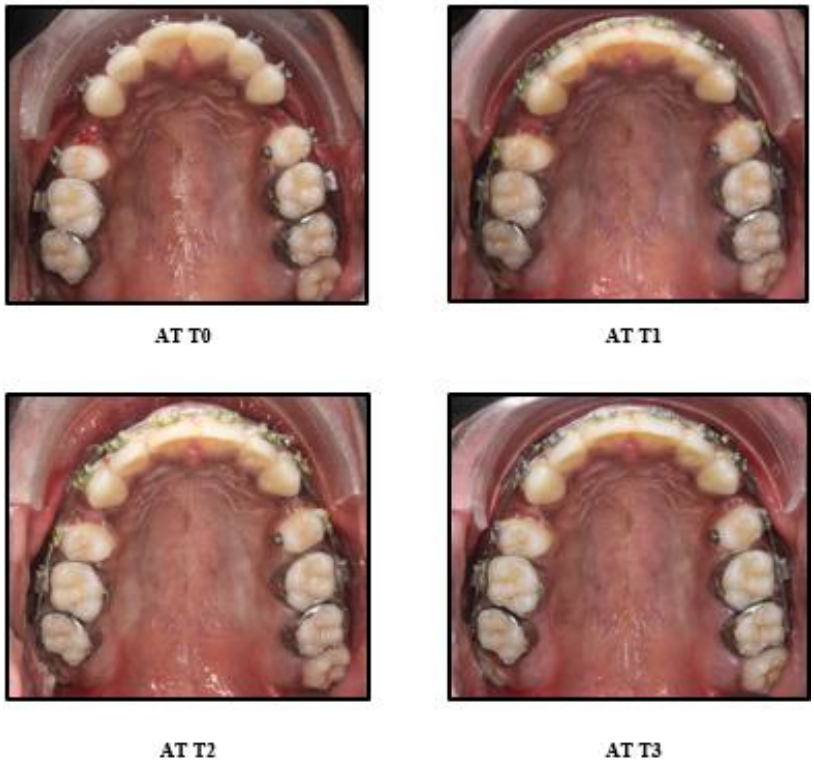


Figure 2(b): Orthodontic study models

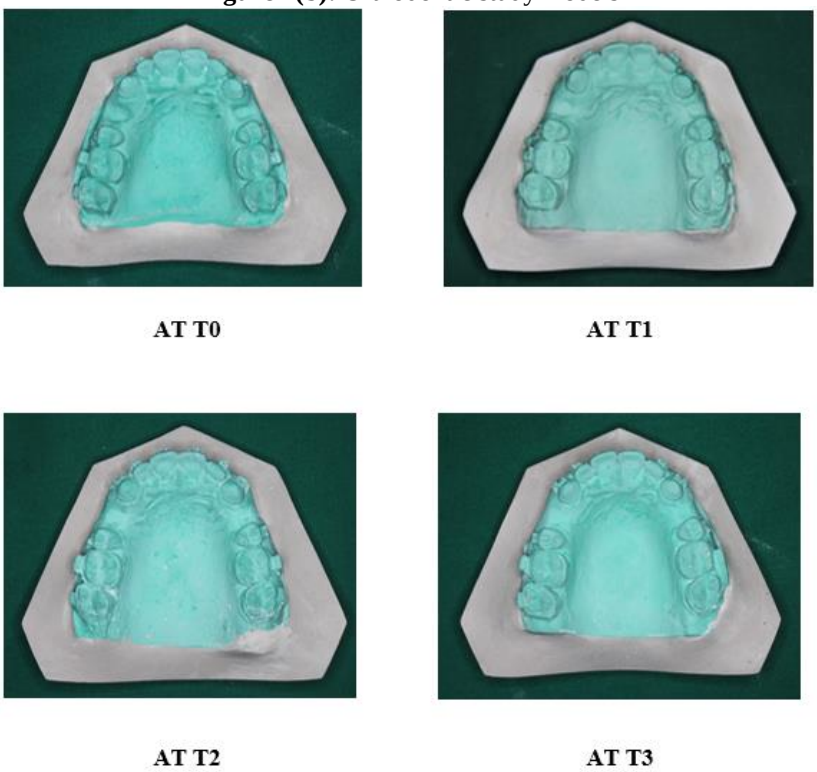


Figure 2(c): Lateral cephalograms with standardization jigs

AT T0

AT T3

Figure 2(d): Orthopantomograms with standardization jigs

AT T0

AT T3

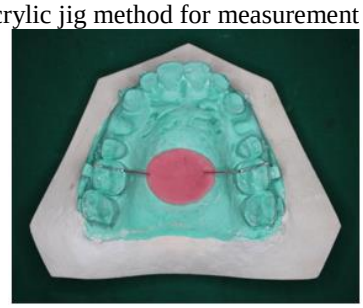
Evaluation of anchor loss per month

In study models:

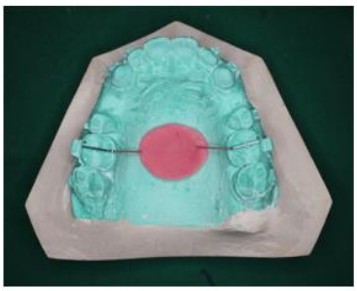
Anchorage loss per month was recorded directly on the cast and was used to determine the amount of retraction as explained before.

The mesial movement of first molars was evaluated through a transfer guide made individually in the T0 models of each patient. An acrylic plug with reference wires (19*25 SS) embedded in acrylic was fabricated on maxillary cast. The wire pointers from the acrylic plug extended to the mesiobuccal cusp tip of the first molars. The plug, made on initial model, was fitted onto the progressive models. The distance between the wire pointer and mesiobuccal cup tip was measured on the progressive models for the determination of anchor loss per month. [Fig 3].

Figure 3: Acrylic jig method for measurement of anchor loss



AT T0

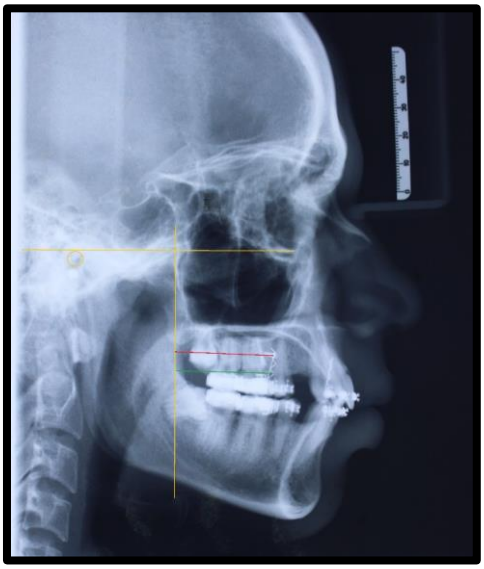


AT T3

In lateral cephalograms:

In the lateral cephalograms, the amount of anchor loss for three months was assessed by measuring the difference between pterygoid vertical line to the molar jigs on both sides and subtracting the value at T3 from value at T1.[Fig 4]

Figure 4: Evaluation of amount of anchor loss for three months



Evaluation and comparison of amount of enmasse retraction between the experimental groups:
In study models:

In the study models, points were marked on the distal most contour of distal surface of canine and the mesial most contour on the mesial aspect of second premolar. The distance between the marked points was measured using a digital vernier caliper and it gave the amount of space closure at each month interval.

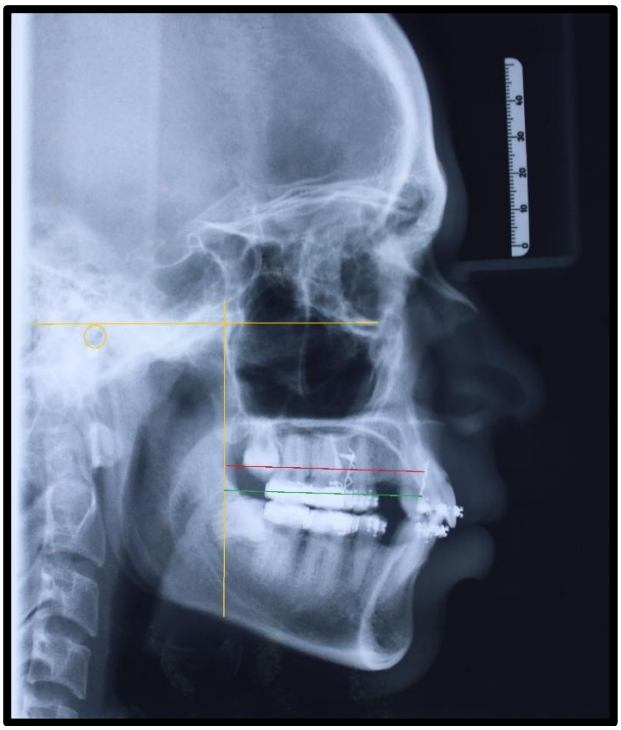
Measurement of amount of anterior en masse retraction was done by subtracting the anchorage loss value from space closure value, that is

Amount of en masse retraction (AR) at each interval = Amount of space closure (AS) – Anchor loss (AL) at each interval

In Lateral Cephalograms:

In the lateral cephalograms, the amount of retraction for three months was assessed by measuring the difference between pterygoid vertical line to the canine jigs on both sides and subtracting the value at T3 from value at T1 as shown in [Fig. 5].

Figure 5: Evaluation of amount of en masse retraction for three months



Statistical analysis

- The statistical analysis was performed using "statistical package for social sciences" ("SPSS", version 26) software package ("IBM corporation, Armonk, USA").
- The descriptive statistics for baseline data (mean age group, gender distribution) was represented using mean, standard deviation, frequency/percentage distribution respectively.
- The descriptive statistics for the assessed study variables "amount of retraction per month" and "anchor loss per month" recorded at three different time periods: after first month, second month and third months were expressed using mean, standard deviation and standard error of mean.

III. Results

- The descriptive statistics for baseline data (mean age group, gender distribution) was represented using mean, standard deviation, frequency/percentage distribution respectively **(Table 1).**

Table 1: Baseline data

	Inter-radicular mini-implants	Infra-zygomatic screws
Mean age group	21±3.5 (in years)	21±3.5 (in years)
Gender		
(1) Male	13 (86.7%)	13 (86.7%)
(2) Female	2 (13.3%)	2 (13.3%)

- The descriptive statistics for the assessed study variables "amount of retraction per month" and "anchor loss per month" recorded at three different time periods: after first month, second month and third months were expressed using mean, standard deviation and standard error of mean **(Table 2 and Table 3).**

Comparison of amount of retraction between two groups

Statistically significant difference was observed between the groups for amount of retraction per month recorded after one month (p=0.003) and after two months (p=0.001) with higher amount of retraction reported for "infra zygomatic screws" [after one month (0.96±0.14), two months (0.94±0.22)] **(Table 2).** Statistically highly significant difference was observed between the groups for amount of retraction per month recorded after three months (p<0.0001) with higher amount of retraction reported for of "infra zygomatic screws" [after three months (0.99±0.22)] **(Table 2).** Amount of retraction recorded after three months in lateral cephalogram was found to be higher for of "infra zygomatic screws" (2.9±0.52) which was statistically significant (p<0.0001) **(Table 2).**

Comparison of anchor loss between two groups

Statistically significant difference was observed between the groups for anchor loss per month recorded after one month (p=0.011) and highly significant difference for values recorded after two months (p<0.0001) and three months (p<0.0001) with higher anchor loss reported for "inter-radicular mini-implants" [after one month (0.05±0.04), two months (0.19±0.05) and three months (0.23±0.06)] **(Table 3).** Anchor loss recorded after three months in lateral cephalogram was found to be higher for "inter-radicular mini-implants" (0.47±0.1) which was statistically highly significant (p<0.0001) **(Table 3).**

Table 2: Descriptive statistics

AMOUNT OF RETRACTION

Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Error Mean
AMOUNT OF RETRACTION PER MONTH (1st month)	Inter-radicular mini implants	15	.8020	.12746	.03291
	Infrazygomatic screws	15	.9^{607}	.13776	.03557
AMOUNT OF RETRACTION PER MONTH (2nd month)	Inter-radicular mini implants	15	.6413	.11849	.03060
	Infrazygomatic screws	15	.9380	.22441	.05794
AMOUNT OF RETRACTION PER MONTH (3rd month)	Inter-radicular mini implants	15	.6187	.16146	.04169
	Infrazygomatic screws	15	.9940	.22405	.05785
AMOUNT OF RETRACTION FOR 3 MONTHS IN LATERAL CEPHALGRAM	Inter-radicular mini implants	15	2.0927	.25747	.06648
	Infrazygomatic screws	15	2.8953	.52766	.13624

Table 3: Descriptive statistics

AMOUNT OF ANCHOR LOSS

Group Statistics					
	Group	N	Mean	Std. Deviation	Std. Error Mean
Anchor loss per month (1st month)	Inter-radicular mini implants	15	.0507	.03845	.00993
	Infrazygomatic screws	15	.0273	.02631	.00679
Anchor loss per month (2nd month)	Inter-radicular mini implants	15	.1887	.04779	.01234
	Infrazygomatic screws	15	.0807	.04728	.01221
Anchor loss per month (3rd month)	Inter-radicular mini implants	15	.2300	.05855	.01512
	Infrazygomatic screws	15	.0993	.07314	.01888
Anchor loss for three months in lateral cephalogram	Inter-radicular mini implants	15	.4740	.09672	.02497
	Infrazygomatic screws	15	.2107	.12964	.03347

IV. Discussion

According to Costa[16] interradicular mini screws with a length between 6mm and 10mm are acceptable. Some studies[17,18,19] have recommended that the ideal diameter of interradicular mini implant should be from 1.2mm – 1.6mm. In this study, 1.5mm diameter and 9mm length mini implant was used on both sides to avoid bias due to difference in diameter of mini implant.

With regards to material, titanium mini implant on both sides in favour of the fact that it is biocompatible and is capable of formation of a direct contact between the bone and the metal surface as mentioned in studies by Ismail SF[20] and Listgarten[21]. Although stainless steel screws because of their high fracture resistance are recommended by some clinicians in high density bone areas such as the IZC, recent studies by Chris H Chang[22] and Bollero[23] indicate that both SS and NiTi mini implants are clinically acceptable for IZC.

Regarding the location, both mini implants were placed at the first molar region; the interradicular mini implant placed interradicularly between the second premolar and first molar near the mesiobuccal root of first molar and the IZC mini implant placed just above the mesiobuccal root of first molar as suggested by Liou et al[24].

Immediate loading of mini implants was done in this study with the concept that when forces of appropriate magnitude are applied, the mini implants can be immediately loaded without jeopardizing the success rate of mini implants as suggested by Nkenke and Lehner[25].

Nickel Titanium closed coil springs of 9mm length with a force calibrated to 150 g were used to produce more constant force levels and less force decay as compared to elastomeric chains[26]. However, a recent randomized controlled trial showed no significant difference in the rate of retraction, or root resorption between usage of NiTi coil springs and e- chains[27]. By this approach, mini implant and IZC were compared so that it could be used in routine clinical scenarios for en masse retraction of maximum anchorage cases.

Amount of anchor loss

The amount of anchor loss in cast was measured with the help of customized acrylic jig as used in studies[28,29] and was superimposed on cast of each month interval. This helped in better visualization and measurement of anchor loss.

Despite the use of mini implants to reinforce anchorage, mesial movement of maxillary molars have been reported[330,31,32]. In this study, there was statistically significant difference between the groups for anchor loss per month with higher anchor loss reported for "inter-radicular mini-implants" [after one month (0.05±0.04), two months (0.19±0.05) and three months (0.23±0.06)]. Although the anchor loss in IRR group was minimal, anchor loss in IZC group was even less compared to IRR group.

The comparison for total amount of retraction and total anchor loss for three months was done using standardization jigs in lateral cephalogram. Badri thiruvengadachari[33] used jigs of different shapes to identify right and left sides of canines and molars. Amount of retraction recorded after three months in lateral cephalogram was found to be higher for of "infra zygomatic screws" (2.9±0.52) which was statistically significant ($p<0.0001$) Anchor loss recorded after three months in lateral cephalogram was found to be higher for "inter-radicular mini-implants" (0.47±0.1) which was statistically highly significant ($p<0.0001$). In this study, pterygoid vertical perpendicular to the Frankfort horizontal was used as the stable reference line[34,35] for measurement of amount of retraction and amount of anchor loss.

Limitations of the study

- Study was prospective in nature with a sample size of 15 patients; therefore, the results obtained from this study may be verified with a larger sample.
- Digital model setup or 3D representation may be used as a measuring tool as 2D Lateral Cephalogram and OPGs have their own limitations.

V. Conclusion

The following conclusions can be drawn from the clinical split mouth study:

- The amount of en masse retraction showed statistically significant values between the two groups with higher retraction in Infrazygomatic Crest (IZC) mini implant group compared to Interradicular (IRR) mini implant group.
- On comparison of the rate of retraction between the two groups, IZC mini implant group exhibited higher rate of retraction as compared to IRR mini implant group with statistically significant difference.
- The anchor loss shows statistically significant difference in both groups with anchor loss being higher in IRR mini implant group as compared to IZC mini implant group.

Thus, it can be concluded that although both Interradicular mini implants and Infrazygomatic Crest mini implants can be successfully used as absolute anchorage techniques, Infrazygomatic crest mini implants prove to be more efficacious than Interradicular mini implants during en masse retraction of maximum anchorage cases.

Data availability:

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary material.

Compliance with Ethical Standards:
Conflict of Interest: All author declares no conflict of interest.
Funding: None.
Ethical approval: Ethical committee approval number 0163/2021
Informed consent: Annexure 1

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