A Comparative Study of Apical Root Resorption During Intrusion of Maxillary Anterior Teeth Treated With Intrusion Arch and Mini-Implants – A CBCT Study

Dr. Hetvi Suthar (hetvisuthar94@gmail.com)
Karnavati School of Dentistry
Dr. Kalyani Trivedi
Karnavati School of Dentistry
Dr. Alap Shah
Karnavati School of Dentistry
Dr. Rushvi Mistry
Karnavati School of Dentistry
Dr. Niyati Nathwani
Karnavati School of Dentistry
Dr. Maulik Bhatt
Karnavati School of Dentistry

Research Article

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Abstract

Background

To evaluate and compare relationship between amount of root resorption after intrusion of maxillary anterior teeth using two different intrusion mechanics i.e. Intrusion arch (Utility arch) and Mini-implants through CBCT scans. 20 patients randomly selected were divided into 2 groups: Group A: 10 patients with intrusion arch mechanics and Group B: 10 patients with mini-implant mechanics. Pre- and post-intrusion sectional CBCT scans of maxillary anterior teeth were taken. Change in volumetric measurements (in mm^3), linear measurements (in mm) and angular measurements (in degree) between pre- and post-intrusion scans were measured for each incisor in both groups using paired t-test. Independent t-test was used for comparing change in all three parameters between both groups. Pearson's correlation test was done for correlating amount of root resorption with amount of intrusion for each incisor in both groups.

Results

Changes in all three parameter between pre- and post-treatment CBCT scans for all incisors for each group and between both groups were statistically significant. Pearson's correlation shows statistically non-significant correlation for all incisors in both groups except lateral incisors in group B.

Conclusion

Clinically significant root resorption is observed with intrusion of maxillary anterior teeth either with utility arch or mini-implants. Amount of root resorption and range of intrusion is more with mini-implants, while amount of proclination is more with use of utility arch. More amount of root resorption is seen in lateral incisors than central incisors in both groups.

Background

Correction of a deep bite is necessary due to the potential deleterious effects on the temporomandibular joint, occlusion, periodontal health and facial esthetics. Maxillary incisor intrusion should be the preferred treatment in nongrowing patients with anterior deep bite caused by overeruption of the maxillary incisors. [1] The treatment of choice depends on variety of factors such as smile line, incisor display, and vertical dimension of the patient.

Conventional methods of incisor intrusion usually involve 2 x 4 appliances such as utility arches, 3-piece intrusion arches, or reverse curved arches. Mini-implants have been used to intrude incisors since 1983 when Creekmore and Eklund reported using a metal implant to correct a deep overbite.[2] By using even light amount of forces and any method for intrusion some degree of root resorption is always anticipated.

External apical root resorption (EARR) is a frequent, undesirable side effect in orthodontic treatment having multifactorial etiology. Since one cause of root resorption is orthodontic movement, a correlation may exist between the type of movement and the degree of root resorption. The presence of risk factors along with orthodontic treatment like age, gender, root morphology, alveolar bone density, type of force (continuous/intermittent), force magnitude and direction have been found to increase the extent of root resorption.

Root resorption occurs 3-dimensionally, and 2D images cannot detect root resorption on lingual or buccal surfaces nor can measure the volume of root loss. Therefore, the quantification of treatment should be assessed with the help of 3-dimensional radiographic methods like cone-beam computed tomography (CBCT) which is more accurate and reliable 3D measuring method for EARR investigation.

For correction of deep bite, mini-implant insertion being an invasive procedure, there are certain limitations in usage for different patients. While intrusion arches like utility arch being non-invasive can be used in cases of the mixed dentition and are easier to use. Comparing intrusion arches with mini-screws, some authors have reported significantly more incisor proclination when using intrusion archwires,[3] while others have found significantly more intrusion using mini-screws.[4] As with different intrusion mechanics used, the amount of force varies, so the amount of root resorption varies. Most of the studies quantifying upper incisor intrusion have used lateral cephalograms,[4,5] while only a few studies have evaluated root resorption using CBCT sagittal sections.[6,7]

Thus, the aim of present study is to evaluate and compare relationship between amount of root resorption after intrusion of maxillary anterior teeth using two different intrusion mechanics i.e. Intrusion arches like Utility arch and Mini-implants using CBCT scans of patients.

Materials And Method

Ethical consideration

The study was undertaken at the department of orthodontics and dentofacial orthopedics of our institution. The ethical approval for study was taken from the ethical committee of the institution before the start of study. The subjects were explained about whole procedure and written consent was obtained from them. All methods were carried out in accordance with relevant guidelines and regulations.

Inclusion criteria:

- Patients with overbite more than 5 mm.
- Incisor display more than 3 mm at rest.
- Males (n = 10) and females (n = 10) above 15 years age.
- No history of marked root resorption before orthodontic treatment as evident on CBCT.
- No signs of any carious lesions.

- Patients undergoing MBT 0.022 fixed mechanotherapy treatment.

Exclusion criteria:

- Previous history of orthodontic treatment.
- Patients with active periodontal disease
- Root canal treated anterior teeth.
- Patients with mutilated dentition.
- Individuals with a history of medical conditions such as asthma, hypothyroidism, diabetes, or other endocrine problems.
- Patients who are not willing to participate.

Materials and equipment for study

- Titanium mini-implants of 1.5 mm x 8 mm size were selected.
- 0.017 x 0.025 inch Beta titanium (TMA) wire was used for the fabrication of Rickett's Utility arch.
- Sectional CBCT of upper anterior teeth were taken before and after the intrusion of maxillary anterior teeth.
- The CBCT scans were taken with the machine – KAVO OP 3D PRO with the following specifications: 13 x 15 field of vision; voxel size 85 Voxel, tube volume of 85 Kvp, tube current of 10 mA, and scan time of 12 seconds.
- The measurements of CBCT scans were carried out in Ez-3Di software version 5.0.0.2 of company Vatech, South Korea. The slice thickness and slice interval during these measurements were 0.1 mm each. All measurements were done by a single observer.

Methodology

20 patients randomly selected were divided into 2 groups:

Group A: 10 patients who were undergoing treatment with intrusion arch mechanics

Group B: 10 patients who were undergoing treatment with mini-implant mechanics

Pre-intrusion sectional CBCT scans and intraoral photographs were taken of maxillary anterior teeth of patients in both groups. The intrusion of patient's teeth using intrusion arches and mini-implant systems was carried out. After a mean period of 6 ± 2 months of intrusion, post-intrusion records were taken.

Intra-group comparison was done for measuring the amount of external root resorption, amount of intrusion and amount of change in inclination by comparing differences in volume, change in linear measurement and angular measurement of each incisor in pre- and post-intrusion CBCT scans for both group patients. The volumetric measurements were done by using the volumetric tool of the software in

such a way that the entire tooth was covered in all three sections i.e. axial, coronal, and sagittal as shown in Fig. 1. Figure 2(A) shows sagittal view of incisor for volumetric measurement in mm^3.

As shown in Fig. 2(B), for linear measurement, the palatal plane was taken as a reference plane passing from ANS (anterior nasal spine) to PNS (posterior nasal spine) and a perpendicular distance from each incisal edge onto the palatal plane was measured. Similarly, for angular measurement, the internal angle between long axis of each incisor and palatal plane was measured as shown in Fig. 2(C).

Inter-group comparison was done for the amount of external root resorption, amount of intrusion, and amount of change in inclination between both groups.

The correlation was measured between the amount of volumetric measurement change during intrusion and the amount of intrusion for all incisors for both groups.

Intrusion mechanics:

In Group A, the intrusion was carried out with utility arch after leveling and alignment of upper four incisors. It was activated by placing a 30° occlusally directed gable bend in the vestibular segment as shown in Fig. 3, to generate 50–60 grams of force measured using a Dontrix gauge as shown in Fig. 4(A). A transpalatal arch was given in every patient for minimal molar movement.

In Group B, the intrusion of maxillary anterior teeth of the patients was carried out with two mini-implants each placed 5–6 mm apically and distal to lateral incisor bilaterally as shown in Fig. 4(B). Leveling and alignment of upper incisors were carried out until 0.017 x 0.025 or 0.019 x 0.025 stainless steel wire was engaged. A force of 50–100 grams as recommended by Burstone[8], was measured using a Dontrix gauge and applied using an elastomeric chain from mini-implant bilaterally onto the archwire connecting four incisors.

STATISTICAL ANALYSIS

- Statistical analyses were done with the help of SPSS software version 20.0.
- Paired t-test was done for intra-group comparison of amount of external root resorption (volumetric measurement in mm^3), amount of intrusion (linear measurement in mm), and amount of change in inclination (angular measurement in degree) of each incisor between pre-intrusion and post-intrusion CBCT scans in each group.
- An Independent t-test was done for inter-group comparison of all three parameters between group A and group B.
- Pearson's correlation was done for correlation between volumetric measurement difference and linear measurement difference of pre-treatment and post-treatment measurements of each incisor for both groups.
- The p-value of < 0.05 was considered statistically significant for all tests.

Results

As shown in table 1 and Fig. 5 and Fig. 6, results of paired t-test for both groups shows the mean values of volumetric and linear measurements for pre-treatment, which are higher than that of post-treatment and are statistically significant with a p-value of < 0.001 for all incisors. While, the mean values of angular measurement for post-treatment are higher than that of pre-treatment which all are statistically significant with a p-value of < 0.05 for all incisors as shown in Fig. 7.

Table 2 shows independent t-test results, in which for volumetric measurements, the mean value difference of all incisors are higher in group B than group A with statistically significant results ($p < 0.05$) except 12 which is statistically non-significant ($p = 0.079$). For linear measurements, the mean value difference of all incisors are higher in group B while for angular measurements, the mean value difference of all incisors are higher in group A and is statistically significant with a p-value of < 0.05.

Table 3 shows Pearson correlation test results. For group A, the correlation for all incisors shows non-significant results. For group B, 12 and 22 shows a significant result while the correlation for 11 and 21 is non-significant.

Discussion

Graber has defined "deep bite" as a condition of an excessive overbite, where the vertical measurement between the maxillary and mandibular incisal margins is excessive when the mandible is brought into habitual or centric occlusion. In patients with excessive incisal display due to overeruption of maxillary anterior teeth, deep bite can be corrected by intrusion of maxillary anterior teeth. The samples selected in the present study had overbite of more than 5 mm and incisal display of more than 3 mm at rest, indicating a requirement for intrusion of upper anterior teeth. Also, the patients were more than 15 years of age, justifying the growth status of most patients in maturation or completion stage, so maxillary anterior intrusion being a more stable treatment option.

Inflammatory root resorption is a side-effect related to the biological tissue response that enables teeth to be moved during orthodontic treatment. The patients selected for study being more than 15 years of age, root resorption might be induced with age. Also, endocrine problems are related to root resorption and so patients with such conditions were excluded.

According to various studies,[9] females are more susceptible to root resorption. However, there were no differences in the incidence of root resorption between genders in an overview by Harris.[10] Based on this, the samples for present study included equal males and females selected randomly.

Radiographs are commonly used as a diagnostic aid for root resorption. In recent years, it is suggested that CBCT can detect precise images of small root defects with greater sensitivity and specificity compared to 2D radiographs.

The present study was carried out to measure the amount of root resorption using CBCT scans after the intrusion of upper four incisors with two different intrusion mechanics like intrusion arch (utility arch) and mini-implants. To avoid more radiation exposure by taking lateral cephalograms for linear and angular measurements, the measurements were done in sagittal sections of CBCT scans only.

For estimating root resorption, there was a significant decrease in volumetric measurements of each incisor being intruded in both the groups in post-treatment scans as compared to pre-treatment scans as shown in Table 1. The results concluded that with intrusion of incisors, there occurs a significant amount of root resorption in all incisors for both groups.

In many studies, resorption percentages are considered for root resorption measurement while in the present study, volumetric change was in mm^3 (cubic millimeter) considering root resorption occurring three-dimensionally and so comparison with two-dimensional linear decreases (in mm) of root resorption is difficult.

For the present study, the amount of intrusion (linear measurement) was measured by taking the palatal plane (ANS-PNS) as a reference plane as in a study by de Almeida et al in 2018.[6] The post-treatment scans show a significant decrease in the values of linear measurement as compared to pre-treatment for both groups as shown in Table 1, suggesting a significant amount of intrusion of all incisors during treatment which is in accordance with various studies.[11]

Utility arch was selected as a means for the intrusion of incisors in group A as it provides less force for intrusion, is simple and non-invasive procedure for the intrusion of anterior teeth. The activation of utility arch was done by placing an occlusally directed gable bend in the vestibular segment of the utility arch as suggested by McNamara in 1986[12] generating 50–60 grams of force.

Mini implants though being a more invasive procedure, have advantages of immediate loading, multiple placement sites, uncomplicated placement and removal procedures, and minimal expenditure for patients. In this study, a rigid stabilizing archwire was used for consolidation during incisor intrusion with two mini-implants so that the center of resistance of four incisors moves closer to each other. Therefore, undesirable side effects such as protrusion could be eliminated during incisor intrusion.

With the use of one mini-implant placed in the center of two incisors, the center of resistance is more anterior as compared to two mini-implants in which it is moved more distally. The center of resistance of the upper four incisors is estimated to be halfway between crest of alveolar bone and apex of lateral incisor roots in the sagittal plane. Results in present study show a significant amount of intrusion and proclination of all four incisors after intrusion as shown in Table 1. This can be attributed to the fact that even though force is passing nearer to the center of resistance of all four incisors, it is still labial to it.

In the present study, the amount of root resorption for group A for all four incisors is statistically non-significant ($p > 0.05$) with the amount of intrusion as shown in Table 3 which is in favor of a study by Costopoulos and Nanda in 1996.

There is a significant change in inclination from pre-treatment to post-treatment in both groups as shown in Table 1 suggesting the proclination of all incisors in both groups. The amount of proclination is more for group A and is less than that achieved in a study done by Polat-Ozsoy et al in 2011.[5] They concluded that unlike utility arches, true maxillary incisor intrusion can be achieved by using miniscrews. Although the amount of proclination achieved in this study is less than the above study when comparing both groups, there is more amount of proclination in group A than group B which is statistically significant as shown in Table 2, and so it can be concluded that relative intrusion is achieved in case of utility arch and true intrusion can be achieved with mini-implants which is in accordance of a study by Jain et al in 2014.

The amount of root resorption achieved by intrusion in group B is more than that in group A for all four incisors as shown in Table 2 which could be presumed as more the distance travelled by root through the bone, the greater will be the time it is in close proximity to the inflammatory process leading to root resorption.

There was no correlation between amount of intrusion and amount of root shortening according to the findings of Dermaut and DeMunck in 1986 stating that in combination with the apical movement of root, the nasal floor is also a limiting factor for intrusion which may have caused root resorption, and this can be related to present study. As shown in Table 3, there is a negative correlation of root resorption with the intrusion of all incisors in group A as well as for both central incisors in group B. The maxillary right lateral incisor shows a more significant positive correlation whereas left lateral incisor shows a significant negative correlation in group B. This suggests more amount of root resorption in right lateral incisor along with intrusion, though the value of correlation being 0.746 and statistically significant, it is clinically insignificant. The correlation between root resorption changes and amount of intrusion for both lateral incisors are different can be due to variability in measurement by a single observer.

The mean volumetric difference of lateral incisors are more than those of central incisors for both groups as shown in Table 1. Maxillary lateral incisors have more narrowed or shortened roots and so more force would be orthodontically distributed over smaller root surface area to intrude the root than with normal root shapes. This is in accordance with a study done by Kennedy et al in 1983.

Lund et al in 2012 measured slanted surface resorptions of buccal and palatal surfaces of upper incisors using CBCT during orthodontic treatment. For this study, the amount of intrusion is less in group A than that in group B while the amount of angular changes are more in group A. It can be inferred that amount of root resorption in group A can be a combination of both apical root resorption as well as slanted surface resorption on labial surfaces.

Conclusion

- Clinically significant root resorption is observed with intrusion of maxillary anterior teeth either with utility arch or mini-implants.

- The amount of root resorption and range of intrusion is more with mini-implants, while amount of proclination is more with the use of utility arch.
- More amount of root resorption is seen in lateral incisors than central incisors in both groups.

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Abbreviations

TMA - Titanium Molybdenum Alloy

p-value - probability value

2D - two dimensional

3D - three dimensional

Declarations

AUTHORS' CONTRIBUTIONS

HS is the principal investigator, did the write-up and study. KT conceptualised, did study design, supervised and interpreted the study data. AS facilitated smooth conduct of study and edited the manuscript. RM assisted in write-up and statistical interpretation. NN helped in study and its interpretation. MB helped in carrying out study and statistics.

AVAILABILITY OF DATA AND MATERIALS

Department of Orthodontics & Dentofacial Orthopedics, Karnavati School of Dentistry, Uvarsad, Gandhinagar, Gujarat

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

Name of ethics committee - Karnavati School of Dentistry Ethics Committee (KSDEC)

COMPETING INTERESTS

Not applicable

The authors declare that they have no competing interests.

Tables

Tables 1-3 not available with this version.

Figures

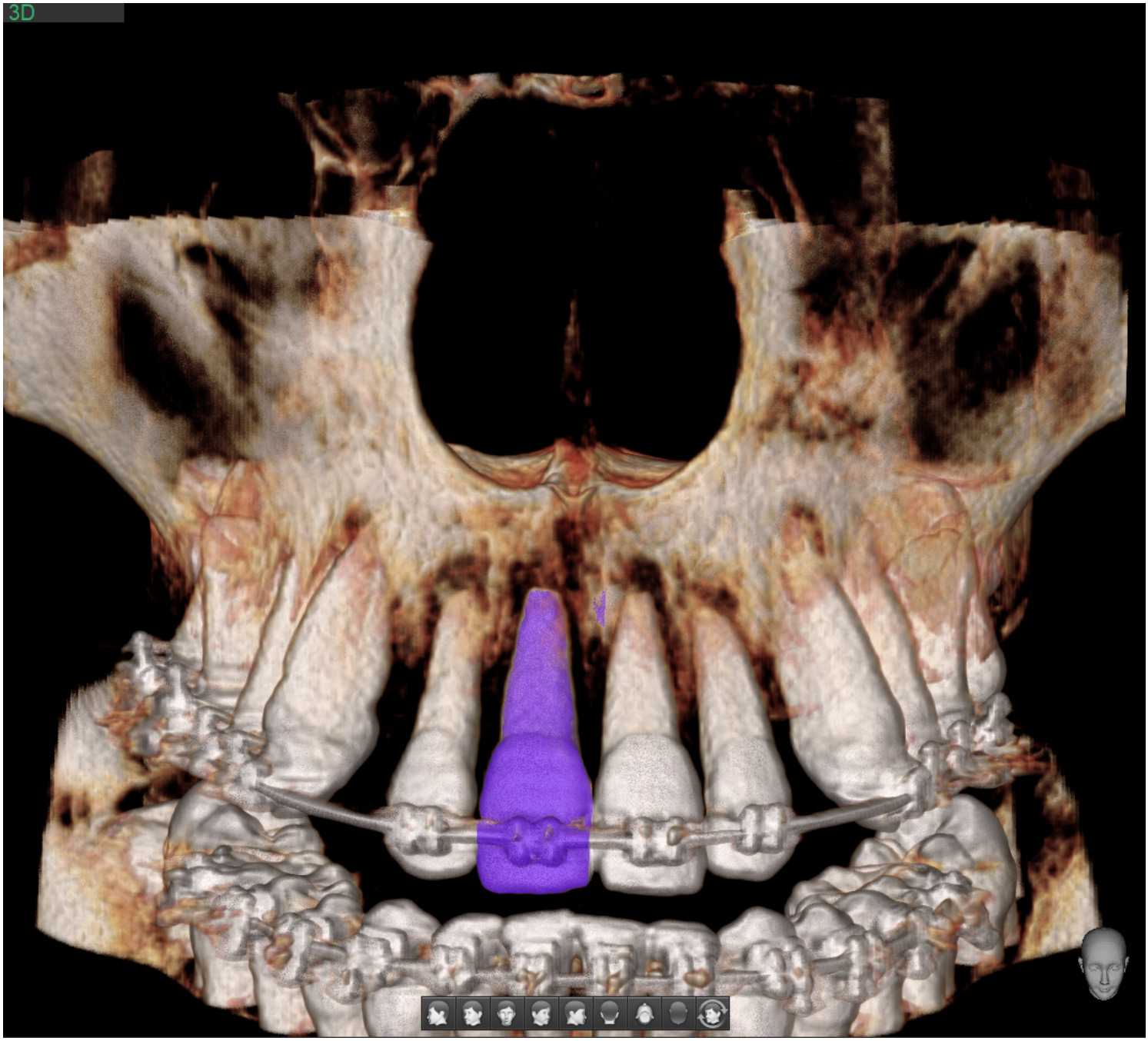
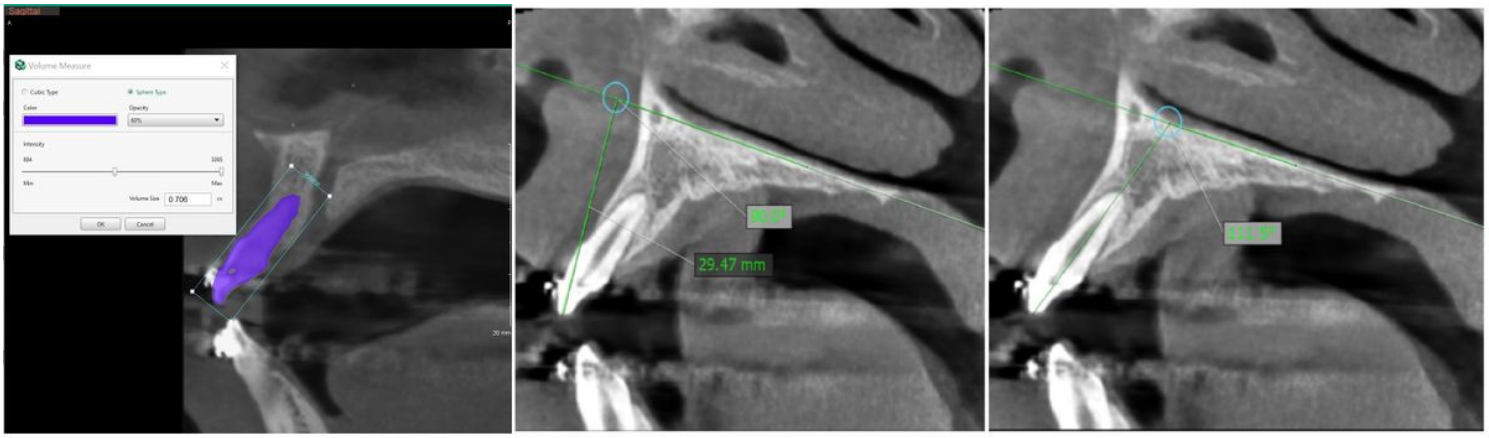


Figure 1

THREE-DIMENSIONAL SECTIONING OF TOOTH FOR VOLUMETRIC MEASUREMENT



(A) VOLUMETRIC MEASUREMENT (SAGITTAL VIEW)

(B) LINEAR MEASUREMENT (PERPENDICULAR DISTANCE FROM INCISAL EDGE - PALATAL PLANE)

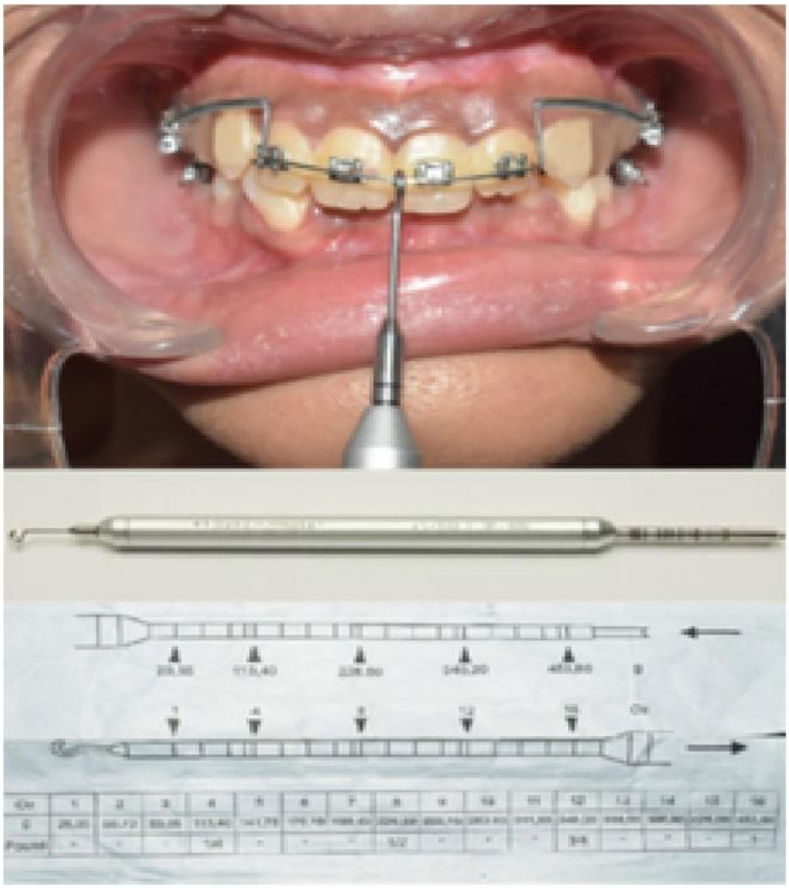
(C) ANGULAR MEASUREMENT (LONG AXIS OF INCISOR - PALATAL PLANE)

Figure 2

(A) SAGITTAL VIEW OF INCISOR FOR VOLUMETRIC MEASUREMENT IN MM^3; (B) LINEAR MEASUREMENT (PERPENDICULAR DISTANCE FROM INCISAL EDGE-PALATAL PLANE); (C) ANGULAR MEASUREMENT (LONG AXIS OF INCISOR- PALATAL PLANE)

Figure 3

INTRAORAL LATERAL VIEW SHOWING GABLE BEND IN VESTIBULAR SEGMENT OF UTILITY ARCH

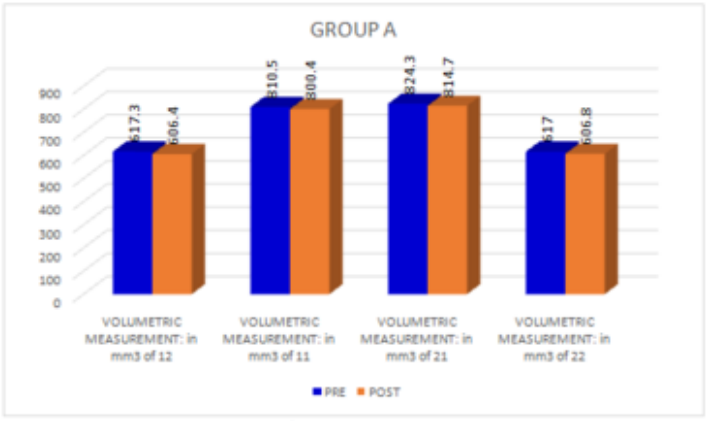


(A) INTRAORAL PHOTOGRAPH SHOWING MEASUREMENT OF FORCE FOR INTRUSION USING DONTRIX GAUGE

(B) INTRAORAL PHOTOGRAPH SHOWING INTRUSION WITH MINI-IMPLANTS

Figure 4

(A) INTRAORAL PHOTOGRAPH SHOWING MEASUREMENT OF FORCE FOR INTRUSION USING DONTRIX GAUGE; (B) INTRAORAL PHOTOGRAPH SHOWING INTRUSION WITH MINI-IMPLANTS



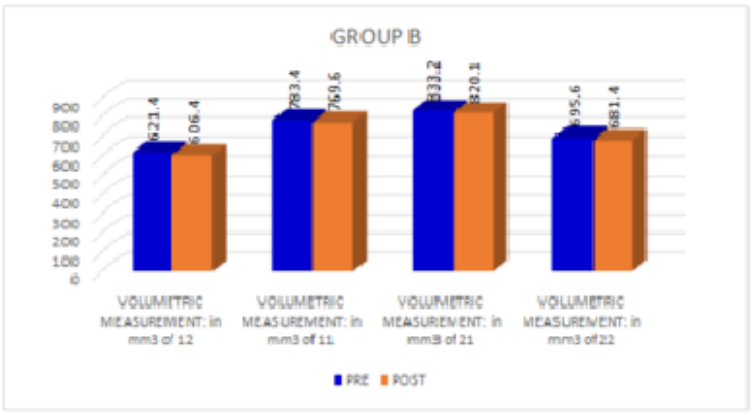
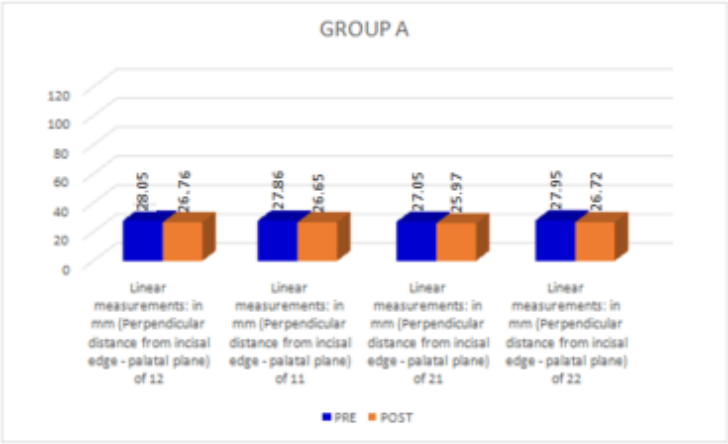
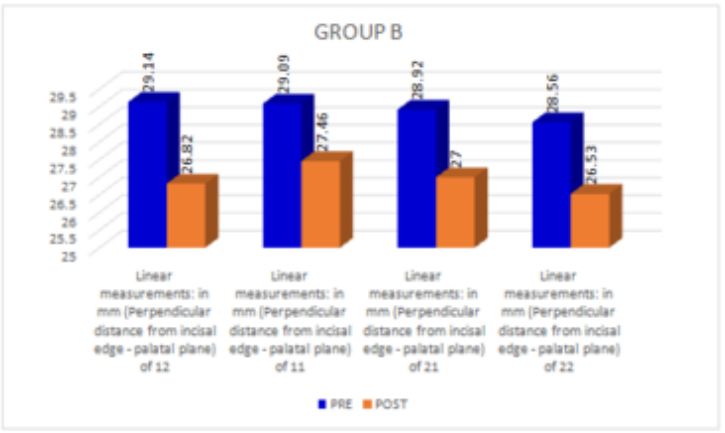


Figure 5

GRAPH SHOWING VOLUMETRIC MEASUREMENTS (IN MM^3) Legend - PRE-TREATMENT AND POST-TREATMENT VALUES OF 12, 11, 21 AND 22 OF GROUP A AND GROUP B



Linear measurements (in mm) of pre-treatment and post-treatment values of 12, 11, 21 and 22 of Group A

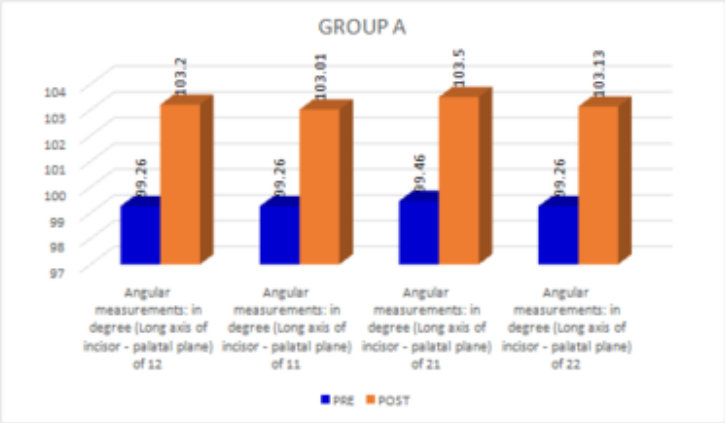


Linear measurements (in mm) of pre-treatment and post-treatment values of 12, 11, 21 and 22 of Group B

Figure 6

GRAPH SHOWING LINEAR MEASUREMENTS (IN MM)

Legend - PRE-TREATMENT AND POST-TREATMENT VALUES OF 12, 11, 21 AND 22 OF GROUP A AND GROUP B



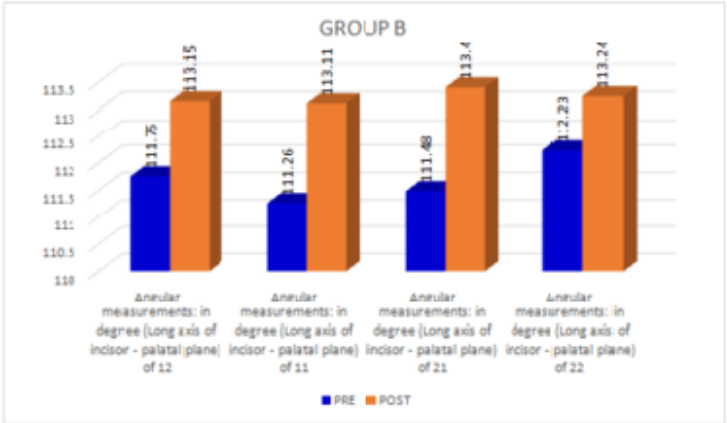


Figure 7

GRAPH SHOWING ANGULAR MEASUREMENTS (IN DEGREE)

Legend - PRE-TREATMENT AND POST-TREATMENT VALUES OF 12, 11, 21 AND 22 OF GROUP A AND GROUP B