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EFFECT OF ANTERIOR INTRUSION ON ROOT RESORPTION USING TWO MINI IMPLANTS VS FOUR MINI IMPLANTS – A COMPARATIVE CLINICAL CBCT STUDY

Dr. Pasala Sathvik[1], Dr. Vattikunta Naresh[2], Dr. Dodda Kiran Kumar[3], Dr. Lakshmi Sowjanya Vemula[4], Dr Annapurna Paladugu[5], Dr. Mohammed Maaz Mohammad Mujaddid[6]

[1]Post Graduate, Dept Of Orthodontics And Dentofacial Orthopaedics, Drs.Sudha And Nageswara Rao Siddhartha Institute Of Dental Sciences, Email Id: Sathvikpasala@Gmail.Com, Orcid Id : 0009-0003-1604-1595
[2]Associate Professor, Dept Of Orthodontics And Dentofacial Orthopaedics, Drs.Sudha And Nageswara Rao Siddhartha Institute Of Dental Sciences, Email Id: Drnareshvattikunta@Gmail.Com, Orcid Id : 0009-0006-4195-7855
[3]Professor And Head Of The Department Dept Of Orthodontics And Dentofacial Orthopaedics , Drs.Sudha And Nageswara Rao Siddhartha Institute Of Dental Sciences, Email Id: Kumardoddakiran@Gmail.Com, Orcid Id : 0009-0001-0403-7252
[4]Assistant Professor, Dept Of Orthodontics And Dentofacial Orthopaedics , Drs.Sudha And Nageswara Rao Siddhartha Institute Of Dental Sciences, Email Id : Ssrmicrodent@Gmail.Com, Orchid Id : 0009-0003-0297-0959
[5]Post Graduate , Dept Of Orthodontics And Dentofacial Orthopaedics , Drs.Sudha And Nageswara Rao Siddhartha Institute Of Dental Sciences, Email Id : Drannapurna.Ortho@Gmail.Com, Orchid Id : 0009-0006-9940-1796
[6]Post Graduate , Dept Of Orthodontics And Dentofacial Orthopaedics , Drs.Sudha And Nageswara Rao Siddhartha Institute Of Dental Sciences, Email Id : Mdmaaz2811@Gmail.Com, Orcid Id : 0009-0006-9574-8872
***Corresponding Author:** Dr. Pasala Sathvik, Sathvikpasala@Gmail.Com

ABSTRACT
The present study compared the effects of maxillary anterior intrusion using two mini-implants and four mini-implants on root resorption and posterior dentoalveolar changes using cone beam computed tomography (CBCT). Ten patients with deep bite were randomly divided into two groups of five subjects each. CBCT scans obtained before and after treatment were used to evaluate incisor intrusion, root resorption, anchorage loss, and molar rotation. Both treatment protocols achieved significant anterior intrusion. The four mini-implant group demonstrated better anchorage control and greater intrusion, whereas the two mini-implant group exhibited greater molar rotation. Root resorption was significantly higher in the four mini-implant group. Within the limitations of the study, both treatment approaches were effective; however, the four mini-implant configuration provided superior biomechanical control despite a higher degree of root resorption.

KEYWORDS: Temporary Anchorage Devices (TADS), gummy smile, mini-implants, CBCT, anchorage loss, deep bite.

1. INTRODUCTION
Deep bite is one of the most prevalent vertical malocclusions encountered in orthodontic practice and is defined by an excessive vertical overlap of the maxillary anterior teeth over the mandibular anterior teeth. It is frequently associated with both functional disturbances and esthetic concerns, particularly when accompanied by excessive gingival display during smiling, commonly referred to as a "gummy smile." Smile aesthetics plays a crucial role in overall facial harmony, and even minor discrepancies in gingival display can significantly influence an individual's appearance and self-esteem. Patients presenting with a deep bite often exhibit increased maxillary incisor display at rest and during smiling, thereby contributing to an aesthetically displeasing gummy smile, which is one of the primary reasons for seeking orthodontic treatment[1].
The aetiology of deep bite and gummy smile is multifactorial, involving skeletal, dental, and soft tissue components. Skeletal factors include vertical maxillary excess and reduced mandibular plane angle, while dental factors involve supra-eruption of anterior teeth and infra-eruption of posterior teeth. Soft tissue factors such as a short or hyperactive upper lip may further exaggerate gingival display. Among these, dentoalveolar extrusion of maxillary anterior teeth is one of the most common contributing factors, particularly in orthodontic patients with a deep bite. This close association between deep bite and gummy smile necessitates a treatment approach that simultaneously addresses both conditions to achieve optimal aesthetic and functional outcomes.
The correction of a deep bite can be accomplished through two principal approaches: extrusion of posterior teeth or intrusion of anterior teeth. Posterior extrusion may be advantageous in patients with decreased lower anterior facial height; however, in patients with vertical growth patterns or excessive gingival display, this approach may worsen facial proportions and increase gingival exposure. Therefore, anterior intrusion is considered the treatment of choice in such cases, as it effectively reduces overbite and decreases maxillary incisor display, thereby improving smile esthetics.

Conventional orthodontic techniques for anterior intrusion include reverse curve of Spee archwires, utility arches, Mulligan's intrusion arch, Burstone intrusion mechanics, and three-piece intrusion systems. While these methods have been used extensively, they are often associated with significant drawbacks. One of the major limitations is the lack of absolute anchorage, which results in undesirable reciprocal effects such as extrusion of posterior teeth, loss of anchorage, and flaring of anterior teeth. Additionally, these techniques may not produce true intrusion but rather relative intrusion, which may not be sufficient in patients with gummy smile where precise vertical control is essential.

Another important limitation of conventional mechanics is the difficulty in controlling the force system. Intrusion requires the application of light, continuous forces directed close to the center of resistance of the teeth. However, conventional appliances often produce uncontrolled force vectors, leading to tipping movements rather than bodily intrusion. This not only compromises treatment efficiency but may also contribute to adverse effects such as root resorption and periodontal stress.[2]

The introduction of temporary anchorage devices (TADS), particularly mini-implants, has revolutionized orthodontic treatment by overcoming the limitations of conventional anchorage systems. Mini-implants provide skeletal anchorage by engaging cortical bone, thereby eliminating the dependence on dental units for support. This allows for the application of controlled and directed forces, resulting in more predictable tooth movement. Their advantages include minimal surgical intervention, ease of placement and removal, immediate loading capability, and cost-effectiveness, making them highly suitable for clinical use.

Mini-implant-assisted intrusion has gained particular importance in the management of gummy smile. By strategically placing mini-implants in the interradicular bone, especially between the lateral incisors and canines, clinicians can apply intrusive forces closer to the center of resistance of the anterior segment. This facilitates true intrusion with minimal tipping and reduces the risk of unwanted tooth movements. Polat-Ozsoy et al. demonstrated that the use of mini-implants for maxillary incisor intrusion results in a significant reduction in overbite and improved incisor positioning without significant changes in axial inclination, thereby confirming the effectiveness of this approach.

In addition to functional correction, mini-implant-assisted intrusion has a profound impact on smile aesthetics. Gomaa et al. demonstrated that patients treated with mini-implants showed significant improvement in smile arc consonance and reduction in gingival display compared to those treated with conventional archwire techniques. This highlights the superiority of mini-implant-supported mechanics in addressing the aesthetic concerns associated with gummy smile[4]. Similarly, Parayaruthottam and Antony reported successful correction of gummy smile using midline mini-implant-assisted intrusion, achieving significant improvement in facial esthetics without adverse periodontal effects.[3]

The concept of force distribution is critical in achieving true intrusion. Ideally, intrusive forces should be evenly distributed across the anterior segment to avoid differential tooth movement and tipping. The addition of posterior implants may help in balancing the force system, reducing unwanted movements, and improving overall treatment efficiency. However, the increased number of implants may also alter stress distribution within the periodontal ligament and surrounding bone, which may have implications for root resorption.

Root resorption is one of the most significant iatrogenic effects associated with orthodontic treatment, particularly during intrusion. Intrusive forces tend to concentrate stress at the apical region of the teeth, making them more susceptible to resorption. Aras and Tuncer demonstrated that root resorption is directly related to the amount of intrusion achieved, with greater intrusion resulting in increased resorption. Their study also highlighted that different mini-implant configurations can influence both intrusion efficiency and the extent of root resorption, emphasizing the importance of controlled biomechanics.[4] A comparative evaluation of different mini-implant configurations using CBCT can provide valuable insights into optimizing treatment protocols and improving patient outcomes.[5]

Therefore, considering the need for effective management of deep bite associated with excessive gingival display, the importance of achieving optimal smile esthetics, and the necessity of minimizing iatrogenic effects such as root resorption, the present study is undertaken to comparatively evaluate the effects of two mini-implant and four mini-implant assisted treatment mechanics on maxillary anterior intrusion and to assess the extent of root resorption using cone-beam computed tomography.

2. AIMS AND OBJECTIVES

Aim of the study

To compare the effect of two mini implant vs four mini maxillary anterior intrusion and to evaluate the amount of root resorption among them using CBCT.

Objectives Of The Study

- To evaluate the amount of incisor intrusion using CBCT.
- To evaluate the amount of incisal root resorption using CBCT after maxillary anterior intrusion
- To evaluate the effect of posterior dentoalveolar changes using CBCT.

3. RESEARCH METHODOLOGY

The present study was designed as a prospective comparative clinical study to evaluate and compare the effects of anterior intrusion using two mini-implants and four mini-implants on root resorption and associated posterior dentoalveolar changes using cone beam computed tomography (CBCT). The study was conducted in the Department of Orthodontics and Dentofacial Orthopaedics at Drs. Sudha and Nageswara Rao Siddhartha Institute of Dental Sciences, Gannavaram, with proper Institutional Ethics Committee approval. The total duration of the study was four months, during which active intrusion of maxillary anterior teeth was carried out and evaluated.

Sample Size: Sample size was derived using G*Power software with the following parameters with effect size 1.8, with α error 0.05, power 95% and allocation ratio of 1.

Study Population: A total of ten subjects were selected from patients reporting to the outpatient department of Orthodontics and were randomly allocated into two groups of five subjects each. The study population included patients aged between 18 and 25 years presenting with dental deep bite, increased maxillary incisor display, vertical maxillary excess, and gummy smile.

Inclusion Criteria

- Patients within the age group of 18 to 25 years were included
- Completed growth individuals are included
- Patients presenting with a clinically significant dental deep bite
- Patients with gummy smile.
- Individuals with an exaggerated curve of Spee were included, as correction of this occlusal discrepancy often necessitated anterior intrusion mechanics.
- Full complete permanent dentition (excluding third molars)
- Individuals willing to undergo orthodontic treatment with mini-implant-supported mechanics and complied with study requirements throughout the treatment duration.

Exclusion Criteria

- Individuals with periodontal disease were excluded, as compromised periodontal support could influence tooth movement and increase the risk of root resorption.
- Patients with poor oral hygiene were also excluded to prevent treatment related complications such as gingival inflammation and peri-implant issues.
- Patients with missing maxillary first permanent molars were excluded
- Patients with missing anterior teeth or impacted teeth were excluded
- Uncooperative patients or those unwilling to adhere to treatment protocols and follow-up visits were also excluded to ensure reliability of results.
- Patients with systemic conditions affecting bone metabolism
- Patients with history of previous orthodontic treatment

Pre-treatment Records

Before treatment, all participants were clinically examined, photographed, studied models were made, lateral cephalogram was taken and CBCT imaging was performed. Treatment was undertaken by fixed orthodontic treatment with the MBT 0.022 × 0.028-inch appliances followed by alignment and levelling. The mini implants were inserted under local anaesthetic after radiography of the insertion sites, two (Group I) or four (Group II) implants.

In Group I, two mini-implants were placed in the interradicular region between the maxillary lateral incisors and canines.

In Group II, four mini-implants were placed, with two in the anterior region between the maxillary lateral incisors and canines and two in the posterior region between the second premolars and first molars.

FIG 1: GROUP1- ANTERIOR BILATERAL TADS BETWEEN LATERAL INCISOR AND CANINE

POSTERIOR RETRACTION USING BENNET TIE TO MOLAR

Fig 2: GROUP2- FOUR TADS BILATERALY TWO TADS IN BETWEEN LATERAL AND CANINE, POSTERIOR TAD BETWEEN PREMOLAR AND MOLAR

Standardised intrusive and retraction forces were applied and patients were examined every 4 wks for 4 months of intrusion and retraction. The CBCT scans before and after treatment were analyzed for maxillary incisor intrusion, root resorption, anchorage loss and molar rotation. All measurements were taken by one examiner and repeated following two weeks for reliability.

CBCT Evaluation

CBCT imaging was used for evaluation due to its ability to provide an accurate three-dimensional assessment of dental and alveolar structures. Scans were obtained before initiation of intrusion (T1) and after completion of intrusion (T2). CBCT was considered superior to conventional radiographic methods for assessing root resorption and dentoalveolar changes.

Assessment of Outcomes

The amount of maxillary incisor intrusion was evaluated by measuring the vertical displacement of the incisal edge and the centroid of the maxillary incisors relative to stable craniofacial reference planes on CBCT images.

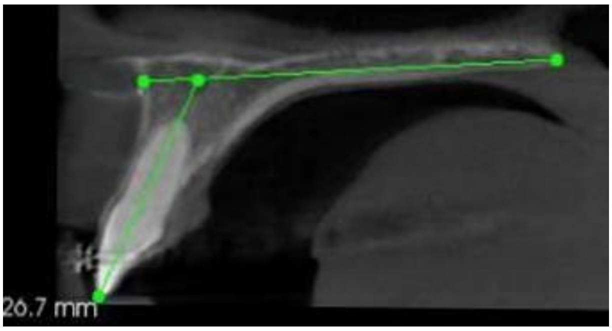
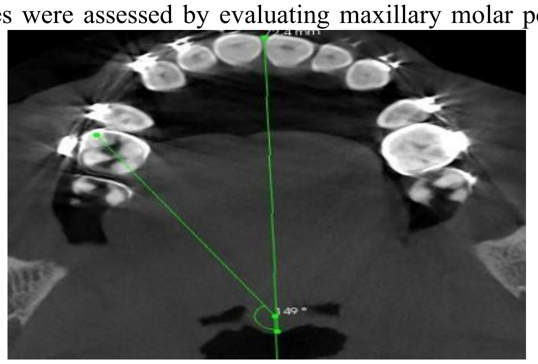


FIG 3: THE AMOUNT OF MAXILLARY INCISOR INTRUSION WAS EVALUATED BY MEASURING THE VERTICAL DISPLACEMENT OF THE INCISAL EDGE AND THE CENTROID OF THE MAXILLARY INCISORS RELATIVE TO STABLE CRANIOFACIAL REFERENCE PLANES ON CBCT IMAGES

Posterior dentoalveolar changes were assessed by evaluating maxillary molar position and rotational changes.



Molar rotation was assessed on axial CBCT sections by measuring the angle formed between a line connecting the mesiobuccal and distopalatal cusps of the maxillary first molar and a stable reference line such as the midpalatal suture.

FIG 4: MOLAR ROTATION BY MEASURING THE ANGLE BETWEEN THE MESIOBUCCAL–DISTOPALATAL CUSP LINE OF THE MAXILLARY FIRST MOLAR

Anchorage loss was measured as the distance between the mesiobuccal root apex and the PNS vertical plane the line drawn from the PNS point perpendicular to palatal plane, and distance between the mesiobuccal cusp tip and the PNS verticular plane to palatal plane viewed from the sagittal aspect.

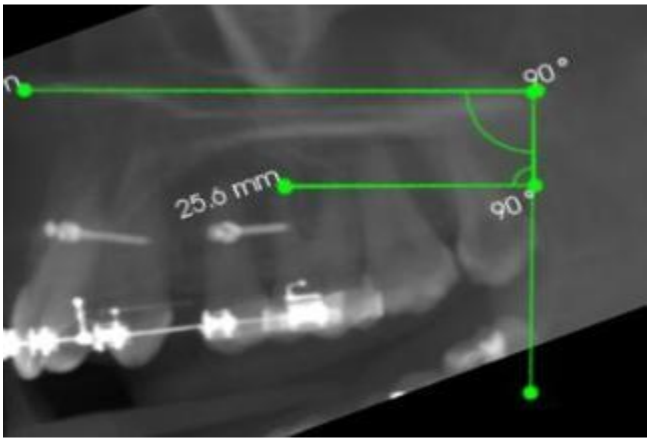


Fig 5: THE AMOUNT OF ANCHORAGE LOSS MEASURED BY LINEAR DISTANCE FROM MESIOBUCCAL ROOT APEX TO PNS VERTICAL PLANE

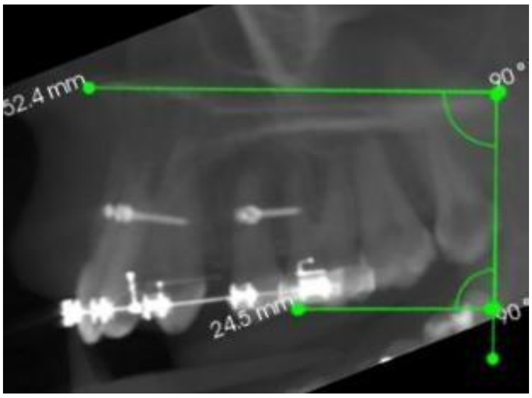


Fig 6: THE AMOUNT OF ANCHORAGE LOSS MEASURED BY LINER DISTANCE FROM MESIOBUCCAL CUSP TIP TO PNS VERTICAL PLANE

Root resorption was evaluated by measuring changes in root length of the maxillary incisors using CBCT imaging software. CBCT-based assessment provided a more accurate and reliable three-dimensional evaluation compared to conventional radiographic methods.

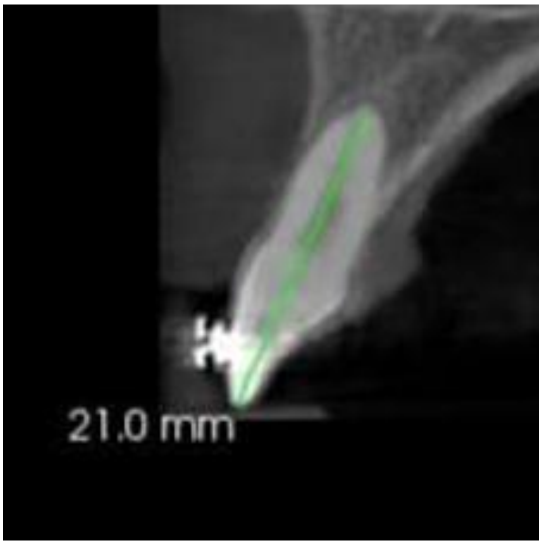


Fig 7: CBCT ASSESSMENT OF ROOT RESORPTION BY MEASURING CHANGES IN ROOT LENGTH OF THE MAXILLARY INCISORS.

All measurements were performed by a single examiner and repeated after a two-week interval to minimize intra-observer variability.

4. RESULTS

Statistical Analysis

Data was compiled using Microsoft excel software in spreadsheets and analyzed using Statistical Package for Social Science (SPSS Version 25). The level of significance was set at $P < 0.05$ for all the statistical tests. Inter-group comparisons were performed using the Independent Samples t-test Intra-group comparisons were carried out using the Paired Samples t-test.

Table 1: Paired Sample Statistics (Pre vs Post) (Group 1)

Parameter	Pre Mean ± SD	Post Mean ± SD	N
Intrusion	31.02 ± 1.79	28.62 ± 1.34	5
Resorption	22.04 ± 0.96	21.06 ± 0.91	5
Anchorage loss- Mesiobuccal Root apex to PNS Vertical Plane (mm)	23.40 ± 2.30	24.62 ± 2.23	5
Anchorage loss- Mesiobuccal Cuspal tip to PNS Vertical Plane (mm)	25.30 ± 1.84	26.34 ± 1.76	5
Molar Rotation	153.20 ± 1.79	158.8 ± 2.59	5

Table 2: Paired Sample Test (Significance of Change) (Pre vs Post) (Group 1)

Parameter	Mean Difference (Pre–Post)	t-value	p-value	Significance
Intrusion	2.40	4.165	0.014	Significant
Resorption	0.98	13.336	0.000	Highly Significant
Anchorage loss – Mesiobuccal Root apex to PNS Vertical Plane (mm)	1.22	12.583	0.000	Highly Significant
Anchorage loss – Mesiobuccal Cuspal tip to PNS Vertical Plane (mm)	1.04	12.802	0.000	Highly Significant
Molar Rotation	5.60	9.333	0.001	Highly Significant

Table 3: Paired Sample Statistics (Pre vs Post) (Group 2)

Parameter	Pre-treatment Mean ± SD	Post-treatment Mean ± SD	N
Intrusion	31.96 ± 1.12	28.78 ± 1.52	5
Resorption	23.42 ± 1.64	22.02 ± 1.67	5

Anchorage loss- Mesiobuccal Root apex to			5
PNS Vertical Plane (mm)	18.98 ± 0.19	19.22 ± 0.15	
Anchorage loss- Mesiobuccal Cuspal tip to PNS Vertical Plane	18.12 ± 1.48	18.58 ± 1.35	5
Parameter	Pre-treatment Mean ± SD	Post-treatment Mean ± SD	N
Molar Rotation	156.80 ± 1.79	159.00 ± 1.58	5

Table 4: Paired Sample Test (Significance of Change) (Pre vs Post) (Group 2)

Parameter	**Mean Difference (Pre–Post)**	**t-value**	**p-value**	**Significance**
Intrusion	3.18	12.435	0.000	Highly Significant
Resorption	1.40	11.832	0.000	Highly Significant
Anchorage loss- Mesiobuccal Root apex to PNS Vertical Plane (mm)	0.24	6.000	0.004	Significant
Anchorage loss- Mesiobuccal Cuspal tip to PNS Vertical Plane (mm)	0.46	6.147	0.004	Significant
Molar Rotation	2.20	2.750	0.06	Not Significant

Table 5: Comparison of Group I and Group II

Parameter	**Group I (Mean ± SD)**	**Group II (Mean± SD)**	**Mean Difference**	**p-value**	**Significance**	**N**
Intrusion (mm)	2.40 ± 1.29	3.18 ± 0.57	-0.78	0.251	Not Significant	10
Root Resorption (mm)	0.98 ± 0.16	1.40 ± 0.26	-0.42	0.017	Significant	10
Anchorage loss- Mesiobuccal Root apex to PNS Vertical Plane (mm)	1.22 ± 0.22	0.24 ± 0.09	0.98	0.000	Highly Significant	10

Anchorage loss- Mesiobuccal Cuspal tip to PNS Vertical Plane (mm)	1.04 ± 0.18	0.46 ± 0.17	0.58	0.001	Highly Significant	10
Molar Rotation (degrees)	5.60 ± 1.34	2.20 ± 1.79	3.40	0.009	Significant	10

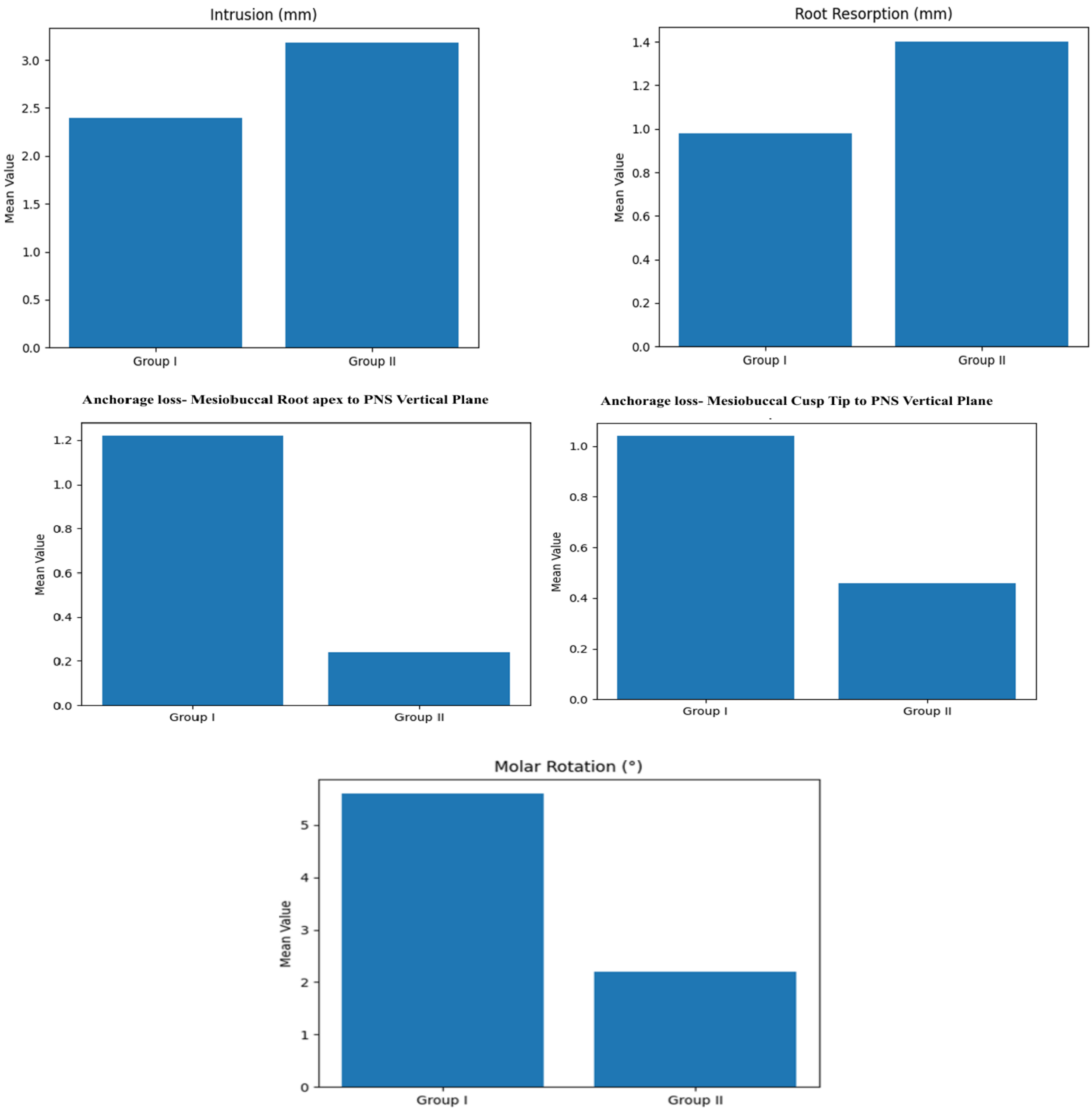


FIG 8: COMPARISON OF PARAMETERS BETWEEN GROUP 1 AND GROUP 2

A Paired Sample T-Test was performed to evaluate the differences between pre-treatment and post-treatment measurements for intrusion, resorption, anchorage loss, and molar rotation for both the groups.

GROUP 1: A statistically significant reduction in intrusion values from pre-treatment (31.02 ± 1.79) to post-treatment (28.62 ± 1.34), with a mean difference of 2.40 ($p = 0.014$). This indicates effective intrusion achieved following treatment. Root resorption also showed a statistically highly significant decrease (mean difference = 0.98, $p < 0.001$), suggesting a measurable but controlled change associated with the intervention. Anchorage loss- Mesio-buccal Root apex to PNS Vertical Plane (mm) and Anchorage loss- Mesio-buccal Cuspal tip to PNS Vertical Plane (mm) demonstrated a significant increase post-treatment, with mean differences of 1.22 and 1.04 respectively ($p < 0.001$). These mean differences indicate positional changes in the same direction. Molar rotation exhibited a highly significant increase from 153.20 ± 1.79 to 158.80 ± 2.59, with a mean difference of 5.60 ($p = 0.001$), indicating effective rotational correction. Overall, the results demonstrate that the treatment produced statistically significant improvements in intrusion and molar rotation, along with measurable changes in root and cuspal positions, confirming the effectiveness of the intervention.

GROUP II: The present study evaluated the changes in various dentoalveolar parameters by comparing pre-treatment and post-treatment values using paired t-test analysis. A statistically highly significant reduction was observed in intrusion (mean difference = 3.18, $p < 0.001$) and resorption (mean difference = 1.40, $p < 0.001$), indicating effective treatment outcomes in these parameters. These findings suggest that the intervention successfully achieved the desired amount of intrusion while maintaining controlled resorptive changes.

The Anchorage loss- Mesio-buccal Root apex to PNS Vertical Plane (mm) and Anchorage loss- Mesio-buccal Cuspal tip to PNS Vertical Plane (mm) also demonstrated statistically significant reductions ($p = 0.004$), although the magnitude of change was comparatively smaller. This indicates minor anchorage loss associated with treatment.

In contrast, molar rotation showed a difference in mean values; the results was not statistically significant ($p = 0.06$). This suggests that although some rotational correction may have occurred, it was not consistent enough across the sample to reach statistical significance. Overall, the study demonstrates that the treatment modality was effective in achieving significant intrusion and controlled dentoalveolar changes, with limited influence on molar rotation.

The present study compared dentoalveolar changes between Group I and Group II using an Independent Samples T-Test. Intrusion was greater in Group II (3.18 mm) compared to Group I (2.40 mm); however, this difference was not statistically significant ($p = 0.251$), indicating comparable intrusion efficiency between the two groups. Root resorption was significantly higher in Group II (1.40 mm) than in Group I (0.98 mm) ($p = 0.017$), suggesting increased biological cost associated with the mechanics used in Group II. Anchorage loss (Mesiobuccal Root apex to PNS Vertical Plane) was significantly greater in Group I (1.22 mm) compared to Group II (0.24 mm) ($p < 0.001$), indicating better root control in Group II. Similarly, Anchorage loss (Mesiobuccal Cuspal tip to PNS Vertical Plane) was significantly higher in Group I (1.04 mm) than in Group II (0.46 mm) ($p = 0.001$), reflecting greater anchorage loss in Group I. Molar rotation was also significantly greater in Group I (5.60°) compared to Group II (2.20°) ($p = 0.009$), suggesting increased rotational changes in Group I. Overall, Group II demonstrated slightly higher intrusion but at the expense of increased root resorption, whereas Group I showed significantly greater dentoalveolar changes including root movement, cuspal displacement, and molar rotation.

5. DISCUSSION

In the present study, the effectiveness of two different intrusion protocols with temporary anchorage devices (TADs) utilized for correction of maxillary anterior deep bite were assessed. The study primarily investigated the differences between two anterior TADs and four TADs with both anterior and posterior anchorage, focusing on incisor intrusion, root resorption, loss of posterior anchorage, and molar rotational changes. Deep bite correction is difficult, since the typical intrusion mechanics can lead to undesirable changes like posterior tooth movement, anchorage loss, incisor tipping, and mandibular rotation. Because of the way TADs are used, there is skeletal anchorage which enables intrusive forces to be more directly applied to the anterior segment, and reduces reliance on the posterior dentition, and thus increases the vertical control.

Both treatments were effective in moving the maxillar incisors in the present study. The mean intrusion in Group I (two anterior TADs) and Group II (four anterior-posterior TADs) was 2.40 ± 1.29 mm and 3.18 ± 0.57 mm, respectively. There was no statistically significant difference between the groups ($p = 0.251$), however, there was a clinically favourable difference between the four-TAD group and the other groups, as the percentage of intrusion was greater in the former group. The reason for the larger intrusion seen when four TADs were used could be due to a more even spread of intrusive forces and better control of the force vector. The results are similar to other studies that showed successful maxillary incisor intrusion with mechanics involving miniscrews. However, the two-TAD approach offers practical benefits including: fewer implants, simpler mechanics, less chairside time, and fewer treatment burdens. The four-TAD approach, however, could offer more biomechanical control in patients that need a significant intrusion, as well as anterior segment control.

Both groups had root resorption after intrusion and retraction. The mean root resorption for Group I (0.98 ± 0.16 mm) and Group II (1.40 ± 0.26 mm) showed a significant difference ($p = 0.017$). Therefore, the four-TAD group had more intrusion and this was also correlated with more root resorption. This discovery corroborates the known fact that various factors affect orthodontic induced root resorption such as magnitude of force, duration of force application, extent of tooth movement, treatment duration, root shape, and individual susceptibility. Intrusion is especially pertinent because the force is applied towards the apex of the root and thus more stress is placed on the apical periodontal ligament. In the present study, the CBCT-based evaluation was used for three-dimensional evaluation of root length and for providing an accurate method for root changes related to the treatment.

Posterior anchorage control was significantly greater in the four-TAD group. A greater change was seen in the two-TAD group, with a mean change of 1.04 ± 0.18 mm and 0.46 ± 0.17 mm in the four-TAD group. In the same way, the difference of root apex position mesiobuccal was 1.22 ± 0.22 mm in Group I, whereas the difference of root apex position mesiobuccal was 0.24 ± 0.09 mm in Group II. These differences were considered statistically significant and suggested a better preservation of posterior anchorage with 4 TADs. Reciprocal forces can be transmitted to the posterior teeth via the continuous archwire, causing the molars to tip mesially or be displaced with only anterior TADs in place. By adding posterior TADs, direct skeletal support is given to the posterior segment and the reactive forces are reduced. Thus the four-TAD setup seems to be advantageous in controlling the position of the crown and the root of molars during anterior intrusion.

The two treatment protocols also had different molar rotations. The two-TAD group had an average molar rotation of $5.60 \pm 1.34°$ while the four-TAD group had an average molar rotation of $2.20 \pm 1.79°$. This difference was significant ($p = 0.009$). The increased rotational movement in the two-TAD group could be due to anterior placement of the intrusive forces and to the reactive moments being transmitted posteriorly via the archwire to the posterior dentition. The inclusion of the posterior TADs, on the other hand, resulted in a more evenly distributed force system and minimized the unwanted torque on the molars. The present data indicate that posterior skeletal anchorage may help maintain three-dimensional control of the position of the posterior teeth during anterior intrusion.

The present study concludes that both two anterior and four anterior-posterior TADs are effective to intrusion maxillary anterior. The four-TAD configuration resulted in slightly higher intrusion and significantly higher control of molar crown position, molar root position and molar rotation. This greater biomechanical control was coupled with much higher root resorption, however. Thus, it can be stated that in certain cases, such as deep bite cases that require maximum anchorage and better three-dimensional control, 4 anterior posterior TADs may be a better choice, while, in moderate deep bite cases where intrusion is needed and good anchorage is provided, 2 anterior TADs may be a simpler and less invasive alternative. The main advantages of the present study are the three-dimensional evaluation using CBCT and the simultaneous assessment of the effectiveness of the treatment and root resorption. The results need to be considered, however, due to small sample sizes, the short follow-up period, lack of long-term stability assessment, limited assessment of molar parameters and comparison of only two TAD configurations. Further research with larger sample sizes, longer follow-ups and variable TAD configurations is needed to validate the results and establish optimal intrusion technique for successful treatment with minimal adverse effects.

6. CONCLUSION

Within the limitations of the present study, intrusion of maxillary anterior teeth using temporary anchorage devices (TADS) proved to be an effective modality for deep-bite correction. Both treatment approaches—using two anterior TADS and using four anterior-posterior TADS—achieved successful anterior intrusion; however, the four anterior-posterior TAD configuration demonstrated superior overall biomechanical control.

The anterior-posterior TAD approach produced greater true incisor intrusion with better control of the vertical dimension and more favourable maintenance of posterior tooth position. Molar vertical changes were minimized in the four-TAD group, indicating enhanced anchorage preservation and reduced undesirable extrusion of posterior teeth. Furthermore, rotational changes were better controlled in the anterior-posterior TAD group, suggesting a more balanced force distribution and improved three-dimensional tooth movement. Assessment of treatment-related root resorption revealed that both TAD-supported intrusion protocols were associated with some degree of external apical root resorption. However, no significant advantage of the anterior-posterior TAD configuration was observed with respect to root preservation. The magnitude of root resorption appeared comparable between the groups, indicating that the addition of posterior TADS, while beneficial for biomechanical control and treatment efficiency, did not substantially reduce the risk of orthodontically induced root resorption.

Overall, the findings of this study suggest that the use of four anterior-posterior TADS offers a more predictable and biomechanically efficient approach for anterior intrusion, resulting in superior intrusion mechanics, better control of molar position and rotation, and improved maintenance of the posterior occlusion. Nevertheless, clinicians should remain vigilant regarding the potential for root resorption during intrusion mechanics irrespective of the anchorage design employed. Future studies with larger sample sizes and long-term follow-up are recommended to further evaluate the stability of treatment outcomes and the biological effects associated with different TAD-supported intrusion protocols.

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