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Intrusion Of Maxillary Anterior Teeth: A Comparative Clinical Study Between Mini-Implants And Utility Arch

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Abstract:
Background*: Deep bite is a common orthodontic malocclusion caused by factors like incisor supra-occlusion, molar infra-occlusion, or incisor angulation. Nonsurgical correction of deep bite involves extrusion of posterior teeth, intrusion of incisors, or both. Extrusion of posterior teeth in growing patients provides stable results due to secondary remodelling. In patients with deep bite and excessive gingival display, intrusion of incisors is typically required which can be accomplished using intrusion arches or mini-implants.*
Materials and Methods*: A total of 10 subjects with an anterior deep bite (overbite >4mm) with excessive incisal display at rest and at smile were taken. Participants were evenly allocated into two groups based on their gingival display. Group I included five participants with less than 4 mm of gingival display, who received treatment using Rickett's intrusion utility arch. Group II consisted of five subjects with more than 4 mm of gingival display, who were treated with two anterior mini-implants. Lateral cephalograms were utilized to evaluate maxillary anterior intrusion at two specific time points: Pre-treatment (T1) and following a 6-month interval (T2).*
Results*: The amount of bite opening in both groups was comparable, however the amount of incisor intrusion was greater with mini-implants than with the utility arch. The utility arch group showed significantly greater labial tipping ($P<0.01$) and increased overjet ($P<0.05$) compared to the mini-implant group. The distance between the maxillary first molar (U6) and palatal plane (PP) significantly increased with the utility arch but decreased with mini-implants. The mandibular plane angle (GoGn-Sn) increased with the utility arch and decreased with mini-implants; however, the difference was statistically non-significant.*
Conclusion: *Deep bite correction with intrusion utility arch occurs through incisor intrusion, incisor flaring, and molar extrusion, whereas with mini-implants, bite opening mainly occurs through incisor intrusion, making it an efficient alternative in cases where dental side effects such as incisor flaring and molar extrusion are undesirable.*
Key Words*: Deep bite, utility arch, mini-implants, incisor intrusion*

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I. Introduction

Facial esthetics significantly influences an individual's personality and physical appearance. Today, over 75% of patients seek orthodontic treatment for aesthetic reasons, with 3 out of 4 patients specifically requesting facial improvement. Deep bite is a common orthodontic malocclusion caused by factors like incisor supra-occlusion, molar infra-occlusion, or incisor angulation. Excessive deep overbite can result in incisor wear, tissue impingement, TMJ damage, periodontal health issues, and compromised esthetics. Correction of deep bite improves the function of masticatory apparatus and stomatognathic system.

The correction of deep overbite requires proper diagnosis, individualized treatment planning, and efficient execution of treatment mechanics. The treatment planning depends on factors like smile line, upper lip length, incisor display, skeletal vertical dimension, and patient's age. Nonsurgical correction of deep bite involves extrusion of posterior teeth, intrusion of incisors, or both. Extrusion of posterior teeth in growing patients provides stable results due to secondary remodelling. In patients with deep bite and excessive gingival display, intrusion of incisors is typically required which can be accomplished using intrusion arches. Conventional mechanics for correcting malocclusion often causes unwanted tooth movement, affecting treatment outcomes. Temporary Anchorage devices like mini-implants are popular in contemporary orthodontics due to minimal anchorage demand and patient compliance, aiming to achieve normal overbite and improving facial aesthetics. Therefore, this study aims to evaluate and compare the effects of utility arch and mini-implant-supported intrusion on maxillary anterior and posterior teeth.

II. Material And Methods

The prospective clinical study was conducted using lateral cephalograms of 10 participants who presented to AMC Dental College, Department of Orthodontics and Dentofacial Orthopedics. The study received approval from the institutional ethics committee of AMC Dental College and Hospital (approval no: AMC/IEC/ORTHO/PG51/19). All subjects signed a consent form to participate in this study after clarifying the purpose of the intervention. Participants were evenly allocated into two groups based on their gingival display. Group I included five participants with less than 4 mm of gingival display, who received treatment using Rickett's intrusion utility arch. Group II consisted of five subjects with more than 4 mm of gingival display, who were treated with two anterior mini-implants. Patients with a full permanent dentition, deep bite of >4 mm, increased gingival display, and aged >16 years were included in the study. Medically compromised patients or those with cleft/facial deformities or periodontal disease were excluded from the study. Radiographs were taken at the beginning of incisor intrusion (T1) and at a 6-month interval (T2).

A preadjusted edgewise fixed appliance with a 0.022 × 0.028-inch slot MBT Prescription was used. Maxillary molars were banded with stainless steel molar bands with a triple tube. Upon reaching a 0.019 × 0.025" stainless steel working arch wire, the intrusion of maxillary incisors was performed using mini-implants or the intrusion utility arch based on the group setting. The placement was conducted by the same investigator.

Group 1: Utility arch group

Rickett's intrusion utility arch wire, as illustrated in figure 1, was constructed using straight, rectangular 0.019 × 0.025" blue Elgiloy wire.[16] The anterior segment of the utility arch was inserted into the incisor brackets, while the posterior segment was anchored into the maxillary first molar bands. The lever arm of the utility arch was utilized to achieve intrusion of the maxillary incisors.[16]

To minimize the impact of occlusal forces, the arch wire was designed with a step-down at the incisors and a step-up at the molars, positioning it within the buccal vestibule. The activation procedure involved placing a 45° tip-back bend in the molar segment. To counteract excessive labial tipping of the incisors, a 10° labial root torque was integrated into the anterior vertical segment, and the arch wire was secured with a cinch-back technique.[16] The utility arch was reactivated at four-week intervals.

Group 2: Mini-implant group

Two mini-implants, each measuring 1.5 mm in diameter and 8 mm in length, were bilaterally inserted into the interradicular space between the lateral incisor and canine within the attached gingiva, under local anesthesia (as depicted in figure 2).[16] Post-implant placement intraoral periapical radiographs were taken to verify the position of the inserted mini-implants and their relation to tooth roots. Inverted crimpable hooks were attached to 0.019 × 0.025-inch stainless steel arch wire; these hooks provided a fixed point of force application. The elastic chain from the mini-implant was attached to the inverted crimpable hooks, exerting a force of 40 grams each on both sides.[17] The magnitude of the intrusive force was measured using a calibrated Dontrix gauge and checked at every appointment. Follow-up was conducted every 4 weeks.

Cephalometric analysis:

All radiographs were captured using the KODAK 8000/8000C CARESTREAM cephalometric system. Exposure parameters for the lateral cephalogram were set to 72 kV, 10 mA, and 0.5 seconds. Lateral cephalometric radiographs were traced on matte acetate film by a single investigator in a darkened room, using an X-ray viewing box and a 0.5-mm lead pencil

Nine cephalometric parameters were employed in the study, as illustrated in figure 3.

Descriptions of these parameters are as follows:

Angular measurements:[18]

Center of resistance to the palatal plane (CR-PP mm): CR of the maxillary central incisor was taken as point, located at one-third of the distance of the root length apical to the alveolar crest.[18]

U1-PP (°): Angle formed by the intersection of the long axis of the central incisor and PP (plane formed by the line connecting ANS and PNS).[18]

U1-sella-nasion plane (S-N plane) (°): Angle formed by the intersection of the line passing through the long axis of the upper incisor and S-N plane.[18]

Mandibular plane (GoGn)-SN plane (°): Angle formed by the intersection of the gonion-gnathion plane and S-N plane.[18]

Linear measurements:[18]

U1-PP (mm): Linear distance between the incisal edge of the maxillary central incisor and PP (plane formed by the line connecting ANS and PNS).[18]

Overjet (mm): Overlap of the maxillary and mandibular incisors in the horizontal plane.[18]

U6-PP (mm): Linear distance between the mesial cusp tip of the maxillary first molar and PP (plane formed by the line connecting ANS and PNS).[18]

Overbite (mm): Overlap of the maxillary and mandibular incisors in the vertical plane.[18]

Maxillary incisor exposure (mm): Linear distance between the incisal edge of the maxillary central incisor and the stomium superius.[18]

Statistical analysis

The study analyzed the treatment duration, mean difference, and standard deviation between the two study groups using IBM SPSS Statistics for Windows Software (version 20.0, IBM Corp., Armonk, NY). Data normality was evaluated using the Shapiro-Wilk test, and paired t-tests or Wilcoxon tests were employed to compare variables T1 and T2 within Group I (utility arch) and Group II (mini-implant). An unpaired t-test was utilized to compare changes at T3 (T2-T1). Multiple regression analysis was used to determine statistically significant parameters for malocclusion assessment, with significance levels set at significant (<0.05), moderately significant (<0.01), and highly significant (<0.001). The same investigator retraced six randomly selected radiographs 1 week after T1 and T2 to determine the method error.

III. Results

The mean treatment duration was 6.22 ± 0.14 for Group I (Utility arch) and 6.22 ± 0.15 for Group II (Mini-implant) between T1 and T2, as shown in **Table 1**

Table 1: Mean and standard deviation of **treatment duration** of both the study groups.

Study groups	Mean (months)	SD (months)	P value
Mini implant(n=5)	6.22	0.15	>0.05
Utility arch(n=5)	6.22	0.14	

(SD: standard deviation, p: intergroup comparison)
*Significant (p <0.05),
** moderately significant (p <0.01)
***highly significant (p <0.001)

Table 2 depicts the cephalometric changes noted in the utility arch group from T0 to T1, along with their pair differences at T3 (T2-T1). A highly significant increase in mean overjet by 2.80 ± 0.45 mm was observed at T3 (P<0.001). Furthermore, U1-PP (linear) decreased by 1.80 ± 0.45 mm, CR-PP reduced by 1 mm, and maxillary incisor exposure decreased by 2.20 ± 0.45 mm at T3. Angular parameters U1-PP and U1-Sn at T3 revealed increases of 6.80° ± 2.7° and 7.40° ± 3.4°, respectively, which were moderately significant (P<0.01). Additionally, the U6-PP value increased by 1.4 ± 0.55 mm, showing moderate significance (P<0.01). The mandibular plane angle (GoGn-Sn) increased by 0.6°, indicating moderately significant results (P<0.01)

Table 2: Mean and standard deviation of cephalometric parameters at T1 (Pre intrusion) and T2 (6 months interval) and their pair difference at T3 (T2-T1) of **utility arch group (group i)**

Cephalometric parameters of Utility arch group	T1		T2		T3 (T2-T1)		P value
	Mean	SD	Mean	SD	Mean	SD	
U1 –PP (mm)	27.40	3.85	25.60	3.58	1.80	0.45	**<0.01
CR-PP (mm)	12.40	2.70	11.40	2.83	1.00	0.55	**<0.01
U1- PP angular (°)	112.40	2.61	119.20	2.77	-6.80	2.77	**<0.01
1 to SN (°)	107.00	4.85	114.40	5.90	-7.40	3.44	**<0.01
Overjet(mm)	4.80	0.84	7.60	0.89	-2.80	0.45	***<0.001
U6- PP (mm)	21.60	2.51	23.00	2.83	-1.40	0.55	**<0.01
Overbite(mm)	4.40	0.55	2.20	0.45	2.20	0.45	***<0.001
Maxillary incisor exposure(mm)	5.60	2.70	4.00	2.45	1.60	0.55	**<0.01
GoGn-Sn (°)	25.80	1.10	26.20	1.31	-0.40	0.55	**<0.01

(SD, standard deviation; p, intragroup comparison, Paired T-test; T1- Preintrusion; T2 – 6-month interval; T3 - Pair difference, U1: Incisal tip of maxillary incisor, PP: palatal plane, CR: centre of resistance of maxillary central incisor, SN: Sella-Nasion plane, U6: Mesial cusp tip of maxillary first molar, GoGn-Sn: Mandibular plane angle)

Table 3 displays the intragroup treatment changes in the mini-implant group between T0 and T1, as well as their pair differences at T3 (T2-T1). A highly significant (P<0.001) reduction in overbite by 2.80 ± 0.45 mm was observed at T3. Furthermore, the U1-PP (mm) value decreased by 3.40 ± 0.89 mm, indicating highly significant results (P<0.001). Moreover, the CR-PP distance decreased by 2.40 ± 0.55 mm with high statistical significance (P<0.001). A moderately significant (P<0.01) reduction of 3.00 ± 0.71 mm was seen in maxillary incisor exposure. A statistically significant increase of 2.4° ± 0.55°(P<0.001) and 2.20°± 0.84° (P<0.001) was observed in the parameters U1-PP and U1-Sn, respectively. The overjet increased by 1.60 ± 0.89 mm (P<0.05), which was statistically significant. The reduction in the linear distance between U6 to PP was statistically non-significant (P>0.05).

Table 3: Mean and standard deviation of cephalometric parameters at T1 (Pre intrusion) and T2 (6 months interval) and their pair difference at T3 (T2-T1) of **mini-implant group (group ii).**

Cephalometric parameters of mini-implant group	T1		T2		T3 (T2-T1)		P value
	Mean	SD	Mean	SD	Mean	SD	
U1 –PP (mm)	28.80	3.83	25.40	4.16	3.40	0.89	***<0.001
CR-PP (mm)	14.60	2.30	12.20	2.05	2.40	0.55	**<0.01
U1- PP angular (°)	118.00	8.03	120.40	8.02	-2.40	0.55	**<0.01
U1 to SN (°)	110.80	6.53	113.00	6.24	-2.20	0.84	**<0.01
Overjet(mm)	6.80	2.77	8.40	2.07	-1.60	0.89	*<0.05
U6- PP (mm)	21.20	2.28	20.40	2.97	0.80	1.79	>0.05
Overbite(mm)	5.40	1.34	2.60	1.14	2.80	0.45	***<0.001
Maxillary incisor exposure(mm)	8.60	2.61	5.60	2.19	3.00	0.71	**<0.01
GoGn- SN (°)	32.00	4.30	30.20	4.09	1.80	0.84	**<0.01

(SD, standard deviation; p, intragroup comparison, Paired T-test; T1- Preintrusion; T2 – 6-month interval; T3 - Pair difference, U1: Incisal tip of maxillary incisor, PP: palatal plane, CR: centre of resistance of maxillary central incisor, SN: Sella-Nasion plane, U6: Mesial cusp tip of maxillary first molar, GoGn-Sn: Mandibular plane angle)

Table 4 represents the intergroup treatment changes between the mini-implant group and the utility arch groups. Upon comparison of parameters such as U1-PP and CR-PP between the utility arch group and the mini-implant group, it was found that the mini-implant group had a greater reduction in these values (U1 to PP - 3.4 ± 0.89 mm, CR to PP - 2.4 ± 0.55 mm) than the utility arch group (U1 to PP - 1.80 ± 0.45 mm, CR to PP - 1.00 ± 0.55 mm); this difference was moderately significant (P<0.01).The angular parameters U1-PP & U1-SN revealed a moderately significant(P<0.01) greater increase in the utility arch group (U1 to PP - 6.80°, U1 to Sn -7.40°) as compared to mini-implant group (U1 to PP - 2.40°, U1 to Sn - 2.20°). The parameter U6-PP increased by 1.40 ± 0.55 mm in the utility arch group, whereas it decreased by 0.80 ± 1.79 mm in the mini-implant group. This difference was statistically significant (P<0.05). This suggests that intrusion of molars was observed with mini-implant group while molar extrusion was noted with utility arch group. A statistically insignificant difference in overbite reduction was noted in both the groups. Compared with the utility arch group, the mini-implant group showed a decrease in maxillary incisor exposure by 1.4 mm (P<0.01), indicating a substantially greater incisor intrusion with mini-implants.

Table 4: Comparison of mean and standard deviation of cephalometric parameters at T3 (T2-T1) amongst **utility arch group and mini-implant group.**

Cephalometric parameters of both study groups	Utility arch(n=5)		Mini implant(n=5)		P value
	Mean	SD	Mean	SD	
U1 –PP (mm)	1.80	0.45	3.40	0.89	**<0.01
CR-PP (mm)	1.00	0.55	2.40	0.55	*<0.05
U1- PP angular (°)	-6.80	2.77	-2.40	0.55	**<0.01
1 to SN (°)	-7.40	3.44	-2.20	0.84	*<0.05
Overjet(mm)	-2.40	0.55	-2.80	1.87	*<0.05
U6- PP (mm)	-1.40	0.55	0.80	1.79	*<0.05
Overbite(mm)	2.20	0.45	2.80	0.45	>0.05
Maxillary incisor exposure(mm)	1.60	0.55	3.00	0.71	**<0.01
GoGn- Sn (°)	2.20	0.84	1.80	0.84	>0.05

(SD, standard deviation; p, intergroup comparison, unpaired T-test, U1: Incisal tip of maxillary incisor, PP: palatal plane, CR: centre of resistance of maxillary central incisor, SN: Sella-Nasion plane, U6: Mesial cusp tip of maxillary first molar, GoGn-Sn: Mandibular plane angle)

IV. Discussion

Intrusion of maxillary incisors is the preferred method for correcting deep bite in individuals with excessive gingival display and an average to increased vertical dimension. The most common methods for incisor intrusion include utility arches and mini-implants. A utility arch, employing a two-couple system, applies an intrusive force away from the center of resistance, whereas a mini-implant applies the force directly at the center of resistance.[18]

The sample for this study was selected from patients who presented to the department of orthodontics and dentofacial orthopedics at AMC Dental College and Hospital in Ahmedabad. A total of 10 patients who met the inclusion criteria were included in the study. Depending on the amount of gingival display, the patients were divided into two groups.

Group I: Utility arch group

In the utility arch group, the mean decrease in overbite and increase in overjet were highly significant (P<0.001). Overjet measured at T3 showed an increase of 2.80 ± 0.45 mm, which could be correlated with the increase in axial inclination of the incisors. Deepak Phor et al.[7] observed a mean increase in overjet by 1.16 mm and increase in U1-PP by 4.5° in the utility arch group, consistent with our findings. Overbite decreased by 2.20 ± 0.45 mm, indicating a significant amount of bite opening with the utility arch. Prachi et al.[6] in their study showed overbite reduction by 1.75 ± 0.72 mm, almost similar to our findings.

The decrease in U1-PP (1.80 ± 0.45 mm), CR-PP (1 mm), and maxillary incisor exposure (2.20 ± 0.45 mm) suggested a considerable amount of incisor intrusion. Evaluation of incisor intrusion using the incisal edge or root apex may yield varied results, as these points depend on the change in incisor inclination. Therefore, as suggested by Burstone,11 the centroid of the maxillary central incisor (located at one-third of the distance of root length from the apex to the alveolar crest)[4] was used to evaluate the amount of incisor intrusion. Omur Polat-Ozsoy[4] in his study measured incisor intrusion using similar parameters, in which U1-PP decreased by 1.81 mm and CR-PP decreased by 0.80 mm. The increase in angular parameters such as U1-PP (°) and U1-Sn (°) indicated pronounced labial tipping.

When U6-PP (mm) was measured, it showed an increase of 1.4 ± 0.55 mm (P<0.01), indicating molar extrusion, which also resulted in clockwise rotation of the mandible, reflected by an increase in the mandibular plane angle by 0.6°.

Group II: Mini-implant group

The mean decrease in overbite was highly significant (P<0.001) in the mini-implant group. As there was no statistically significant change in U6-PP, the overbite reduction by 2.80±0.45 mm at T3 may be solely attributable to intrusion and minor labial tipping of the incisors. The previously reported results were confirmed by the highly significant (P<0.001) decrease in CR-PP and U1-PP. Significant incisor intrusion was noted in the mini-implant group, as evidenced by the noteworthy decrease in U1-PP (linear) and CR-PP at T3 by 3.40 ± 0.89 mm and 2.40 ± 0.55 mm, respectively. When maxillary incisor exposure was measured at T3, it showed a decrease by 3.00 ± 0.71 mm, which was moderately significant (P<0.01). Gupta N et al.[5] reported similar incisor intrusion as CR-PP decreased by 2.46 ± 1.21 mm and overbite was reduced by 2.46 ± 1.21 mm in their study.

The angular parameters U1-PP and U1-Sn increased with significant labial tipping; the previously mentioned results were both moderately significant (P<0.01). U1-PP and U1-Sn increased by 2.4° ± 0.55° and 2.20° ± 0.84°, respectively, when the angular parameters were measured at T3. The increase in overjet was 1.60 ± 0.89 mm, which was statistically moderately significant (P<0.05) and could be accounted for by mild labial tipping of the incisors. This was in accordance with the study performed by Deepak Phor et al.[7], who also reported an increase in overjet by 1.66 mm in the mini-implant group.

A statistically non-significant decrease (P>0.05) in the linear distance between U6 -PP was seen in the mini-implant group indicating mild molar intrusion. A counterclockwise rotation of the mandible was observed due to molar intrusion, it was reflected as a moderately significant decrease (P<0.01) of 1.80° ± 0.84° in GoGn-Sn. Gupta et al.[5] in his study reported a decrease in GoGn-Sn by 1.1°, which is similar to our findings.

Comparison between the utility arch and mini-implant groups

When comparing the utility arch and mini-implant groups using the parameters U1-PP and CR-PP, the mini-implant group had more incisor intrusion (U1-PP: 3.4 ± 0.89 mm, CR-PP: 2.4 ± 0.55 mm) than the utility arch group (U1-PP: 1.80 ± 0.45 mm, CR-PP: 1.00 ± 0.55 mm); both parameters were moderately significant (P<0.01). The application of forces closer to CR using mini-implants for intrusion could be the reason for this variation in the amount of intrusion.

When angular parameters U1-PP and U1-Sn were compared between the groups, the utility arch group (U1-PP: 6.80°, U1-Sn: 7.40°) showed greater labial tipping than the mini-implant group (U1-PP: 2.40°, U1-Sn: 2.20°); this difference was moderately significant (P<0.05), and both angular parameters revealed the same results.

On comparing overjet between the groups, the utility arch group had increased overjet (2.8 mm) compared with the mini-implant group (1.6 mm), which was statistically significant (P<0.05). This is attributed to the fact that with the utility arch, the forces are applied labial to the center of resistance.

This study found that the utility arch group showed molar extrusion (U6-PP: 1.40 ± 0.55 mm), whereas the mini-implant group showed mild intrusion (U6-PP: 1.80 ±1.79 mm). This difference was statistically significant (P<0.05). The tip-back bend caused forceful engagement of arch wire in the incisor brackets in the utility arch group, resulting in vertical equilibrium forces that were extrusive at the molars and intrusive at the incisors. Contrastingly, maxillary molars experienced mild intrusion in the mini-implant group, as intrusive force was obtained from mini-implants, which acted as an anchor unit. Ravindra Jain et al.[3] observed comparable results, with molar extrusion of 0.75 mm in the utility arch group and molar intrusion of 0.17 mm in the mini-implant group. The analysis of overbite reduction revealed minimal differences between the groups, which were statistically non-significant (P > 0.05).

However, on comparing maxillary incisor exposure, the mini-implant group showed a 1.4 mm greater reduction than the utility arch group (P < 0.01), likely due to greater incisor intrusion in the mini-implant group. Ravindra Jain et al.[3] similarly reported a 0.5 mm greater reduction in maxillary incisor exposure in the mini-implant group compared to the utility arch group. No statistically significant difference was found in the mean GoGn-Sn measurements between the two groups (P > 0.05).

Unfortunately, the anticipated number of samples was not reached because the COVID-19 epidemic disrupted clinical practice. Owing to the pandemic scenario, the study's sample size and design had to be modified to include a reduced number of participants and a 6-month time interval. A larger sample size for the study would aid in the establishment of more definite findings, and a longer follow-up period could help in predicting the stability of the results obtained.

V. Conclusion

Based on the results of the present clinical study, the following conclusions can be drawn:
1. Both appliances aim for bite opening, but the utility arch achieves it through a combination of incisor intrusion, incisor flaring, and molar extrusion, making it advantageous for patients with retroclined incisors and a horizontal growth pattern.
2. Mini-implants facilitate bite opening primarily through incisor intrusion and mild labial tipping, avoiding the side effects of molar extrusion.
3. The utility arch group experienced significant extrusion of molars, while the mini-implant group experienced mild intrusion. The mandibular plane angle increased in the utility arch group.

Declaration of conflict of interest:
The authors do not have any conflicts of interest to declare.

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Ethical approval:
Approval was obtained from the institutional ethics committee (AMC/IEC/ORTHO/PG51/19).

Patient consent:
Informed consent was taken. Patients of both the groups were explained about the treatment protocols & procedures

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