Content available at: https://www.ipinnovative.com/open-access-journals

Journal of Contemporary Orthodontics

Journal homepage: https://www.jco-ios.org/

Original Research Article

Comparative evaluation of orthodontic intrusion of maxillary incisors with midline mini implants using ligature wire or elastic chain - A prospective cohort study

Hasanath Kulangarakath[1], Vincy Antony[1]*, Muhamed Shaloob[1], Mohammed Nayaz[1], Prathapan Parayaruthottam[2], Divyashree Prasad[3]

[1]Dept. of Orthodontics, MES Dental College, Affiliated to Kerala University of Health Science (KUHS), Kerala, India.
[2]Dept. of Orthodontics, Government Dental College, Vandanam Post, Alappuzha, Kerala, India
[3]Dept. of Periodontics, MES Dental College, Affiliated to Kerala University of Health Science (KUHS), Kerala, India.

Abstract

Background and Objective: The simplicity of placing Temporary Anchorage Devices (TADs) has made them popular for controlling anchorage and treating vertical maxillary excess. This study aimed to compare the effects of stainless-steel ligature wire and elastic chain on maxillary incisor intrusion and root resorption in patients with Angle's Class I maxillary dentoalveolar protrusion requiring simultaneous retraction and intrusion.
Materials and Methods: Twenty-two patients were divided into two groups of eleven. Group 1 was treated with midline mini-implants and intrusive force via ligature wire. Group 2 received the mini-implants and intrusive force applied via elastic chain. Lateral cephalograms and Radiovisiographs were taken at the start (T1) and after space closure (T2) to evaluate intrusion and root resorption.
Results: Group 1, utilizing midline mini-implants with ligature tie, demonstrated an average intrusion of approximately 2.66±1.67 mm and 2.72±1.48mm with respect to SN plane and Palatal plane PP respectively. Meanwhile, Group 2, employing midline mini-implants with elastic chain, exhibited an average intrusion of 3±1.32mm and 3.06±1.22mm with respect to SN plane and PP respectively. Amount of root resorption was 0.40±0.19 mm in Group 1 and 0.82±0.77 mm in Group 2, and was found to be statistically significant (P<0.05).
Conclusion: Group 2 showed greater intrusion and root resorption in a shorter duration than Group 1. The method of force application influenced the extent of intrusion and root resorption.

Keywords: Mini-implant, Intrusion, Root resorption, Temporary anchorage devices, Vertical maxillary excess

Received: 18-07-2024; **Accepted:** 28-08-2024; **Available Online**: 07-08-2025

1. Introduction

Vertical maxillary excess (VME) results from the overgrowth of the maxilla and related dentalveolar structures, creating a vertically elongated facial appearance. When anterior vertical maxillary excess occurs, it may manifest as an excessive gingival display with normal overjet and overbite or as a more severe form featuring a narrow maxilla, pronounced display of anterior dentoalveolar structures and anterior open bite. This severe form is often associated with a large mandibular plane angle and a large gonial angle. Individuals with these characteristics exhibit increased anterior facial height, downward rotation of the posterior maxilla and a short ramus. Collectively, these features are more precisely described as 'long face syndrome.[1]

The management of anterior vertical maxillary excess often involves corrective surgical procedures, which can either focus solely on the maxilla or take a bimaxillary approach. Additionally, orthodontic techniques, such as the intrusion of the maxillary anterior segment using intrusion arches or orthodontic mini-screws, can yield clinically successful outcomes, especially in the correction of a gummy smile.[2] The introduction of temporary anchorage devices (TADs) and skeletal anchorage systems (SAS) has revolutionized the ability to intrude the upper anterior

*Corresponding author: Vincy Antony
Email: shamsudeenhasna@gmail.com

https://doi.org/10.18231/j.jco.v.9.i.3.4

segments, potentially eliminating the need for Le Fort I impaction. Temporary skeletal anchorage devices (mini-implants) are effective for intruding the incisors without needing patient cooperation.[3] Their simple placement procedure has made TADs a popular choice for anchorage control and treating vertical maxillary excess in both anterior and posterior regions.

Many studies have been undertaken to quantify the intrusion between mini-implants and other intrusion appliances like Utility arches, J-hook head gear, Burstone intrusion arch and Connecticut intrusion arch.

They found that mini-implants were significantly more effective in the intrusion of maxillary anteriors when compared with other modalities. In the literature, various methods have been employed to apply force to mini-implants for incisor intrusion. These methods include NiTi (nickel-titanium) coil springs, elastic chains and ligature tie. Each of these mechanisms offers unique advantages and considerations in terms of force delivery and control.

Therefore, this study aimed to assess and compare the effects of intrusion on maxillary incisors while using a midline mini-implant with either stainless steel ligature wire or elastic chain in conjunction with fixed appliance treatment in patients with Angle's Class I bimaxillary protrusion who require simultaneous retraction and intrusion. Furthermore, we compared and evaluated the amount of root resorption during incisor intrusion with midline mini-implant applying force using either stainless steel ligature wire or elastic chain.[4-5]

2. Materials and Methods

This prospective cohort study received ethical approval from the Institutional Ethical Committee (IEC/MES/62/2022 on 02/05/2022) and was registered under the Clinical Trials Registry of India (CTRI/2024/03/064895). The study adhered to the principles of the Declaration of Helsinki, and all enrolled patients provided written informed consent/assent before participation.

2.1. Sample selection

The sampling was conducted using a convenience sampling procedure among patients who reported to the Department of Orthodontics and satisfied the inclusion and exclusion criteria. The sample size was calculated as 11 patients in each group, based on a standard deviation of 0.5, an effect size of 0.7, a significance level of 5% and power of 90%. The total sample size was 22 patients.

Patients presenting to the Department of Orthodontics with Angle's Class I bimaxillary dentoalveolar protrusion malocclusion and maxillary anterior display $\geq$ 4mm, requiring simultaneous intrusion and retraction of incisors using a maxillary midline mini-implant after extraction of all four first premolars, were included in the study and assigned to two groups.

1. Group1 – Patients were treated with midline Mini implants (Implant Genesis, mini screw 1.4x 8mm, Self-drilling, Kerala) and intrusive force applied with ligature wire (KODEN, SS ligature wires, 0.23mm (0.009inch).(**Figure 1**)

2. Group 2– Patients were treated with midline Mini implants (IMPLANT GENESIS, mini screw 1.4x 8mm, Self-drilling, Kerala) and intrusive force applied with elastic chain (KODEN, elastomeric e-chain, short).(**Figure 2**)

Patients with history of previous orthodontic treatment/ trauma or endodontic treatment of anteriors, missing or supernumerary teeth and Upper anterior crowding $\geq$ 4mm were excluded from the study.

Following extraction of four premolars, all patients in both the groups received orthodontic treatment with PEA 0.022" MBT prescription, ORMCO MINI 2000. A standardized bonding protocol was followed for all the patients. Teeth were aligned with 0.016" Nitinol, 0.017 × 0.025" Nitinol, 0.019 × 0.025" Nitinol followed by 0.019×0.025" rectangular SS wire for enmasse retraction of anterior teeth. Mid-treatment oral prophylaxis was performed for the patients following the alignment of their teeth. After leveling and aligning, a mini-implant (Implant Genesis) measuring 8 mm in length and 1.4 mm in diameter was placed in the midline of the anterior surface of the maxilla, between the root tips of the central incisors, in both groups. The site of insertion was restricted to the attached gingival region to prevent soft-tissue coverage over the mini-implant.

All clinical procedures and tracing of radiographs were performed by the same investigator (HK). In Group 1, stainless steel ligature wire was tied to the midline mini-implant. The type of force applied was interrupted force. The stainless-steel ligatures were tightened and subsequently reactivated by twisting the ligature wire 1-2mm at each monthly appointment. In Group 2, elastic traction with a force of 90g was applied after placing the arch wire. The elastomeric chain was changed at each monthly appointment. With an upward force from a midline mini-implant, along with active tie-back from the second molar hook to the canine hook applied, the resultant force vector aligned closer to the center of resistance of the anterior segment, facilitating genuine incisor intrusion. Lateral cephalograms of these patients were taken at the beginning of treatment (T1) and at the end of space closure (T2) to compare and evaluate the amount of intrusion on maxillary incisors while applying force using midline mini-implant with either stainless steel ligature wire or elastic chai. **Table 1** and **Figure 3**.

The Radiovisiography (RVG) technique was employed to measure root resorption at two specific time-points: initially at the start of treatment (T1) and subsequently at the conclusion of space closure (T2). A paralleling cone technique was used to maintain a constant distance from the object to the sensor. Pre- and post-intrusion radiographic images were measured from the incisal tip to the root apex using CS Imaging version 7 (Carestream Health Inc., 2015) (**Figure 4**) and the root resorption values from all four incisors were aggregated and averaged.

2.2. Data entry and analysis

Data obtained from cephalometric measurements were recorded in a Microsoft® Excel 2019® spreadsheet. The study focused on upper incisor measurements, both linear and angular, taken at two time-points: T1 and T2. Statistical analysis was performed using SPSS 26.0 (SPSS Inc., Chicago, IL), with a significance level set at $p<0.05$. Descriptive statistics, including mean and standard deviation, were calculated for each group. Normality of the data was assessed using the Shapiro-Wilk test. Differences between groups were evaluated using the Mann-Whitney U test, while within-group comparisons were conducted using the Wilcoxon Signed Rank Test.

3. Results

The mean age was 17.75±3.19years in Group 1 and 16.87±2.84years in Group 2. The data provided shows that there was no evidence of a significance difference between the groups regarding age ($P>0.05$) (**Table 2**).

In the study, Group 1 (mini-implant with ligature wire) achieved an intrusion of 2.66±1.67 mm, while Group 2 (mini-implant with an elastic chain) achieved an intrusion of 3±1.32 mm with respect to the SN plane (**Table 3**). The Wilcoxon Sign Rank Test, reported statistically significant results for both study groups ($P<0.05$) and a higher mean difference was observed in Group 2 compared to Group 1. There was 2.72±1.48 mm intrusion in Group 1 and 3.06±1.22 mm in Group 2 with respect to the Palatal Plane. The higher mean difference was again observed in the 'Mini-implant with E-chain' group compared to the 'Mini-implant with ligature wire' group (3.06±1.22 > 2.72±1.48). The comparison of mean differences reported statistical significance ($P<0.05$) (**Table 3**).

The mean reduction in root length was 0.40±0.19 mm in Group 1 and 0.82±0.77 mm in Group 2 (**Table 3**). The Wilcoxon Sign Rank Test revealed statistically significant results for both Group 1 and Group 2 ($P<0.05$), with mean root resorption being comparatively higher in Group 2. The mean duration of simultaneous intrusion and retraction for groups 1 and 2 was found to be 9.72±1.21 months and 9.18±1.19 months, respectively.

Table 1: Landmarks, planes and upper incisor linear measurements

Hard tissue landmarks		
1	Anterior nasal spine (ANS)	The anterior tip of the sharp bony process of the maxilla at the lower margin of the anterior nasal opening.
2	Posterior nasal spine (PNS)	The posterior spine of the palatine bone constituting the hard palate.
3	Nasion (N)	The most anterior point on the frontonasal suture in the midsagittal plane.
4	Sella (S)	The geometric center of the pituitary fossa.
5	Incision superius incisalis (Isi)	Incisal edge of maxillary central incisor.
6	Incision superius apicalis (Isa)	Root apex of most anterior maxillary central incisor.
Reference planes		
1	SN Plane (SN)	Anteroposterior extent of anterior cranial base.
2	Palatal plane (PP)	Line connecting ANS and PNS.
Upper incisor measurements (Linear measurements in mm)		
1	UI-SN	Vertical distance from the incisal edge of upper incisor to SN plane drawn perpendicular to SN.
2	UI Root-SN	Vertical distance from the root apex of upper incisor to SN plane drawn perpendicular to SN.
3	UI-PP	Vertical distance from the incisal edge of upper incisor to palatal plane (PP) drawn perpendicular to PP.
4	UI-PTV	Horizontal distance from the incisal edge of upper incisor to pterygoid vertical (PTV) drawn perpendicular to PTV.

Table 2: Mean age and treatment duration of the study groups

	Patients (n)	Age (years) Mean±SD	Duration (months) Mean±SD
Mini implant with ligature tie- Group 1	11	17.75±3.19	9.72±1.21
Mini implant with elastic chain- Group 2	11	16.87±2.84	9.18±1.19

Table 3: Comparison of pre-treatment and post-intrusion measurements

	Mini implant with SS ligature – Group 1				Mini implant with elastic chain- Group 2			
Variables	**Pre-treatment (mm)**	**Post-treatment(mm)**	**Mean Difference (mm)**	**P value (significance)**	**Pre-treatment (mm)**	**Post-treatment (mm)**	**Mean Difference (mm)**	**P value (significance)**
UI-SN	75.90±1.94	73.23±1.49	2.66±1.67	0.001*(z=3.73)	78.1±1.38	75.1±1.78	3±1.32	0.0001*(z=4.24)
UI Root-SN	55±1.09	52±1.02	3±1.05	0.001*(z=5.35)	56.13±8.18	52.33±8.08	3.8±8.13	0.0001*(z=6.23)
UI-PP	26.5±1.09	23.84±1.86	2.72±1.48	0.001*(z=5.13)	29.25±1.39	25.19± 25.19	3.06±1.22	0.0001*(z=7.72)
UI-Root Apex	0	0.40±0.19	0.40±0.19	0.0001*(z=5.72)	0	0.82±0.77	0.82±0.77	0.0001*(z=7.24)
UI-PTV	64.63±6.38	56.88±4.02	7.75±5.2	NS	60.88±4.23	55.5±4.03	7.38±4.13	NS

NS, Not significant,*P<0.05- statistically significant

Figure 1: Midline mini-implant with ligature tie.

Figure 2: Midline mini-implant with elastic chain.

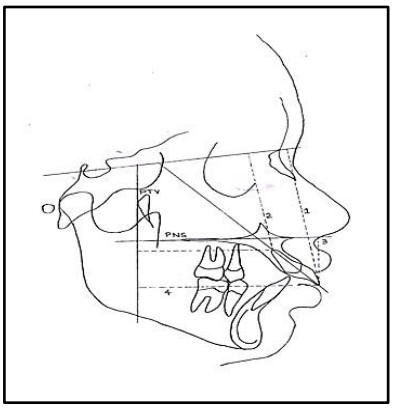

Figure 3: Linear measurements 1-(UI-SN) mm, 2-(UI Root-SN) mm, 3-(UI-PP) mm, 4- (UI-PTV) mm

Figure 4: Total tooth length of 22 on RVG

4. Discussion

This prospective study aimed to compare the treatment outcomes of maxillary incisor intrusion using a midline mini-implant with two different methods: either stainless steel ligature tie or elastic chain. The evaluation of these methods was carried out using cephalometric analysis in two patient groups. The mean age of the patients included in this study was 17.75±3.19 years in Group 1 and 16.87±2.84years in Group 2 (**Table 2**). Statistical analysis was done using the Mann-Whitney U test and has revealed no significant difference between the two groups in terms of age ($p > 0.05$). In the literature, various methods have been employed to apply force to mini-implants for incisor intrusion. Studies by Jain RK *et al*,[6] Vela-Hernández A *et al*[7] and Parayaruthottam P and Antony V[8] used NiTi (nickel-titanium) coil springs, elastic chains and ligature ties respectively. Each of these force modalities offers unique advantages and considerations in terms of force delivery and control.

4.1. Upper incisor intrusion

The selection of reference points for measuring vertical incisor movement in orthodontic studies is pivotal for accurately evaluating treatment outcomes. While the incisal edge and the center of resistance (CR) are commonly employed as reference points, the reliability and consistency of the CR have sparked debate among researchers. Some scholars advocate for the CR as a more reliable reference point for assessing incisor intrusion, asserting its independence from incisor inclination.[9-10] However, the definition and localization of the CR vary considerably across studies.[9-12] Therefore, in this study, the incisor tip was chosen as a reference point. This decision aligned with the approach taken by Deguchi T *et al.*[4] and Jain RK *et al*,[6] who also used the incisor tip as a reference point in their respective studies. In the present study, both the Sella-Nasion (SN) and Palatal Plane (PP) were incorporated as cephalometric reference planes for measuring vertical incisor movement. This methodological decision was driven by the need to ensure compatibility and facilitate comparison with a diverse range of existing literature.

In the present study, Group 1, utilizing midline mini-implants with ligature tie, demonstrated an average intrusion of approximately 2.66±1.67 mm and 2.72±1.48mm with respect to SN plane and PP respectively. Meanwhile, Group 2, employing midline mini-implants with elastic chain, exhibited an average intrusion of 3±1.32mm and 3.06±1.22mm with respect to SN plane and PP respectively (**Table 3**). These results not only indicate a statistically significant difference in intrusion within each group but also highlight a notable discrepancy between the two approaches. The greater intrusion observed in Group 2 suggests that the method of utilizing midline mini-implants with elastic chain may be more effective in achieving incisor intrusion compared to the use of ligature tie. The maxillary incisors were retracted by 7.75±5.2mm in Group 1 and 7.38±4.13mm in Group 2. However, the comparison of these mean differences did not reveal any statistical significance.

The discrepancy in the mean amount of intrusion achieved may stem from differences in the type of force applied. In Group 1 patients, force applied was checked by setting the force gauge at the archwire level. However, accurately measuring the actual force exerted by the ligature wire in Group 1 was not feasible in this study. In contrast, in Group 2 patients, elastomeric chains were used to apply intrusive force (90 g) from the miniscrews to the archwire. In Group 1, force application is interrupted because incisors are intruded using ligature wires instead of a continuous elastomeric chain. The force remains active only during the initial days after ligature wire activation, leading to longer periods of quiescence compared to Group 2, where continuous force is maintained despite force decay.

Several studies and case reports have explored the use of ligature ties for upper incisor intrusion. Ohnishi H *et al*[13] reported an intrusion of 5.5±0.7mm, while Parayaruthottam P and Antony V[8] achieved an intrusion of 4.5mm. Deguchi T *et al*[4] had observed an intrusion of 3.6±3.1mm in their study. K Hasanath *et al*[14] (2023) in their case report utilised ligature tie with elastic module and maxillary intrusion of 3mm was observed.

The studies by Vela-Hernández *et al.*,[7] Mittal *et al.*,[15] and Tilekar *et al.*[16] provide valuable insights into the efficacy of elastic chain for upper incisor intrusion, with each investigation employing distinct methodologies and achieving varying degrees of intrusion. Vela-Hernández A *et al.*[7] reported a mean intrusion of 5.69 ± 2.66 mm in Group 1 and 8.19 ± 3.66 mm in Group 2, where Group 1 utilized one miniscrew between the upper central incisors, while Group 2 employed two miniscrews between the upper lateral incisors and canines. Similarly, Tilekar NR *et al.*[16] utilized elastic chain with mini-implants for intrusion, reporting mean intrusions of 1.67 mm and 2.38 mm for a single midline mini-implant and two anterior mini-implants, respectively. Conversely, Mittal R *et al.*[15] achieved a mean intrusion of 2.8 mm using a single midline mini-implant, indicating that the number and location of implants can significantly impact the magnitude of intrusion.

The wide range of mean values reported in the literature for maxillary incisor intrusion using mini-implants highlights the variability in treatment outcomes across different studies. These values, which range from 1.67 mm to 8.19 mm**,** reflect the diversity in treatment protocols, patient populations, and methodological approaches employed by researchers. The findings in this study align with reported ranges in this field, indicating consistency across the spectrum.

4.2. Root resorption

The potential for root resorption stands as a significant drawback to intrusion mechanics in orthodontic treatment. Orthodontic technique and force magnitude have been proposed as potential contributors to root resorption by many researchers.[17-20] Additionally, radiographic studies by DeShields R[21] and Dermaut LR and DeMunck A,[22] have implicated intrusion as a causative factor in root resorption. Furthermore, according to Harris EF,[23] a person's genotype appears to have the strongest correlation with apical root resorption. Familial studies suggest that genotype explains approximately two-thirds of the variation in the extent of periapical root resorption. To mitigate confounding factors, the present study excluded patients with maxillary incisors having a history of trauma, endodontic treatment, or systemic diseases, as these conditions have been associated with root resorption. Considering these variables, this study aimed to elucidate the specific impact of intrusion mechanics on root resorption, providing valuable insights into the orthodontic treatment process and informing clinical decision-making.

In the present study, root resorption was measured from the incisal tip of the incisor to the root apex. Although many studies use grading, we did not employ it due to its subjective nature.[24-25] The combined mean root resorption of maxillary incisors was 0.40 ± 0.19mm in Group 1 and 0.82 ± 0.77mm in Group 2, which were statistically significant (**Table 3**). The comparison of root resorption outcomes across various studies sheds light on the potential impact of different treatment modalities and study parameters on this phenomenon. Deguchi T *et al.*[4] had observed that root resorption averaged 0.8 mm in the implant group and 1.2 mm in the J-hook headgear (J-HG) group; the "jiggling" effect associated with J-HG treatment may have contributed to the increased root resorption in the J-HG group. While Deguchi T *et al.*[4] also used ligature tie with the implants for light force Application, they utilized two implants instead of one, potentially contributing to higher mean resorption in their study when compared with the present study.

Mittal R *et al.*[15] similarly explored the effectiveness of midline mini-implants for true incisor intrusion. However, they did not detect notable root resorption, which could be attributed to the short treatment period and limitations in accurately assessing root changes within 3–5 months using intraoral periapical radiographs (IOPAR). Vela-Hernández A *et al.*[7] reported a mean resorption of 2.20 ± 0.88 for Group 1 (single mini-implant) and 2.11 ± 0.82 for Group 2 (two mini-implants), with greater overbite correction and incisor intrusion observed in Group 2. Root resorption and overbite correction were positively related. Thus, the root resorption observed was greater compared to that in the present study. The reason for this variation may be due to the smaller sample size used in this study. Overall, these comparisons highlight the complex interplay of treatment parameters, patient factors, and study design in influencing root resorption outcomes in orthodontic interventions. The average duration of simultaneous intrusion and retraction for Groups 1 and 2 was found to be 9.72±1.21 months and 9.18±1.19 months, respectively (**Table 2**).

In conclusion, while this study sheds light on maxillary incisor intrusion using mini-implants, there are notable limitations and opportunities for future research. Enhancements in sample size and follow-up duration could bolster the study's reliability and provide deeper insights into long-term treatment effects, particularly regarding root resorption. Future investigations could explore biomechanical aspects and patient-reported outcomes to enrich our understanding of treatment efficacy and patient experiences. By addressing these limitations and pursuing these research directions, the orthodontic community can advance the field and optimize treatment outcomes for patients undergoing maxillary incisor intrusion using mini-implants.

5. Conclusions

This prospective study compared the treatment outcomes of maxillary incisor intrusion using a midline mini-implant with two different force modalities: either stainless steel ligature wire or elastic chain. The evaluation of these methods was done through cephalometric analysis. On the basis of the results, it was concluded that.

1. Both force modalities resulted in significant intrusion of maxillary incisors, yet Group 2 (mini-implant with elastic chain), exhibited greater intrusion compared to Group 1 (mini-implant with SS ligature wires).
2. Group 2 displayed a higher mean amount of intrusion as well as more root resorption, that was statistically significant.
3. The mean duration of simultaneous intrusion and retraction was slightly longer for Group 1 compared to Group 2.

This conclusion provides a concise summary of the research outcomes and suggests avenues for further investigation, encapsulating the key findings and implications discussed in the study.

6. Source of Funding

None.

7. Conflict of Interest

None.

8. Acknowledgement

The authors would like to acknowledge the Kerala University of Health Sciences and thank Dr. Abdul Saheer for his assistance with statistics

References

1. Kharbanda OP. Orthodontics: Diagnosis and Management of Malocclusion and Dentofacial Deformities, 3rd ed. Elsevier Health Sciences; 2019. p.1280
2. Kim H, Keum BT, Seo HJ, Park C, Chun JH, Lee KJ. Rationale of total arch intrusion for gummy smile correction. *Semin Orthod*. 2022;28(3);149-56.
3. AlMaghlouth B, AlMubarak A, Almaghlouth I, AlKhalifah R, Alsadah A, Hassan A. Orthodontic Intrusion Using Temporary Anchorage Devices Compared to Other Orthodontic Intrusion Methods: A Systematic Review. *Clin Cosmet Investig Dent.* 2021;13:11-9.
4. Deguchi T, Murakami T, Kuroda S, Yabuuchi T, Kamioka H, Takano-Yamamoto T. Comparison of the intrusion effects on the maxillary incisors between implant anchorage and J-hook headgear. *Am J Orthod Dentofac Orthop*. 2008;133(5):654-60.
5. Francis PG, Parayaruthottam P, Antony V, Ummar F, Shaloob KMM, Hassan KJ. A comparative assessment of the effect of professional oral hygiene measures on the periodontal health of patients undergoing fixed orthodontic appliance therapy. *J Indian Orthod Soc.* 2019;53(1):43-8.
6. Jain RK, Kumar SP, Manjula WS. Comparison of intrusion effects on maxillary incisors among mini implant anchorage, j-hook headgear and utility arch. *J Clin Diagn Res.* 2014;8(7):ZC21-4.
7. Vela-Hernández A, Gutiérrez-Zubeldia L, López-García R, García-Sanz V, Paredes-Gallardo V, Gandía-Franco JL, Lasagabaster-Latorre F. One versus two anterior miniscrews for correcting upper incisor overbite and angulation: a retrospective comparative study. *Prog Orthod*. 2020;21(1):34.
8. Parayaruthottam P, Antony V. Midline mini-implant-assisted true intrusion of maxillary anterior teeth for improved smile esthetics in gummy smile. *Contemp Clin Dent*. 2021;12(3):332-35.
9. Hans MG, Kishiyama C, Parker SH, Wolf GR, Noachtar R. Cephalometric evaluation of two treatment strategies for deep overbite correction. *Angle Orthod*. 1994;64(4):265-74.
10. Kinzel J, Aberschek P, Mischak I, Droschl H. Study of the extent of torque, protrusion and intrusion of the incisors in the context of Class II, division 2 treatment in adults. *J Orofac Orthop*. 2002;63(4):283-99.
11. El Namrawy MM, El Sharaby F, Bushnak M. Intrusive arch versus miniscrew-supported intrusion for deep bite correction. *Open Access Maced J Med Sci.*2019;7(11):1841-6.
12. Kuruthukulam RM, Patil AS. The center of resistance of a tooth: A review of the literature. *Biophysical Rev*. 2023;15(1):35-41.
13. Ohnishi H, Yagi T, Yasuda Y, Takada K. A mini-implant for orthodontic anchorage in a deep overbite case. *Angle Orthod*. 2005;75(3):444-52.
14. K Hasanath, Raheesh M, Shaloob M, CA Prachodh, Antony V. Midline mini implant-assisted correction of vertical maxillary excess -a case report. *Int J Sci Res*. 2023;12(9);62-4.
15. Mittal R, Patil AK, Jain AK, Ganeshkar SV. Evaluation of True Incisor Intrusion Achieved with Single Mini Implant for Correction of Deep Overbite in Adult Patients. *J Contemp Orthod.* 2018;2(1):11-7.
16. Tilekar NR, Swami V, Sabane A, Bhosale V. Comparison of the effects of varying positions of mini-implants on intrusion of maxillary incisors-an In vivo study. *J Indian Orthod Soc*. 2018;52(1):35-43.
17. Linge BO, Linge L. Apical root resorption in upper anterior teeth. *Eur J Orthod*. 1983;5(3):173-83.
18. Goldson L, Henrikson CO. Root resorption during Begg treatment; a longitudinal roentgenologic study. *Am J Orthod*. 1975;68(1):55-66.
19. Reitan K. Effects of force magnitude and direction of tooth movement on different alveolar bone types. *Angle Orthod.* 1964; 34(4):244-55.
20. Dellinger EL. A histologic and cephalometric investigation of premolar intrusion in the Macaca speciosa monkey. *Am J Orthod.* 1967;53(5):325-55.
21. DeShields RW. A study of root resorption in treated Class II, Division I malocclusions. *Angle Orthod*. 1969;39(4):231-45.
22. Dermaut LR, De Munck A. Apical root resorption of upper incisors caused by intrusive tooth movement: a radiographic study. *Am J Orthod Dentofac Orthop*. 1986;90(4):321-6.
23. Harris EF. Root resorption during orthodontic therapy. *Semin Orthod*. 2000;6(3):183-94.
24. Janson GR, de Luca Canto G, Martins DR, Henriques JF, de Freitas MR. A radiographic comparison of apical root resorption after orthodontic treatment with 3 different fixed appliance techniques. *Am J Orthod Dentofac Orthop*. 2000;118(3):262-73.
25. Alassiry A. Comparative Evaluation of Orthodontically-Induced Root Resorption Using Cone Beam Computed Tomography (CBCT) and Orthopantomogram (OPG) During En-Masse Retraction of Maxillary Anterior Teeth. *Cureus.* 2022;14(11):e31219.

Cite this article: Kulangarakath H, Antony V, Shaloob M, Nayaz M, Parayaruthottam P, Prasad D. Comparative evaluation of orthodontic intrusion of maxillary incisors with midline mini implants using ligature wire or elastic chain - A prospective cohort study. *J Contemp Orthod.* 2025;9(3):315-321.