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Review

Maxillary Incisor Intrusion Using Mini-Implants and Conventional Intrusion Arch: A Systematic Review and Meta-Analysis

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Main Points

- Multiple studies have been conducted to assess maxillary intrusion using mini-implants and conventional intrusion. However, no comparative assessment has been made of the achieved maxillary intrusion using the 2 techniques.
- Mini-implants were compared with the Connecticut intrusion arch specifically as there is some amount of variation in mechanics and force application in all the conventional methods of incisor intrusion. This meta-analysis will assist in the creation of new evidence in the field.
- Incisor intrusion and overbite correction were found to be higher with mini-implants as compared to Connecticut intrusion arches.

ABSTRACT

The aim of this analysis was to evaluate the maxillary incisor intrusion and change in overbite achieved by micro-implants compared to Connecticut intrusion arches among post-pubertal patients with deep bite. Medline, PubMed, Cochrane, and Google scholar were searched for studies falling under the inclusion criteria. Randomized controlled trials (RCTs) and controlled clinical trials (CCTs) comparing maxillary incisor intrusion among post-pubertal deep bite cases treated by mini-implants and Connecticut intrusion arches were to be included. Outcome data were extracted using guidelines published by the Cochrane Collaboration. A systematic review was conducted using Cochrane Program Review Manager, version 5. A random effects model was used to assess the mean difference in the amount of incisor intrusion and overbite correction achieved between the 2 methods. Statistical significance was set at $P < .05$. Assessment of certainty of evidence was conducted using GRADE analysis. Six trials met the inclusion criteria. Mean differences for incisor intrusion −0.67 [95% CI, 0.97, 0.38] $I^2 = 31\%$; $P < .00001$) and overbite correction −0.51 [95% CI, 0.85, 0.16] $I^2 = 50\%$; $P = .004$) achieved with mini-implants were found to be significantly effective when compared to the Connecticut intrusion arch. Low to moderate heterogeneity was noted for incisor intrusion and change in overbite analysis respectively. High certainty of evidence was noted for higher association of mini-implants with incisor intrusion and overbite correction. Our meta-analysis suggests that mini-implants are superior to the Connecticut intrusion arch with respect to the amount of incisor intrusion and overbite correction. Further studies are still needed to confirm the superiority.

Keywords: Incisor intrusion, mini-implants, connecticut intrusion arch

INTRODUCTION

The aesthetics and attractiveness of the smile is one of the major demands in contemporary orthodontic treatment. One of the most frequent demands for orthodontic treatment is obtaining a more beautiful appearance in order to overcome psychosocial problems due to dentofacial abnormalities.[1] The smile being one of the most important facial functions, is often the measure of success or failure, especially in the patient's point of view.[2] At the beginning of the 21st century, an intention toward the soft tissue paradigm became the base of diagnosis and treatment planning in orthodontics.[3]

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Although treatment of choice depends on multiple factors such as smile line, incisor display, and vertical dimension, the correction of deep overbite with incisor intrusion has its own role during orthodontic treatment.[4] Depending on the diagnosis and treatment objectives, a deep overbite can be corrected by intruding the incisors, extruding the buccal segments, or combining these treatments.

Extrusion of incisors, which results in a pseudo deep bite, can be corrected by various appliances like the utility arch, Mulligan arch, Connecticut arch, three-piece intrusion arch, and implants. By using implants, true intrusion is brought about by passing the force close to the center of resistance. In the conventional methods, true intrusion is obtained by maintaining the moment-to-force ratio. Maxillary incisor intrusion should be the preferred treatment in non-growing patients with anterior deep bites caused by over eruption of the maxillary incisors.[5]

Al Maghlouth et al.[6] conducted a systematic review with only 2 studies and reported insufficient evidence for use of mini-implants for incisor intrusion. Atalla et al.[7] and Sosly et al.[8] compared the effectiveness of mini-implants with all other conventional intrusion methods combined, in a meta-analysis, and reported superior but not clinically significant intrusion results with mini-implants. However, the 2 meta-analyses did not specifically compare the Connecticut intrusion arch with mini-implants for incisor intrusion. Variation exists in the mechanics and method of force application in all the methods of incisor intrusion, and a comparison of different conventional methods is essential.

The Connecticut intrusion arch and mini-implants have shown conflicting results with regard to the obtained mean levels of maxillary incisor intrusion. The variation in mean level of incisor intrusion might be due to several factors like magnitude of force applied, different mini-implant locations, direction of force applied, and treatment duration. This paper is a meta-analysis to evaluate the amount of incisor intrusion and change in overbite achieved using mini-implants, compared specifically to Connecticut intrusion arches, among post-pubertal patients with deep bite.

METHODS

Search Strategy

A comprehensive search was conducted in Medline, PubMed, and Cochrane databases and Google scholar through February, 2021. PRISMA guidelines were followed while conducting the meta-analysis. A literature search was conducted using the keywords: incisor intrusion, mini-implants, and Connecticut intrusion arch. Studies were selected independently by 2 investigators (P.S. and A.S.). Abstracts were pre-screened to determine studies that would be retrieved in full and to exclude ineligible studies. The retrieved articles were read prior to inclusion in the review. Differences between investigators were resolved by discussion. The references in the selected articles were manually reviewed and retrieved if found possibly relevant. The search was done using English keywords. No restrictions were placed on language of publications. An attempt was made to search gray literature for unpublished articles, and one relevant study was found to be included in the systematic review.

Inclusion Criteria

The inclusion and exclusion criteria were determined prior to the literature search. The criteria followed for selection of studies were as follows:

1. Study design: Randomized controlled trials (RCT) and controlled clinical trials (CCT).
2. Participants: Post-pubertal patients with deepbite of at least 4 mm requiring intrusion of maxillary incisors.
3. Intervention: Maxillary incisor intrusion with mini-implants.
4. Comparison: Maxillary incisor intrusion with Connecticut intrusion arch.
5. Exclusion criteria: Case series, case reports, animal studies, syndromic patients, periodontally compromised patients, and deepbite cases treated with orthognathic surgery.
6. Outcome measure: Amount of Maxillary incisor intrusion.
7. Outcome parameter: The measure of the perpendicular distance from the point of center of resistance of the central incisor to the palatal plane.

The Population, Intervention, Comparison, and Outcome were population: post-pubertal patients with deepbite of at least 4mm requiring intrusion of maxillary incisors; intervention: incisor intrusion using mini-implants; comparison: incisor intrusion using Connecticut intrusion; and outcome: achieved upper incisal intrusion.

Data Extraction and Quality Assessment

Outcome data were extracted by 2 investigators (P.S. and A.S.) using guidelines published by Cochrane Collaboration.[9] Differences between the 2 investigators were resolved by discussion. The characteristics of the trials included in the meta-analysis are presented in Table 1. The quality assessment tool by Cochrane Collaboration was used for the clinical trials, with the following assessment criteria: sequence generation, allocation concealment, blinding of participants, blinding of assessors, incomplete outcome data, selective reporting of outcomes, and other potential sources of bias.[10] The quality of the controlled clinical trials (CCTs) was assessed according to the methodological index for non-randomized trials (MINORS).[11] It contains a list of 12 items with scores of 0 (not reported), 1 (reported but inadequate), and 2 (reported and adequate). A maximum score of 24 is achievable. Studies with a score of 13 points or below are considered to be of low quality, studies with a score between 14 and 19 points are considered to be of moderate quality, whereas studies with a score of 20 points and above are considered to be of high quality.

Statistical Analysis

Meta-analysis was conducted using Cochrane Program Review Manager, version 5.[12] A random effects model was used to assess mean difference in the amount of maxillary incisor intrusion achieved by the 2 treatment modalities (mini-implants and Connecticut intrusion arch). Heterogeneity among

Table 1. Characteristics of studies icluded in the meta-analysis

Study	Type of Study	Sample Size (Patients)	Age		Intrusion (mm)		Overbite Correction (mm)	
			Mini-Implants (MI)	Connecticut Intrusion Arch (CIA)	Mini-Implants (MI)	Connecticut Intrusion Arch (CIA)	Mini-Implants (MI)	Connecticut Intrusion Arch (CIA)
Gupta et al., 2017, India[16]	CCT	24	17.75 ± 3.49	18.75 ± 3.47	–2.46 ± 1.21	–1.75 ± 0.72	–2.46 ± 1.21	–2.04 ± 1.37
Gurlen et al., 2016, Turkey[13]	RCT	32	12y 6m–16y 5m	12y 5m–16y	–2.45 ± 0.59	–1.49 ± 0.98	–3.27 ± 0.86	–2.05 ± 1.09
Kaushik et al., 2015, India[15]	CCT	14	14y-25 y	14y–25y	–2.46 ± 1.11	–1.84 ± 0.36	–4.14 ± 1.20	–3.20 ± 0.77
Kumar et al., 2015, India[14]	RCT	30	15y–20y	15y–20y	–3.10 ± 0.67	–2.07 ± 0.53	-	
Senisik et al., 2012, Turkey[5]	RCT	45	20.13 ± 2.48	20.32 ± 3.22	–2.47 ± 0.81	–2.20 ± 0.90	–2.27 ± 0.59	–2.10 ± 1.20
Shakti et al., 2015, India[17]	CCT	10	16y–25y	16y 25y	–1.7 ± 0.44	–1.4 ± 0.41	–1.90 ± 0.41	–1.90 ± 0.65

studies included in the analysis was evaluated using the I^2 test. The Cochrane guide was used for interpretation of the I^2 test: values ranging from 0% to 40% represented no heterogeneity, between 30% and 60% represented moderate heterogeneity, between 50% and 90% represented substantial heterogeneity, and between 75% and 100% represented considerable heterogeneity. The number of studies included in the analysis was less than 10; therefore, publication bias was not assessed. Assessment of certainty of evidence was conducted using GRADE analysis. Statistical significance was set at $P < .05$.

RESULTS

A total of 384 articles were identified through the database search. Duplicates were removed and 376 citations were taken for screening. Out of these 376 titles, 364 articles were not relevant and excluded on abstract screening (first level of screening) for the current meta-analysis. The remaining 12 studies were included for the next level of screening (full text screening). Out of these 12 studies, 6 studies were excluded based on differences in methodologies and interventions used. Eventually, a total of 6 studies were obtained, including 3 RCTs and 3 CCTs. The flow chart depicting the complete search strategy is presented in Figure 1. Demographic and outcome data extracted from the included studies are presented in Table 1.

The quality of studies included in the analysis is presented in Tables 2 and 3. Randomized sequence generation was made in the included trials. However, allocation concealment was found to be unclear in the included RCTs. Blinding of outcome assessment was ensured in all the 3 included randomized trials. Blinding of participants and personnel was inadequately reported by Gurlen et al.[13] and Kumar et al.[14] Incomplete outcome data and selective outcome reporting were not noted in any of the included RCTs (Table 2). Quality assessment of the included CCTs using the methodological index for non-randomized trials (MINORS) tool is presented in Table 3. All the 3 included studies had scores ranging between 14 and 20, suggestive of moderate quality.[15-17]

The meta-analysis of 6 trials (3 RCTs, 3 CCTs) which evaluated the amount of incisor intrusion using mini-implants and the Connecticut intrusion arch is presented in Figure 2. Incisor intrusion with mini-implants was found to be significantly effective when compared to use of the Connecticut intrusion arch (pooled mean difference: –0.67 [95% CI, 0.97, 0.38], $P < .00001$; Figure 2). The test for heterogeneity showed low heterogeneity ($I^2 = 31\%$).

The meta-analysis of clinical trials (2 RCTs, 3 CCTs) which evaluated change in overbite following incisor intrusion using mini-implants and the Connecticut intrusion arch is presented in Figure 3. Correction in overbite was found to be significantly higher while using mini-implants compared to use of the Connecticut intrusion arch (pooled mean difference: –0.51 [95% CI, 0.85, 0.16], $P = .004$; Figure 3). The test for heterogeneity reflected a moderate heterogeneity ($I^2 = 50\%$). High certainty of evidence was noted for higher association of mini-implants with incisor intrusion and overbite correction (Table 4).

DISCUSSION

The present meta-analysis is the first in scientific literature to compare maxillary incisor intrusion and overbite correction between mini-implants and the Connecticut intrusion arch. It suggests mini-implants to be superior with respect to the extent of achieved incisor intrusion and overbite correction. It was also evident from the included studies that true incisor intrusion is achievable with both the mini-implant and the Connecticut intrusion arch. Ng et al.[18] conducted a meta-analysis to quantify the amount of true incisor intrusion obtained during orthodontic treatment, but the review was not specific regarding methods of intrusion.

Conflicting results exist in the literature about mean levels of maxillary incisor intrusion achieved by the Connecticut intrusion arch[19] and mini-implant treatments.[20-24] Several factors, such as different mini-implant locations,[21,23] force magnitudes,[19,21,23,24] force directions,[21,22,24] treatment durations,[21,22,23] and different methods[19-24] used to evaluate the amounts of maxillary incisor

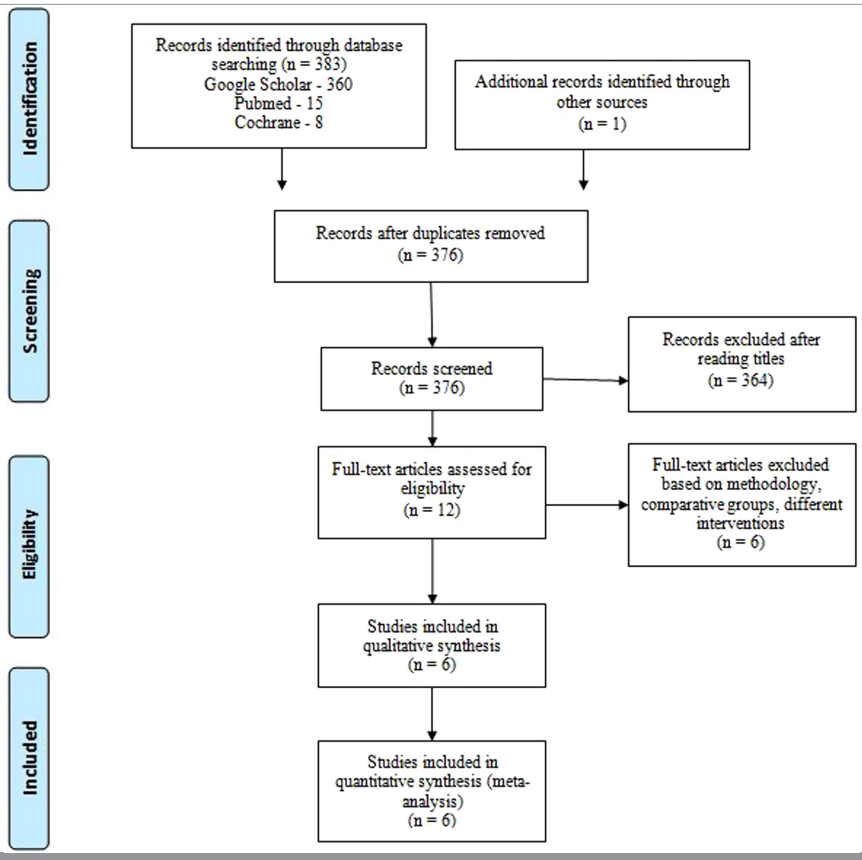

Figure 1. Flow diagram of study selection process

intrusion, might have accounted for the different rates of incisor intrusion. Based on the included studies, an average range of 2.0 mm to 3.1 mm of true incisor intrusion was achieved by both the techniques. The exception was Shakti et al.[17] who achieved incisor intrusion of 1.7 and 1.4 mm by mini-implants and Connecticut intrusion arch respectively. The reason for this variation may be the smaller study sample and less treatment duration (4 months) as compared to the remaining included studies (average 5-6 months).

The age and facial type play an important role in incisor intrusion. In order to avoid any theoretical bias, the present meta-analysis included studies which had subjects with mean age above 14 years, that is, post-pubertal. Senisik et al.[5] had used hand wrist radiographs to evaluate skeletal developmental age.[5] Skeletal developmental age was not evaluated by authors of the other included studies in the analysis. Otto et al.[25] had suggested that skeletal maturity has no correlation with the amount of intrusion. In growing children, the amount of true incisor intrusion usually is greater than what might be recorded, because of vertical growth of maxilla and mandible simultaneous to the actual intrusion mechanics. Otto et al.[25] suggested that neither patient's age nor facial type was related to incisor intrusion. Furthermore, skeletal pattern could influence the relative incisor intrusion compared to molar extrusion in overbite reduction. Hence, incisor intrusion is indicated in patients with deepbite due to over-erupted incisors and not due to inadequately erupted molars, which is usually seen in a horizontal growth pattern.

True intrusion occurs when forces are directed through the center of resistance.[26] When implants are placed bilaterally between

Table 2. Quality assessment of randomized controlled trials (RCT) included in the meta-analysis

	Criteria						
Studies	**Sequence Generation**	**Allocation Concealment**	**Blinding of Participants**	**Blinding of Outcome Assessment**	**Incomplete Outcome Data**	**Selective Reporting**	**Free of Other Bias**
Gurlen et al., 2016, Turkey[13]	Low	Unclear	Unclear	Low	Low	Low	Unclear
Kumar et al., 2015, India[14]	Low	Unclear	Unclear	Low	Low	Low	Unclear
Senisik et al., 2012, Turkey[5]	Low	Unclear	High	Low	Low	Low	Unclear

Table 3. Quality assessment of controlled clinical trials (CCTs) included in the meta-analysis (MINORS)

	Kaushik et al., 2015, India	Gupta et al., 2017, India	Shakti et al., 2015, India
1. A clearly stated aim	2	1	2
2. Inclusion of consecutive patients	2	2	2
3. Prospective collection of data	2	2	2
4. Endpoints appropriate to the aim of the study	2	2	2
5. Unbiased assessment of the study end point	0	0	0
6. Follow-up period appropriate	2	2	2
7. Loss to follow-up less than 5 %	2	2	2
8. Prospective calculation of the study size	0	0	0
9. An adequate control group	0	0	0
10. Contemporary groups	2	2	2
11. Baseline equivalence of groups	2	2	2
12. Adequate statistical analyses	1	1	1
Total	17	16	17

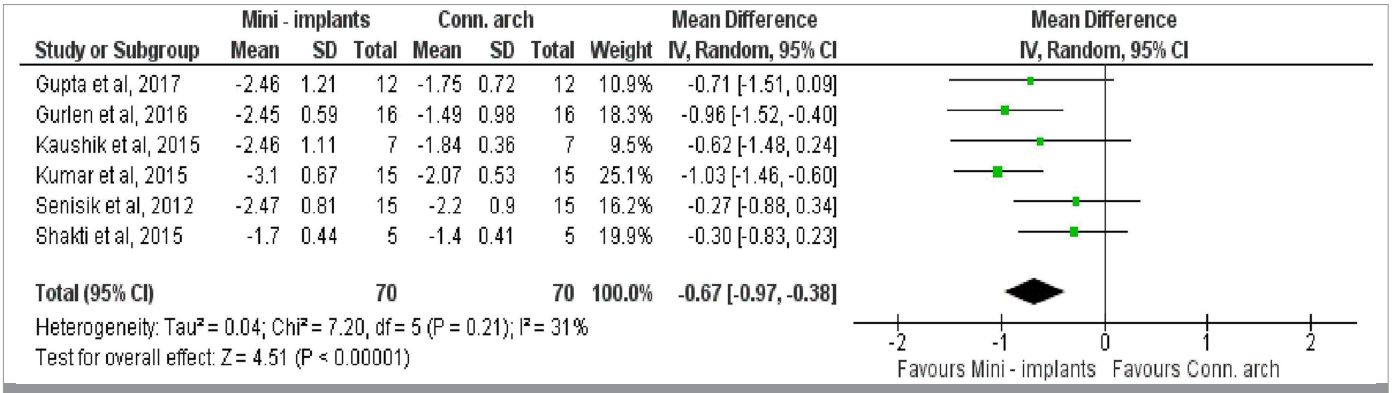

Figure 2. Incisor intrusion achieved by mini-implants versus Connecticut intrusion arch

the canine and lateral incisors, the point of application of force is closer to the center of resistance.[27] In the present meta-analysis, all the included studies, except Gurlen et al.[13] had mini-implants placed bilaterally between the canine and lateral incisors, facilitating the direction of force to pass through the center of resistance. However, in the study conducted by Gurlen et al.[13], the mini-implants were placed between the central and lateral incisors bilaterally. The point of force application was the same in cases treated by the Connecticut intrusion arch in all the included studies.

Very light forces of 15-25 g per tooth have been recommended for intrusion.[26,28,29] It has been documented that heavier forces may lead to root resorption. In agreement with the above-mentioned findings, all the studies included in our meta-analysis used force levels in the range of 15-25 g per tooth for intrusion of 4 incisors. Variation in the cephalometric reference planes selected to determine the amount of incisor intrusion may contribute to differences in results. All the studies included in our meta-analysis used the same reference plane—the palatal plane—for evaluation of incisor intrusion, to maintain the homogeneity of the

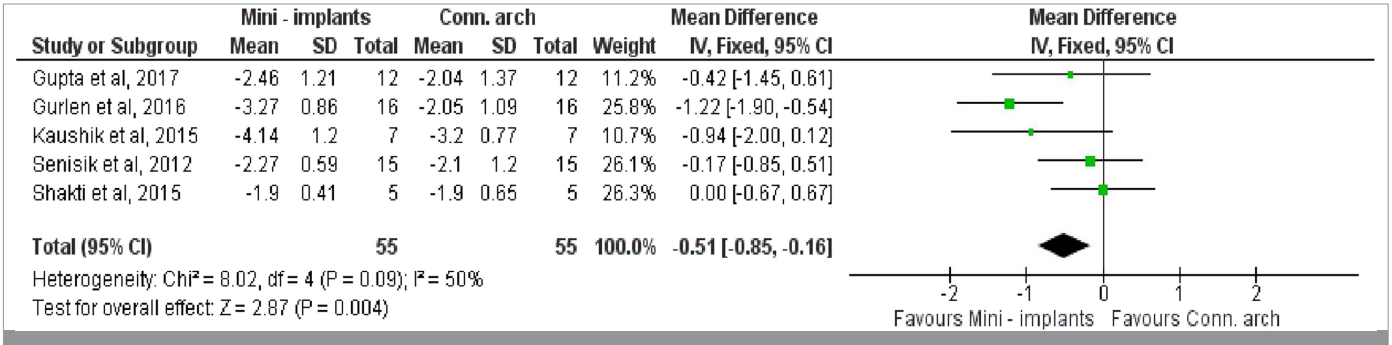

Figure 3. Overbite correction achieved by mini-implants versus Connecticut intrusion arch

Table 4. GRADE analysis for certainty of eevidence for association between mini-implants versus connecticut intrusion arch

Certainty Assessment							Number of Patients		Effect	
Number of Studies	Study Design	Risk of Bias	Inconsistency	Indirectness	Imprecision	Other Considerations	Mini-Implants Group	Connecticut Intrusion Group	Absolute (95% CI)	Certainty
Mini-implants versus Connecticut Intrusion Arch for Incisor Intrusion										
6	Randomized Trials	Not serious	Not Serious	Not serious	Not serious	Strong association, all plausible residual confounding would suggest spurious effect	70	70	MD 0.67 lower (0.97 lower to 0.38 lower)	⊕⊕⊕⊕HIGH
Mini-Implants Versus Connecticut Intrusion Arch for Overbite Correction										
5	Observational studies	Not serious	Not serious	Not serious	Not serious	Strong association, all plausible residual confounding would suggest spurious effect	55	55	MD 0.51 lower (0.85 lower to 0.16lower)	⊕⊕⊕⊕HIGH

obtained results. Perpendicular distance from the centroid point of the central incisor to the palatal plane was measured in order to evaluate true incisor intrusion. Studies using reference points other than the centroid, that is, incisal edge[21,23,30] or root apex,[25] were excluded from the meta-analysis, to avoid causing a false perception of intrusion.

Assessment of the consistency of effects across studies is an essential part of a meta-analysis; the I^2 value of 0% indicated no observed heterogeneity, and larger values reflected increase in heterogeneity. Low heterogeneity is always appreciated, as it demonstrates consistent finding across studies. Low to moderate level of heterogeneity was observed for extent of incisor intrusion and overbite correction. A significant reduction in I^2 value was noted when findings of Shakti et al.[17] were excluded from the meta-analysis due to small sample size and treatment time.

The overall quality of the included studies was moderate. Thus research in future, with well conducted methodology, may alter the evidence in hand. The limitations of the present study included the limited number of analyzed studies, and the fact that the study protocol was not registered. More randomized clinical trials should be conducted in future to quantify the amount of incisor intrusion with the least number of confounding factors like random patient selection, controlled treatment time and force, similar intrusion requirement, and growth factor consideration.

CONCLUSION

Maxillary incisor intrusion can be carried out by both mini-implants and the Connectict intrusion arch. Mini-implants were found to be superior to the Connecticut intrusion arch with respect to the amount of maxillary incisor intrusion and overbite correction. Further studies are still needed to confirm the superiority.

Peer-review: Externally peer-reviewed.

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