Effectiveness of Orthodontic Mini-Screw Implants in Adult Deep Bite Patients during Incisor Intrusion: A Systematic Review

Ahmed Ibrahim Atalla, Mai Hamdy AboulFotouh, Fady Hussein Fahim, Manal Yehia Foda

Department of Orthodontic, Faculty of Oral and Dental Medicine, Cairo University, Cairo, Egypt

Abstract

Aims: The aim of this systematic review was to compare the effectiveness of temporary anchorage devices (TADs) and conventional segmented arches (CSAs) during incisor intrusion in adult patients with a deep bite and their adverse effects. **Settings and Design:** Four electronic databases were searched. In addition, articles were manually searched for using the reference lists of relevant articles, grey literature, and peer-reviewed orthodontic journals. **Subjects and Methods:** Data from the retrieved articles were selected and evaluated by two independent reviewers using a new systematic review software program, DistillerSR. A meta-analysis of raw mean differences was performed. **Results:** Initially, we retrieved 9600 articles, but the selection process resulted in six articles. The included studies ranged from low to high in quality. Meta-analysis showed that TADs enabled 0.78 mm more upper incisor intrusion than the conventional method (95% confidence interval [CI] = 0.28–1.29). There was no significant anchorage loss difference in the CSA group compared to the TAD group (mean difference [MD] −3.68; 95% CI −7.41–0.05). Furthermore, a significant molar tipping of 1.03° was observed in the CSA group (P = 0.008) compared to the TAD group (MD −1.03; 95% CI −1.79–−0.27). **Conclusions:** The results of this meta-analysis showed that patients receiving TADs had 0.78 mm greater upper incisor intrusion than patients receiving the conventional treatment. This was statistically significant, but not clinically relevant. No clinical difference was found between TADs and the conventional method of anchorage loss.

Keywords: *Deep bite, incisor, intrusion, mini-implant*

Introduction

Deep bite correction during orthodontic treatment is often tricky, and relapse may occur in some cases.[1] The action of the orthodontic appliance in overbite correction is based on an extrusion of molars, an intrusion of incisors, or by a combination of both.[2] Several studies have attempted to quantify these different approaches.[3] The orthodontic intrusion of the anterior teeth is indicated for the management of a deep overbite. The functional evaluation of the upper gingival line in relation to the upper lip indicates whether the maxillary or mandibular anterior teeth should be intruded.[4]

Orthodontic intrusion techniques for the anterior teeth can be achieved by either conventional segmented arch (CSA)[5] and utility arch or recent method as segmented arch connected by temporary anchorage devices (TADs)[6] which is used as fixed anchorage units.

With a CSA, it was found that it can produce genuine incisor intrusion with little side effects on the molars. The application of this technique, rather than using continuous arch wires, therefore, was indicated if correction of deep bite by intrusion is desired as shown in Figure 1.[7]

Mini-screw implants or TADs are a compliance-free alternative to more traditional forms of incisor intrusion. It has recently been developed. They are smaller than regular dental implants and have the advantages of reducing patient compliance, immediate loading, uncomplicated placement, and minimal expense for patients.[8] Mini-screw implants have also been successfully used for intruding teeth because they make it possible to apply light continuous forces of known magnitudes. Better control of the forces could decrease external apical root resorption, which often associated with intrusive movements as shown in Figure 2.[9] However, several recent studies have demonstrated significant incisor intrusion with TADs,

How to cite this article: Atalla AI, AboulFotouh MH, Fahim FH, Foda MY. Effectiveness of orthodontic mini-screw implants in adult deep bite patients during incisor intrusion: A systematic review. Contemp Clin Dent 2019;10:372-81.

Address for correspondence:
Dr. Ahmed Ibrahim Atalla, Mansoura University, Mansoura, Egypt.
Department of Orthodontic, Cairo University, 14 Street, Seliman El Fawal, Maadi, Cairo, Egypt.
E-mail: ahmed.atalla@dentistry.cu.edu.eg

Access this article online

Website: www.contempclindent.org

DOI: 10.4103/ccd.ccd_618_18

Quick Response Code:

whereas others found that it causes significant tipping of incisors according to its location away from center of resistance (CR),[10] and also others found no difference between these methods.[6] Moreover, last systematic review has been published in 2005 entitled, "True incisor intrusion attained during orthodontic treatment: A systematic review and meta-analysis," tried to quantify the amount of true incisor intrusion; however, since this review was somehow old, it did not consider mini-implants as a method for the intrusion.[11]

Objectives

The aim of this systematic review was to compare the effectiveness of TADs and the CSAs during incisor intrusion in the patients with an increased overbite.

Materials and Methods

This systematic review was conducted according to the preferred reporting items for systematic review and meta-analysis protocols (PRISMA) 2015 checklist. This review was registered on the International Prospective Register of Systematic Reviews on July 25, 2016, and the registration number was CRD42016043491.

Eligibility criteria

1 Study design: randomized controlled trials (RCTs) and controlled clinical trials (CCTs)
2 Participants: Deep bite patients with permanent dentition
3 Interventions: Upper incisor intrusion with TADs
4 Control group: Upper incisor intrusion with CSA
5 Outcome measures: The primary outcome was the amount of upper incisor intrusion. The secondary outcomes were the amount of upper incisor tipping, the treatment duration, the amount of anchorage loss, and the amount of molar tipping as shown in Table 1.

Exclusion criteria

- Cohort studies, cross-sectional studies, case series, case reports, and animal studies
- Studies published before 2000
- Deep bite cases treated with orthognathic surgery.

Search strategy, study selection, and information sources

The following electronic databases were searched as shown in Table 2: MEDLINE (2000 to November 2017), Central-Cochrane Registers of Controlled Trials (2000 to November 2017), SCOPUS, and LILACS. Unpublished literature was searched electronically using ClinicalTrials.gov (www.clinicaltrials.gov), Google Scholar, and Egyptian University Library Consortium.

The following journals were manually screened: European Journal of Orthodontics, American Journal of Orthodontics and Dentofacial Orthopedics, and Angle Orthodontist. The literature search, assessment of relevance, risk of bias analysis, and data extraction were performed. Data collection was performed by two investigators (A.A. and M.A.) and exported to DistillerSR (Recent Systematic Review Software, Ottawa, Canada). Both investigators used program for handling of the retrieved article. Disagreements were resolved by discussion and consultation with the third author (F.H.) while the fourth author (M.F.) was consulted for her scientific expertise on orthodontics.

Data extraction

Data extraction sheets were developed, and data were extracted independently by the two investigators (A.A. and M.A.) as shown in Tables 3-5. We contacted authors for further information.

Risk of bias in individual studies

The Cochrane collaboration tool[12] for assessing the risk of bias in RCTs was applied using the following criteria as shown in Figure 3. An overall assessment of the risk of bias (high, unclear, and low) was made accordingly. Studies with at least one criterion for a high/unclear risk of bias were designated as having an overall high/unclear risk of bias. The quality of nonrandomized clinical trials was assessed using the risk of bias in nonrandomized studies of interventions (ROBINS-I) as shown in Table 6.[13]

Figure 1: Illustrating using conventional segmented arch in incisor intrusion

Figure 2: Illustrating using temporary anchorage devices in incisor intrusion

Table 1: Outcome table

Outcome	Reading	Definition
1. Amount of upper incisor intrusion	CR1-PP	Linear distance between CR of upper central incisor and PP
2. Amount of upper incisor tipping	U1/PP	Angle between line connecting incisal edge and root apex of the maxillary central incisor and PP
3. Treatment duration	Calendar	-
4. Amount of anchorage loss	U6-PTV	Linear distance between the mesiobuccal cusp tip of the maxillary first molar and pterygoid vertical
5. Amount of molar tipping	U6/PP	Angle between line connecting mesiobuccal cusp tip and root apex of mesiobuccal root of the maxillary first molar and PP

CR1-PP: Central incisor-palatal plane; U6-PTV: Upper first molar - Pterygoid vertical; CR: Center of resistance

Table 2: Search Strategy showing databases with keywords used

Database	Key words	Limits
PubMed	Overbite [Mesh] OR deepbite OR over-bite OR over bite OR deep overbite OR gummy smile AND implant OR mini implant* OR micro implant* OR microimplant* OR screw* OR mini screw* OR miniscrew* OR micro screw* OR microscrew* OR temporary anchorage device OR skeletal anchorage OR tad OR plate OR intrus* OR incisor* OR anterior*	2000-November 2017
COCHRANE	Overbite [Mesh] OR deepbite OR over-bite OR over bite OR deep overbite OR gummy smile AND implant OR mini implant* OR micro implant* OR microimplant* OR screw* OR mini screw* OR miniscrew* OR micro screw* OR microscrew* OR temporary anchorage device OR skeletal anchorage OR tad OR plate OR intrus* OR incisor* OR anterior*	2000-November 2017
LILACS	Overbite [Mesh] OR deepbite OR over-bite OR over bite OR deep overbite OR gummy smile AND implant OR mini implant* OR micro implant* OR microimplant* OR screw* OR mini screw* OR miniscrew* OR micro screw* OR microscrew* OR temporary anchorage device OR skeletal anchorage OR tad OR plate OR intrus* OR incisor* OR anterior*	2000-November 2017

Table 3: Data extraction (demographic difference table of included studies)

Authors	Publication year	Country	Journal	Type of study	Sample size (patients)	Gender		Age (years)	
						Women	Men	CSA	TADs
Senışık and Türkkahraman	2012	Turkey	AJODO	RCT	45	26	19	20.32±3.22	20.13±2.48
Polat-Özsoy *et al*.	2011	Turkey	AJODO	CCT	24	14	10	15.25±3.93	20.90±7.12
Krishna *et al*.	2011	India	Journal of Indian Orthodontic Society	CCT	14	-	-	-	-
Raj *et al*.	2015	India	J Res Adv Dent	CCT	20	8	12	14-20	14-20
El Namarawy *et al*.	2014	Cairo	Master thesis at Cairo University	CCT	30	21	9	22.6±5.3	19.5±2.5
Jain *et al*.	2014	India	Journal of clinical and diagnostic research	RCT	30	19	11	16-22	16-22

CSA: Conventional segmented arch; TADs: Temporary anchorage devices

Summary measures and approach to synthesis

Random-effect meta-analysis of the mean differences (MDs) was carried out as the principal method to estimate all the pooled estimates.[14] Randomized and controlled clinical studies were statistically evaluated both jointly and separately with subgroup analysis and significance established at $P < 0.05$. Results of the analyses are presented graphically with forest plots after comparisons of study designs, methods of intrusion, and participants to judge the clinical heterogeneity of the studies. Heterogeneity among studies in every analysis performed was done using the I^2 test. The Cochrane rough guide of interpretation of the I^2 test was used where values ranging from 0% to 40% represented no heterogeneity, 30% to 60% represented a moderate heterogeneity, 50% to 90% represented a substantial heterogeneity, and finally 75% to 100% represented a considerable heterogeneity. All calculations were carried out using the software: Review Manager (version 5.3; Cochrane Collaboration, Boston, Mass, USA).

Additional analysis

Sensitivity analysis was performed by drawing sensitivity plots to define the influence of specific studies on the total calculated effect (RCTs versus CCTs).

Results

Retrieved studies and data extraction

The PRISMA flowchart depicting the flow of 9600 initially retrieved articles is presented in Figure 4. A total of 9250 titles were screened after duplicates removal

Table 4: Data extraction (methodological difference table of included studies)

Authors	Groups Compared	Leveling and alignment	Screw used							Wire used			Force	
			Number	Diameter (mm)	Length (mm)	Type	Location	Loading	Application of force	Diameter	Type	Base Arch	CSA (g)	TAD (g)
Senışık and Türkkahraman	3 groups: 2 treatment groups and 1 untreated control group (*n*=15/each group)	Not performed	Two	1.3	5	Absoanchor	Between the roots of the lateral incisors and canines	Immediately	NITI closed coil springs	0.016 × 0.022 Niti	Ortho organizers	0.016 st.st	60	90
Polat-Özsoy *et al.*	2 groups: Group 1 (TAD), (*n*=13) Group 2 (CSA) (*n*=11)	Done	Two	1.2	6	Absoanchor	Distally to the maxillary lateral incisors	1 week later	NITI closed coil springs	0.016 × 0.016-in blue Elgiloy	Rocky mountain orthodontics	0.016 × 0.022 st.st	-	80
Krishna *et al.*	Two groups (*n*=7/each group)	Done (approximately 2 months)	One	2	8	Leone	Between the maxillary central incisors	2 weeks later	NITI closed coil springs	0.016" × 0.022" TMA	-	-	50	50
Raj *et al.*	2 groups (*n*=10/each group)	Done (approximately 3 months)	Two	-	-	-	Between roots of upper laterals, canines	2 weeks later	NITI closed coil springs	Burstone intrusive arch	-	-	70	70
El namarawy *et al.*	Two groups (*n*=15/each group)	Done	Two	1.4	6	Jeil	Distally to the maxillary lateral incisors	2 weeks later	NITI closed coil springs	0.017" × 0.025" TMA	Ormco	0.016" × 0.022" st.st	100	100
Jain *et al.*	Three Groups: Group 1 (TAD) (*n*=10) Group 2 (J-hook headgear) (*n*=10) Group 3 (utility arch) (*n*=10)	Done	Two	1.4	6	Absoanchor	Between the maxillary central and lateral incisor	Not mentioned	NITI closed coil springs	19 × 25 blue elgiloy	Not mentioned	19 × 25 St.st	1.5 ounces = 42.5	1.5 ounces =4 2.5

CSA: Conventional segmented arch; TAD: Temporary anchorage device

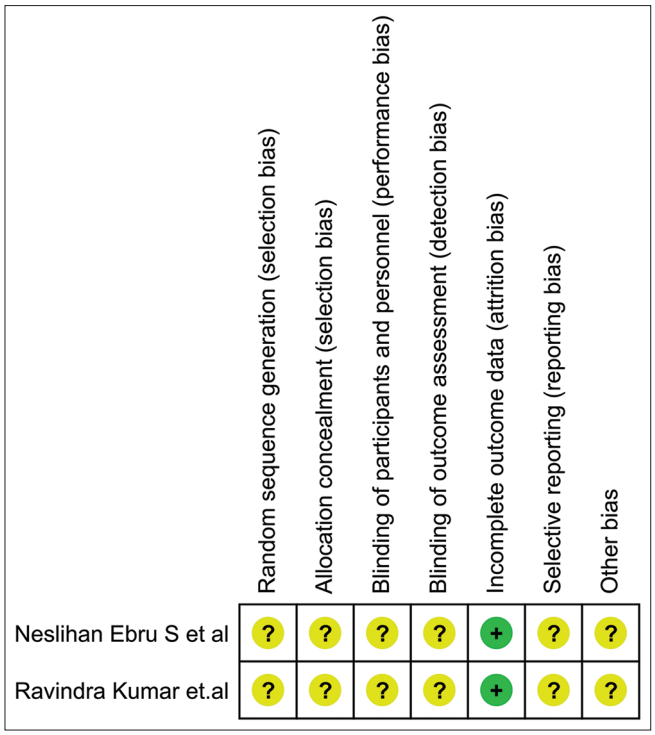

Figure 3: Risk of bias summary

using DistillerSR. The number of citations that required title screening was 9250. Of these titles, 9150 studies were excluded on title screening (first level of screening) for reasons of irrelevance for the systematic review, so One hundred studies went to the second level of screening (abstract screening). Of these 100 abstracts, 92 studies were excluded for inclusion and exclusion criteria, so eight studies went to the third level of screening (full-text screening). Of these eight full-text articles, two studies were excluded due to being methodologically irrelevant. Eventually, we obtained two RCTs and four CCTs, giving a total of six studies. A summary of the data extracted from the articles is shown in Tables 3-5.

Risk of bias within studies

The assessment of the risk of bias in the RCTs is summarized in Figure 3. Due to lack of information about the randomization process, we assessed the risk of bias as high in the studies by Senışık and Türkkahraman[15] and Jain *et al*.[3] The quality assessment of the included CCTs is shown in Table 6 using the risk of bias in non-ROBINS-I.[13] Three studies, i.e. Polat-Özsoy *et al*.,[16] El Namarawy *et al*.,[17] and Raj *et al*.,[9] were of moderate quality. One study by Krishna *et al*.[10] was of serious quality.

Primary outcome measure

Amount of upper incisor intrusion

The data obtained from three studies, based on the similarity in the intervention, Raj *et al*., El Namarawy *et al*., and Polat-Özsoy *et al*., were pooled to compare the effect of mini-implant group versus control group when measured from CR of maxillary central incisor (CR1) to palatal plane (PP) (CR1-PP). A meta-analysis was undertaken on data from two studies, involving 38 participants who had been treated with the mini-implants and 36 participants who had been treated with conventional intrusion arches. The pooled estimate showed a significant improvement about 0.78 mm of upper incisor intrusion (P = 0.002) in the TAD group compared to control group (MD 0.78; 95% confidence interval [CI] 0.28–1.29) as shown in Figure 5. The test for the heterogeneity showed minimal heterogeneity (I^2 = 0%). Subgroup analysis of the RCTs was not possible since there were no RCTs containing this outcome measure.

Secondary outcome measures

Amount of upper incisor tipping

Data obtained from four studies evaluating similar interventions (Senışık and Türkkahraman, Raj *et al*., Polat-Özsoy *et al*., and El Namarawy *et al*.) and involving 53 participants who had treated with the mini-implants were compared with 51 who acted as a control were pooled to compare the effect of mini-implants versus the control group On U1/PP (°). The overall effect showed no statistically significant difference (MD 4.72; 95% CI −1.09–10.53) as shown in Figure 6. The test for heterogeneity showed a high level of heterogeneity (I^2 = 87%). Subgroup analysis of the RCTs was not possible since there was only one RCT containing this outcome measure, and the result showed 3.23° more incisors tipping in the CSA group.

The sensitivity analysis after exclusion of the study by Senışık and Türkkahraman from this meta-analysis showed that a significant improvement about 7.32° of upper incisor tipping (P < 0.00001) in the TAD group compared to control group (MD 7.32; 95% CI 5.00–9.63) as shown in Figure 7. The test for heterogeneity showed minimal heterogeneity (I^2 = 0%).

Treatment duration

Data obtained from three studies assessing similar interventions (El Namarawy *et al*., Senışık and Türkkahraman, and Polat-Özsoy *et al*.) and involving 43 participants who had been treated with the mini-implants were compared with 41 participants who acted as a control were pooled to compare the effect of mini-implant group versus the control group on the treatment duration. The overall effect showed no statistical differences between TAD and CSA groups (MD −0.27; 95% CI −0.78–0.23) as shown in Figure 8. The test for heterogeneity showed minimal heterogeneity (I^2 = 0%). Subgroup analysis of the RCTs was not possible since there was only one RCT containing this outcome measure.

The sensitivity analysis after exclusion of the study by Senışık and Türkkahraman from this meta-analysis showed

Table 5: Data extraction (results of included studies)

Authors	Duration (months)		U1/PP (°)		CR1-PP (mm)		U6-PTV (mm)		U6/PP (°)	
	CSA	TAD	CSA	TAD	CSA	TAD	CSA	TAD	CSA	TAD
Senışık and Türkkahraman	6.88±0.95	6.93±1.17	4.87±5.64	8.10±5.17	-	-			9.83±3.53	0.00±0.00
Polat-Özsoy *et al*.	6.61±2.46	6.61±2.95	13.55±13.45	3.85±5.36	−0.86±2.30	−1.75±2.66	-0.98±6.48	0.15±3.96		
Krishna *et al*.	6	6								
Raj *et al*.	5	5	10.9±4.61	2.7±2.11	−2.3±1.54	−3.5±1.51	−4.2±2.07	0.9±0.96		
El Namarawy *et al*.	4.8±1	5.3±1	7.9±4.7	2.3±5.7	−1.6±0.8	−2.3±0.8			−1±1.5	0.03±0.1
Jain *et al*.	4	4			-	-				

CSA: Conventional segmented arch; TAD: Temporary anchorage device

Table 6: Risk of bias in nonrandomized studies of interventions risk of bias assessment for the controlled clinical trials

Authors	Confounding	Selection	Measurement of intervention	Missing data	Measurement of outcomes	Reported result	Overall
Polat-Özsoy *et al*.	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
Krishna *et al*.	Serious	Moderate	Moderate	Serious	Serious	Moderate	Serious
Raj *et al*.	Moderate	?	Moderate	Moderate	Moderate	Moderate	Moderate
El Namarawy *et al*.	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate

Low: "Comparable to a well-performed randomized trial," Moderate: "Sound for a non-randomized study" but not comparable to a rigorous randomized trial, Serious: Presence of "important problems," Critical: "too problematic . to provide any useful evidence on the effects of intervention," No information (?): Insufficient information provided to determine risk of bias, Overall risk of bias: Equal to the most severe level of bias found in any domain

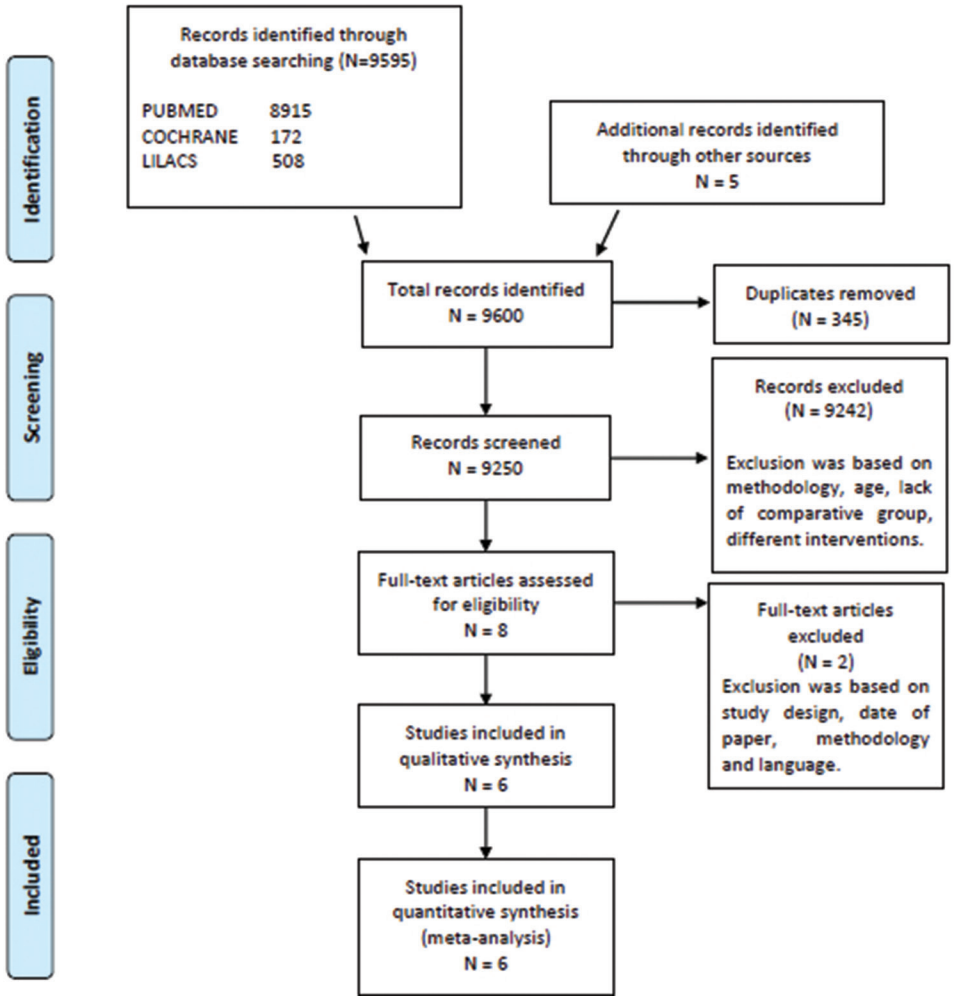

Figure 4: Preferred reporting items for systematic review and meta-analysis diagram of article retrieval

that no statistically significant difference (MD −0.45; 95% CI −1.13–0.23) as shown in Figure 9. The test for heterogeneity showed minimal heterogeneity (I^2 = 0%).

Amount of anchorage loss

Data obtained from two studies assessing similar interventions (Raj *et al*. and Polat-Özsoy *et al*.) and involving 23 participants who had been treated with the mini-implants was compared with 21 participants who acted as a control were pooled to compare the effect of mini-implant group versus the control group on U6-PTV. The overall effect showed no statistically significant difference (MD −3.68; 95% CI − 7.41–0.05) as shown in Figure 10. The test for the heterogeneity showed substantial heterogeneity (I^2 = 65%). Subgroup analysis of the RCTs was not possible since there were no RCTs containing this outcome measure.

Amount of molar tipping

Data obtained from two studies assessing similar interventions (Senışık and Türkkahraman and El Namarawy *et al*.) and involving 30 participants who had been treated with the mini-implants was compared with 30 participants who acted as a control were pooled to compare the effect of mini-implant group versus the control group on U6-PP (°). The pooled estimate showed a significant 1.03° molar tipping (P = 0.008) in the control group compared to TAD group (MD − 1.03; 95% CI −1.79–−0.27) as shown in Figure 11. The test for the heterogeneity showed not applicable. Subgroup analysis of the RCTs was not possible since there were no RCTs containing this outcome measure.

The sensitivity analysis after exclusion of the study by Senışık and Türkkahraman from this meta-analysis showed that no statistically significant difference (MD 0.42; 95%

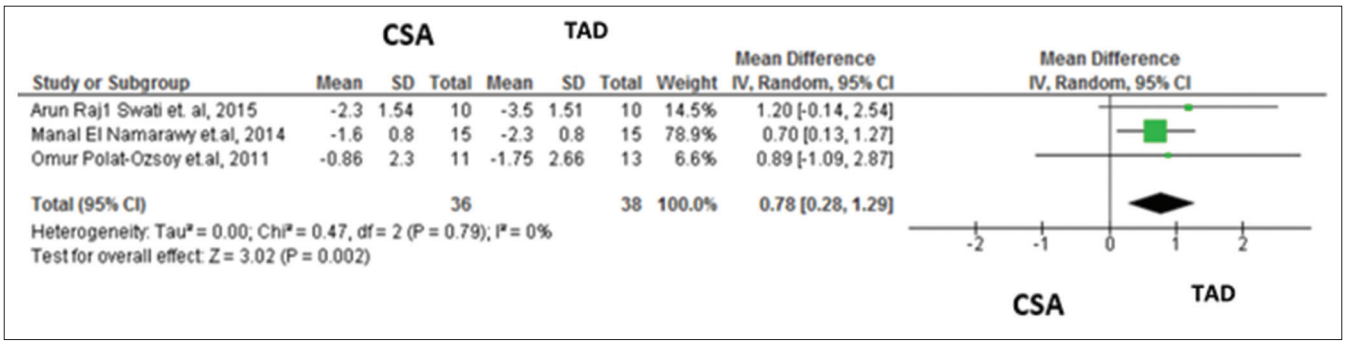

Figure 5: Amount of incisors intrusion meta-analysis

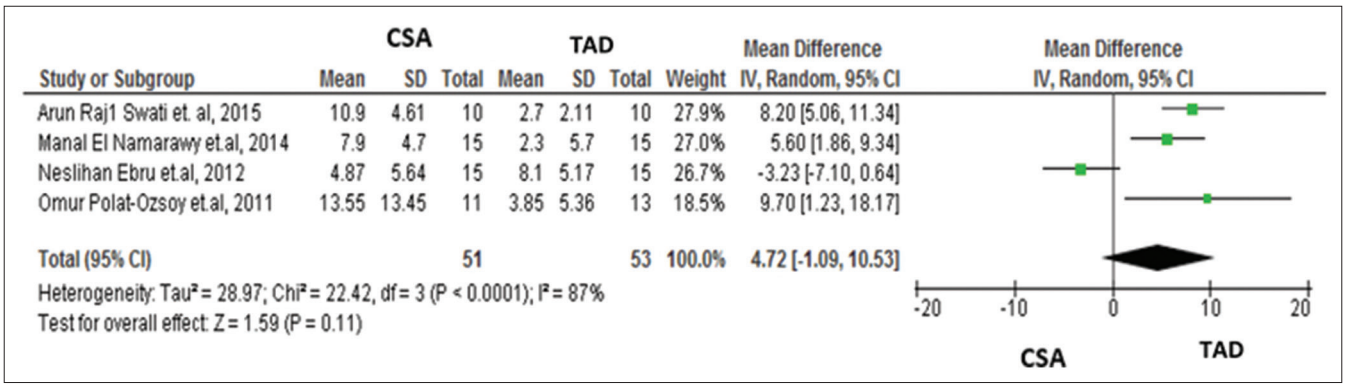

Figure 6: Amount of incisors tipping meta-analysis

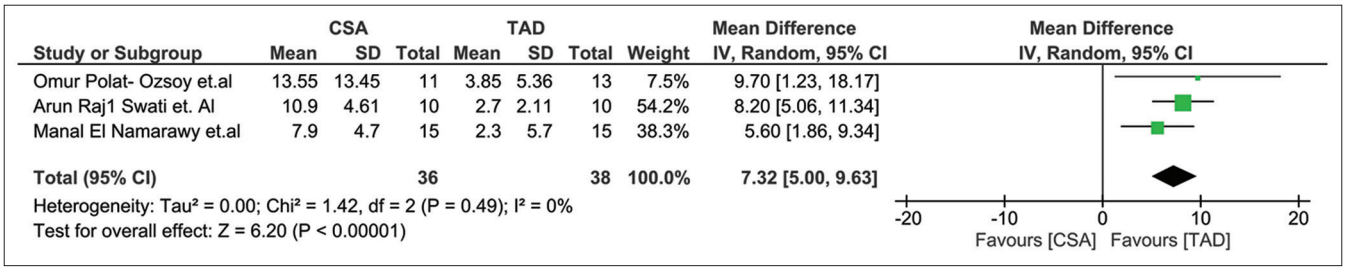

Figure 7: Amount of incisors tipping meta-analysis (sensitivity analysis)

CI −0.25–1.09) as shown in Figure 12. The test for the heterogeneity showed not applicable.

Discussion

Deep bite is a complex orthodontic problem that needs to be corrected at the beginning of the treatment. The maxillary incisor position, especially with the upper lip, is a key factor in determining the type of treatment, since correction of deep bite with maxillary incisor intrusion in patients with insufficient incisor display leads to flattening of the smile arc and reduces smile attractiveness.[16]

The data obtained from meta-analyses showed significant upper incisors intrusion about 0.78 mm in the TAD group compared to control group when measured from CR of maxillary central incisor to PP. The amount of upper incisors intrusion can be assessed by two linear measurements (U1-PP, CR1-PP). Caution is also advised during the implementation of U1-PP finding due to using the incisal edge of upper central as a reference point was unreliable. The CR of the maxillary central incisor was more reliable and determined for each patient rather than the CR of the anterior segment because of its ease of location and high reproducibility.[18] The CR of the maxillary central incisor was taken as the point located at one-third of the distance of the root length apical to the alveolar crest.[16]

As for amount of upper incisor tipping, the data obtained from meta-analyses showed no significant differences in the amount of incisors tipping between groups. Caution is also advised due to Krishna *et al*. and Jain *et al*., using TAD away from CR of the anterior segment which may increase incisors tipping and Senışık and Türkkahraman *et al*., did not do leveling and alignment before the intrusion.

The data obtained from meta-analyses showed no significant differences in the treatment duration between two groups. Caution is also advised during the implementation of these findings due to different forces used for intrusion between the included studies.

The data obtained from meta-analyses showed that no significant anchorage loss between both groups when measured from (U6-PTV). Caution is also advised during the implementation of these findings due to El Namarawy *et al*. using posterior anchor unit (transpalatal arch) cemented to the first maxillary molars.

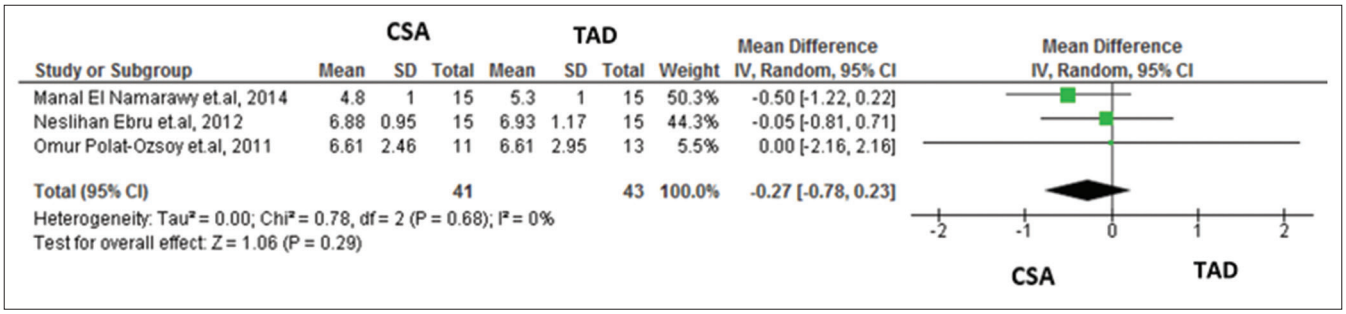

Figure 8: Amount of treatment duration meta-analysis

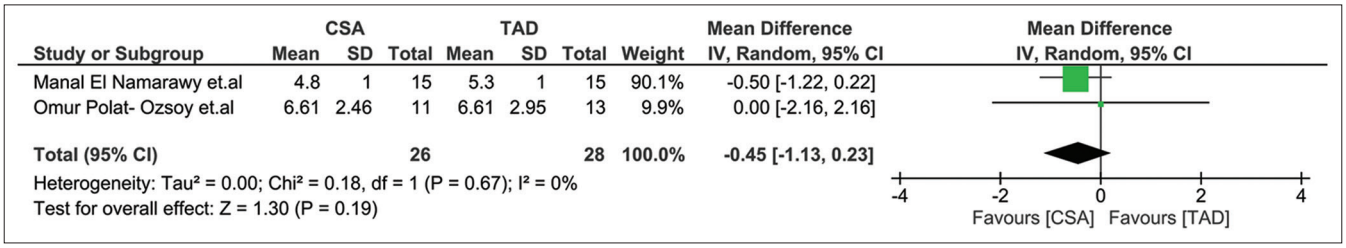

Figure 9: Amount of treatment duration meta-analysis (sensitivity analysis)

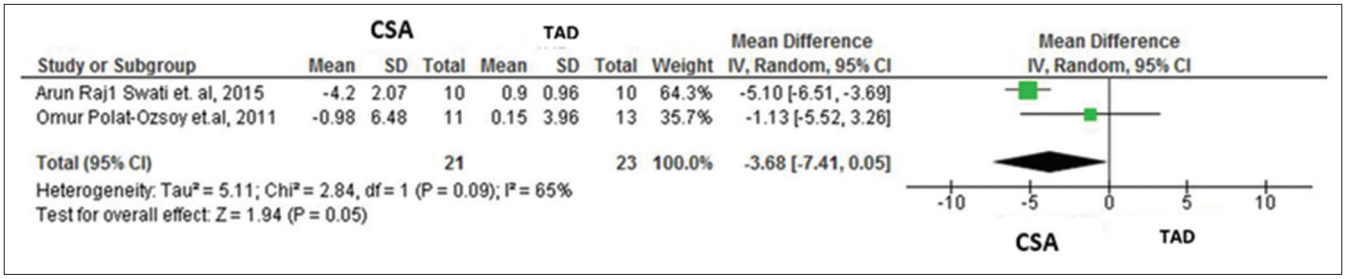

Figure 10: Amount of Anchorage loss meta-analysis

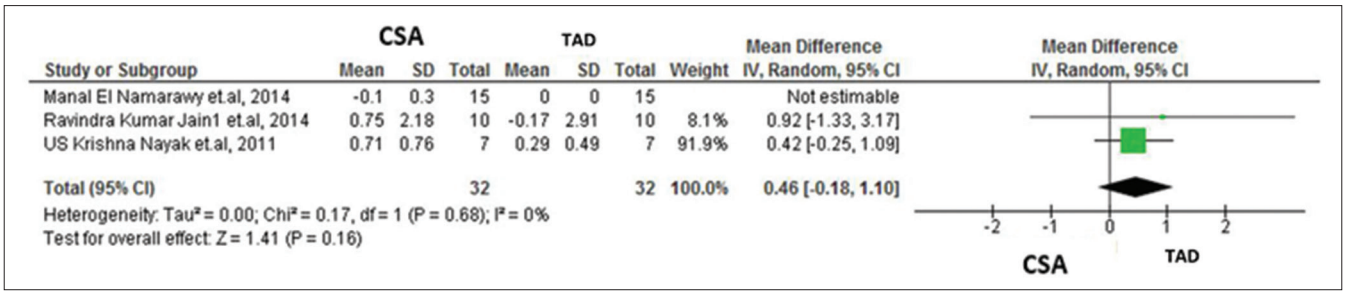

Figure 11: Amount of molar tipping meta-analysis

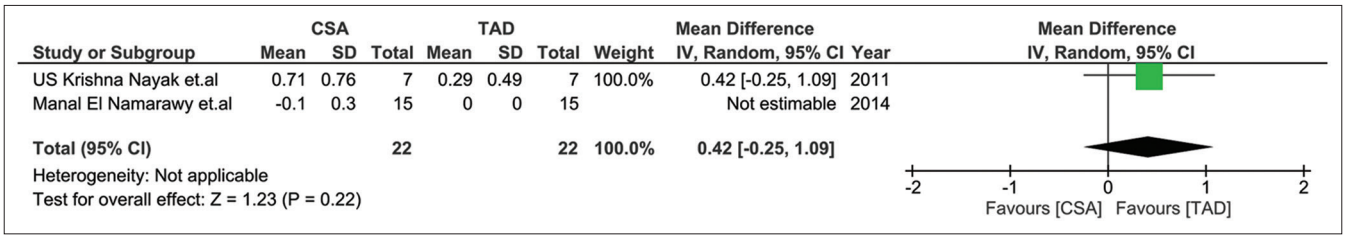

Figure 12: Amount of molar tipping meta-analysis (sensitivity analysis)

The data obtained from meta-analyses showed that significant molar tipping about 1.03° in the control group compared to TAD group when measured from U6/PP.

The overall quality of the included studies was found to be high, moderate, and low; thus, future research, with a well-conducted methodology, may alter the evidence in hand. For this reason, clinicians should be cautious when interpreting these results.

Conclusions

On the basis of this systematic review and meta-analysis, we concluded the following:

1. The average difference of 0.78 mm regarding the amount of incisors intrusion in TADs group which seems statistically significant, but clinically insignificant
2. No significant difference was found regarding the amount of incisors tipping and the anchorage loss between the two groups
3. A significant distal molar tipping of 1.03° in control group greater than TAD group
4. Clinicians need to interpret these results with caution since they are based on studies with low, moderate, and high qualities which imply that a future well-conducted research may change the available evidence.

Acknowledgement

I would also like to thank Dr. Ahmed El Khadem for his assistance during the study and having the role of methodological expert.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

References

1. Parker CD, Nanda RS, Currier GF. Skeletal and dental changes associated with the treatment of deep bite malocclusion. Am J Orthod Dentofacial Orthop 1995;107:382-93.
2. Björk A. Variability and age changes in overjet and overbite. Am J Orthod 1953;39:779-801.
3. 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:ZC21-4.
4. Zachrisson BU. Esthetic factors involved in anterior tooth display and the smile: Vertical dimension. J Clin Orthod 1988;32:432-45.
5. Burstone CJ. The mechanics of the segmented arch techniques. Angle Orthod 1966;36:99-120.
6. Aydoğdu E, Özsoy ÖP. Effects of mandibular incisor intrusion obtained using a conventional utility arch vs. bone anchorage. Angle Orthod 2011;81:767-75.
7. Weiland FJ, Bantleon HP, Droschl H. Evaluation of continuous arch and segmented arch leveling techniques in adult patients – A clinical study. Am J Orthod Dentofacial Orthop 1996;110:647-52.
8. Veltri M, Balleri B, Goracci C, Giorgetti R, Balleri P, Ferrari M, *et al.* Soft bone primary stability of 3 different miniscrews for orthodontic anchorage: A resonance frequency investigation. Am J Orthod Dentofacial Orthop 2009;135:642-8.
9. Raj A, Acharya SS, Mohanty P, Prabhakar R, Karthikeyan MK, Saravanan R, *et al*. Comparison of intrusive effects of mini screws and burstone intrusive Arch: A radiographic study. Adv Hum Biol 2015;5:49-55.
10. Krishna NU, Varun G, Farhat G, Rahul S. Comparison of skeletodental changes occurring during deep overbite correction with mini-implant anchorage system and the utility arches reinforced by a transpalatal arch. J Indian Orthod Soc 2011;45:9-14.
11. Ng J, Major PW, Heo G, Flores-Mir C. True incisor intrusion attained during orthodontic treatment: A systematic review and meta-analysis. Am J Orthod Dentofacial Orthop 2005;128:212-9.

12. Cochrane. Cochrane Risk Of Bias Tool (Modified) For Quality Assessment of Randomized Controlled Trials Study. Available from: https://www.ncbi.nlm.nih.gov/books/NBK132434/bin/appd-fm3.pdf. [Last accessed on Aug 2018].
13. Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, *et al.* ROBINS-I: A tool for assessing risk of bias in non-randomised studies of interventions. BMJ 2016;355:i4919.
14. DerSimonian R, Laird N. Meta-analysis in clinical trials. Control Clin Trials 1986;7:177-88.
15. Senışık NE, Türkkahraman H. Treatment effects of intrusion arches and mini-implant systems in deepbite patients. Am J Orthod Dentofacial Orthop 2012;141:723-33.
16. Polat-Özsoy Ö, Arman-Özçırpıcı A, Veziroğlu F, Çetinşahin A. Comparison of the intrusive effects of miniscrews and utility arches. Am J Orthod Dentofacial Orthop 2011;139:526-32.
17. El Namarawy M, El Sharaby F, Bushnak M. Evaluation of two Modalities for Deep Bite Correction by Maxillary Incisor Intrusion. Thesis: Cairo University; 2014.
18. van Steenbergen E, Burstone CJ, Prahl-Andersen B, Aartman IH. The influence of force magnitude on intrusion of the maxillary segment. Angle Orthod 2005;75:723-9.