Clinical use of orthodontic mini-implants for intrusion and retraction: a systematic review

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Background: Bimaxillary dental protrusion is common in many ethnic groups and is generally treated by the extraction of all first premolars. However, temporary anchorage devices (TADs) are currently gaining popularity and most studies have focused on anchorage loss, treatment duration, mini-implant success and failure rates, pain, discomfort and root resorption. Few studies have focused on the clinical effectiveness of implants for the intrusion and retraction of anterior teeth.

Objectives: To assess the clinical use of orthodontic mini-implants for the intrusion and retraction of anterior teeth.

Methods: A systematic review of articles selected from PUBMED and Google Scholar was carried out to determine the clinical use of orthodontic mini-implants for anterior tooth intrusion and retraction. Additional studies were hand searched to identify and include clinical trials, prospective and retrospective studies, while excluding finite element method (FEM) studies and case reports. A total of 598 articles were identified, of which 37 papers met the inclusion criteria and, following the elimination of duplicates, 20 articles were selected.

Results: Orthodontic mini-implants are more efficient for intrusion and retraction when compared to conventional intraoral and extra-oral anchorage devices. A greater amount of intrusion and retraction is achieved when mini-implants are placed between the first and second premolars without using any specific intrusive mechanics.

Conclusion: The present review highlights the clinical effectiveness of orthodontic mini-implants for anterior tooth intrusion and retraction and the results suggest that orthodontic mini-implants are more effective than other conventional methods of anchorage reinforcement.

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Introduction

Background

Bimaxillary dental protrusion is common in many ethnic groups and is characterised by dentoalveolar flaring of the maxillary and mandibular anterior teeth with resultant protrusion of the lips and convexity of the face. The present trend to treat bimaxillary protrusion is by extraction of the four first premolars, followed by anterior tooth retraction to obtain the desired dental and soft-tissue profile changes.[1] However, the extraction of premolars often raises the query of anchorage demands.

Orthodontic anchorage has always been an integral aspect of treatment planning and execution. To address the problem of anchorage loss, many appliances and techniques have been devised, including the Nance holding arch, transpalatal bars, extra-oral traction, multiple teeth serving as one anchorage segment, anchorage preparation, and the employment of light forces.[2] Recently, titanium-alloy mini-implants have been suggested as a source of skeletal anchorage.[3] There have been numerous studies conducted in which mini-implants have been compared with other anchorage devices. Sandler et al. showed that there was no difference between the effectiveness of

TADs, a Nance button palatal arch, and headgear for reinforcing anchorage during orthodontic anterior retraction.[4]

Benson et al. showed that headgear and midpalatal implants were equally effective in providing anchorage;[5] whereas Upadhyay et al. have shown that TADs were more effective than other methods of anchorage supplementation.[1]

Creekmore and Eklund were the first to report the use of TADs, in a clinical report published in 1983.[6] With the recent emergence of mini-implant applications, studies have been performed to investigate their efficacy as an anchorage source for en-masse retraction of anterior teeth.

Most of the studies have focused on anchorage loss, treatment duration, mini-implant success and failure rates, pain, discomfort and root resorption. Few studies have focused on the clinical effectiveness of implants for anterior tooth intrusion and retraction.

Although the anchorage control of posterior teeth is superior with mini-implants, the nature of the displacement of maxillary incisors with both methods of space closure will be of interest for clinicians. The type and direction of the resulting tooth movement depends on the interaction between the line of force and centre of resistance (Cr) of any specific tooth or group of teeth.[7] The line of force application, amount of force, force decay and constancy, archwire-bracket play and archwire deflection (regulated primarily by the archwire properties) are critical factors for controlling incisor retraction with mini-implant supported anchorage.[8]

Therefore, the present study aimed to summarise the clinical effectiveness of mini-implant use for incisor intrusion and retraction.

Material and methods

Selection criteria

Inclusion criteria:

1. Articles published between January 2000 and January 2018.
2. Articles stating the use of orthodontic mini-implants for anterior tooth intrusion and retraction.
3. RCT, clinical trials, prospective and retrospective studies.

Exclusion criteria:

1. FEM studies.
2. Case reports and animal studies.

PICO:

Participants*:* orthodontic patients

Intervention: mini-implants

Comparison: intraoral and extra-oral anchorage reinforcement

Outcomes: intrusion and retraction

Information sources:

Two Internet sources of evidence were used by the first author (S.O.) in the search for appropriate papers satisfying the study purpose: The National Library of Medicine (MEDLINE PubMed) and Google Scholar; and a manual search was conduct using DPU college library resources. All cross reference lists of the selected studies were screened for additional papers that could meet the eligibility criteria of the study. The databases were searched until January 2018 using the keywords provided in Table I and search strategy given in Table II.

Study selection:

Various electronic databases were searched by the first author (S.O.) using different strategies and the key words and possible combinations. The number of articles identified through the database search was 598. Duplicate articles were removed. After thorough reading of titles and abstracts, the number of relevant articles reduced to 27. Of these, 20 met the inclusion criteria and were selected and confirmed by the other authors (S.A. and J.R.).

Table I. Keywords.

Primary Keywords	Secondary Keywords
Orthodontic	
Mini-implant	Micro-implant, mini screw, temporary anchorage device, TADs, skeletal anchorage
Intrusion	Incisor intrusion, incisor displacement
Retraction	Anterior teeth retraction, en masse retraction

Table II. Search strategy.

Sr. No.	Search strategy	Number of articles found	Number of articles selected	Reason for exclusion
SS1	Orthodontic AND mini implant AND intrusion AND retraction	15	4	FEM study/case report/not relevant to this study
SS2	Orthodontic AND micro implant AND intrusion AND retraction	2	0	FEM study/case report/not relevant to this study/duplicate
SS3	Orthodontic AND mini screw AND intrusion AND retraction	10	0	FEM study/case report/not relevant to this study/duplicate
SS4	Orthodontic AND temporary anchorage device AND intrusion AND retraction	5	1	FEM study/case report/not relevant to this study/duplicate
SS5	Orthodontic AND TADs AND intrusion AND retraction	3	0	FEM study/case report/not relevant to this study/duplicate
SS6	Orthodontic AND skeletal anchorage AND intrusion AND retraction	25	2	FEM study/case report/not relevant to this study/duplicate
SS7	Orthodontic AND mini implant OR micro implant OR mini screw OR temporary anchorage device OR TADs OR skeletal anchorage AND intrusion AND retraction	46	2	FEM study/case report/not relevant to this study/duplicate
SS8	Orthodontic AND mini implant AND intrusion OR incisor intrusion OR incisor displacement AND retraction	101	1	FEM study/case report/not relevant to this study/duplicate
SS9	Orthodontic AND mini implant AND intrusion AND retraction OR anterior teeth retraction OR en masse retraction	384	10	FEM study/case report/not relevant to this study/duplicate

Data collection process:

The data collection process was performed by the first author (S.O.). A Microsoft Excel Spreadsheet was populated with the study data, which was re-evaluated by the other authors (S.A. and J.R.).

Data items:

The data items included were study ID, author's name, year of publication, location, study design, sample size, population, implant specification, intervention, comparison, outcome, results and conclusion.

Results

Risk of bias/quality assessment in individual studies

The quality of the selected articles was analysed using a self-modified MINORs checklist.[9,10] A total of 10 criteria were analysed to grade the risk of the studies:

- a clearly stated aim
- an inclusion criteria of consecutive patients
- data collection
- an endpoint appropriate to the aim of the study
- sample size adequacy
- distribution of sample size within the groups
- adequate statistical analysis
- main outcome to be measured is clearly described in the introduction/methods section
- intervention and sites of interest clearly described
- and main findings of the study.

The items were scored 0 (not reported), 1 (reported but inadequate) or 2 (reported and adequate). If the total score of each study was <15, it was considered a low quality study, 15–17 was considered a moderate quality study, and 18–20 was considered a high quality study (Tables III, IV, V).

As this was a systematic review, the heterogeneity of the selected studies was not assessed.

Study selection

The data search was carried out based on the title relevance to the systematic review. A total of 598 titles were screened across various medical and

Table III. Quality of studies when mini-implants are compared with extra oral anchorage devices.

Sr. No.	Methodological items	Deguchi et al.	Yao CC et al.	Lai EH et al.	Chen M et al.	A.Y. Lee and Y. H. Kim	Park HM et al.
1.	Clearly stated aim	2	2	2	2	2	2
2.	Inclusion criteria of consecutive patients	1	1	1	1	2	2
3.	Data collection	2	2	2	2	2	2
4.	Endpoint appropriate to the aim of study	2	2	2	2	2	2
5.	Is the sample size adequate	1	1	1	1	1	1
6.	Distribution of sample size in different groups	1	1	1	1	2	2
7.	Adequate statistical analysis	2	2	2	2	2	2
8.	Are the main outcome to be measures are clearly described in introduction/ methods section	2	2	2	2	2	2
9.	Are the intervention and sites of interest clearly described	2	2	2	2	2	2
10.	Are the main finding of study clearly described.	2	2	2	2	2	2
	TOTAL	17	17	17	17	19	19

Interpretation: <15 = low quality studies, 15–17 = moderate quality study, 18–20 = high quality study.
The items are scored 0 (not reported), 1 (reported but inadequate) or 2 (reported and adequate).

Table IV. Quality of studies when mini-implants are compared with intra oral anchorage devices.

Sr. No.	Methodological items	Upadhyay et al.	Liu YH et al.	Liou and Chang	Basha AG et al.
1.	Clearly stated aim	2	2	2	2
2.	Inclusion criteria of consecutive patients	1	2	1	2
3.	Data collection	2	2	1	1
4.	Endpoint appropriate to the aim of study	2	2	2	2
5.	Is the sample size adequate	1	1	1	1
6.	Distribution of sample size in different groups	2	2	1	2
7.	Adequate statistical analysis	2	2	2	2
8.	Are the main outcome to be measures are clearly described in introduction/ methods section	2	2	2	2
9.	Are the intervention and sites of interest clearly described	2	2	2	2
10.	Are the main finding of study clearly described.	2	2	2	2
	TOTAL	18	19	16	18

Interpretation: <15 = low quality studies, 15–17 = moderate quality study, 18–20 = high quality study.
The items are scored 0 (not reported), 1 (reported but inadequate) or 2 (reported and adequate).

Table V. Quality of studies when mini-implants are used for intrusion and retraction.

Sr. No.	Methodological items	Upadhyay et al.	Kim SH et al.	Liu H et al.	Lee KJ et al.	Upadhyay et al.	Victor D. et al.	Jee JH et al.	Monga N. et al.
1.	Clearly stated aim	2	2	2	2	2	2	2	2
2.	Inclusion criteria of consecutive patients	2	1	1	2	2	1	1	2
3.	Data collection	2	1	2	1	2	2	2	2
4.	Endpoint appropriate to the aim of study	2	2	2	2	2	1	2	2
5.	Is the sample size adequate	1	1	1	1	1	1	2	1
6.	Distribution of sample size in different groups	1	1	2	1	1	2	1	2
7.	Adequate statistical analysis	2	2	2	2	2	2	2	2
8.	Are the main outcome to be measured clearly described in introduction/ methods section	2	2	1	2	2	2	2	2
9.	Are the intervention and sites of interest clearly described	2	2	2	2	1	2	2	2
10.	Are the main findings of study clearly described.	2	2	1	2	2	2	2	2
	TOTAL	18	16	16	17	17	17	18	19

Interpretation: <15 = low quality studies, 15–17 = moderate quality study, 18–20 = high quality study.
The items are scored 0 (not reported), 1 (reported but inadequate) or 2 (reported and adequate).

dental journals, of which 93 titles were short-listed. On duplicate removal and a thorough review of the abstracts, 27 full-text articles were obtained. A final total of 20 articles met the selection criteria and were selected for qualitative synthesis for the systematic review. The outline of the selection process is illustrated in Figure 1.

Table VI shows the effectiveness of mini-implants when compared with extra-oral anchorage reinforcement such as J-hook headgear and conventional headgears. It was evident that mini-implants provide better vertical and sagittal control but do not significantly decrease treatment time.

Table VII shows the effectiveness of mini-implants when compared with intraoral anchorage reinforcement devices such as a Nance holding arch, a transpalatal arch, or banding of the second molars.

Table VIII shows the results when mini-implants are used for intrusion and retraction without a comparison with conventional anchorage reinforcement devices.

Discussion

The present systematic review identified articles in which the effectiveness of mini-implants was compared with intraoral and extra-oral anchorage reinforcement for anterior tooth intrusion and retraction. Also, additional studies stated the effectiveness of mini-implants for intrusion and retraction without comparison against traditional methods of anchorage reinforcement. Therefore, the effectiveness of mini-implants may be evaluated under the following headings:

a. Effectiveness of mini-implants when compared with extra-oral anchorage reinforcement.

b. Effectiveness of mini-implants when compared with intraoral anchorage reinforcement.

c. Effectiveness of mini-implants alone.

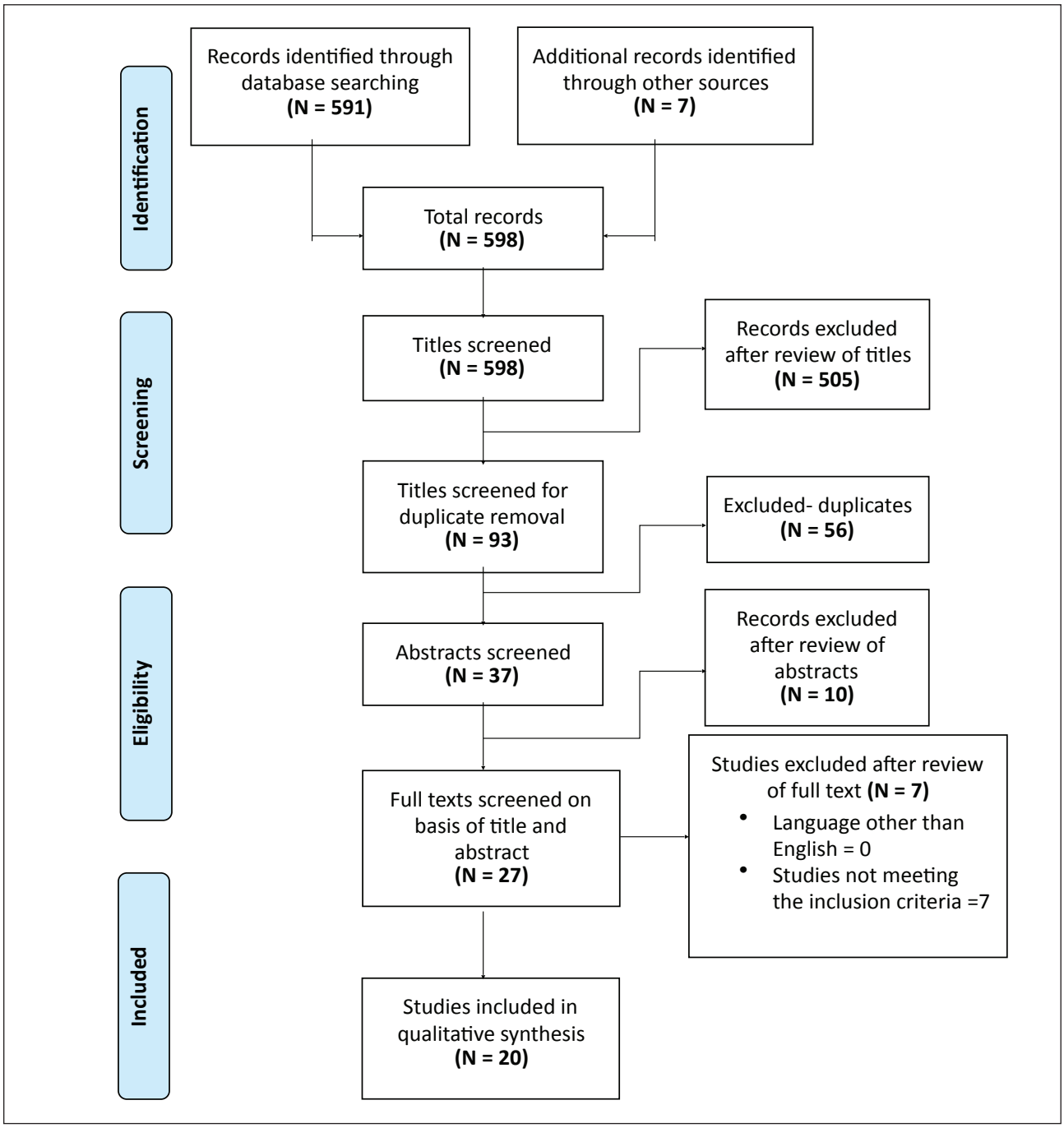

Figure 1. PRISMA 2009 Flow Diagram.

Effectiveness of mini-implants when compared with extra-oral anchorage reinforcement

The present systematic review identified six articles that compared the effectiveness of mini-implants with extra-oral anchorage reinforcements such as J-hook headgear and/or headgear anchorage.

When comparing the intrusion effects between implant anchorage and J-hook headgear on the maxillary incisors, Deguchi et al.[11] found that the incisors intruded by 3.6 ± 1.7 mm and the molars extruded by 0.1 ± 2.0 mm in the implant group. In the J-HG group, the incisors intruded by 1.1 ± 1.6 mm and the molars extruded by 1.3 ± 2.9 mm. There was

Table VI. Mini-implants compared with extra oral anchorage devices.

Author and year	Study design	Sample size	Comparison	Intervention	Outcome
T. Deguchi et al. 2008	CS	18	MI and J-hook headgear	MI: 8 J-HG: 10	MI group – more incisor intrusion J-HG group – more molar extrusion J-HG group – more root resorption
Yao CC et al. 2008	RS	47	MI and HG	HG: 22 MI: 25	MI group – greater anterior tooth retraction MI group – less maxillary molar mesialisation MI group – more intrusion of the maxillary first molar HG group – more extrusion of maxillary first molar
Lai EH et al. 2008	RS	40	MI, miniplates and HG	HG: 16 MI: 15 Miniplates: 9	Miniplate group – significant intrusion of the maxillary posterior teeth MI group – greater retraction of the maxillary anterior teeth, MI group – less anchorage loss of the maxillary posterior teeth MI group – maxillary molar intrusion
Chen M et al. 2015	CS	31	MI and HG with SL brackets	MI: 15 HG: 16	MI group – treatment time almost similar MI group – better control in both the antero-posterior and vertical directions MI group – more retraction of the maxillary incisors MI group – less anchorage loss of the maxillary first molar
Ah-Young Lee and Young Ho Kim 2011	CS	40	MI and HG	HG: 20 MI: 20	MI group – maximum anchorage of molars, greater retraction of incisors, greater intrusion of incisor and molar
Park HM et al. 2012	CS	24	MI and HG	HG: 12 MI: 12	MI group – more backward movement of MXCI, MXLI, and MXC more intrusion of MXCI and MXC less forward movement of MXP2, MXM1, and MXM2 less contraction of MXP2 and MXM1

CS: clinical study, RS: retrospective study, MI: mini implant, HG: headgear, J-HG: J-hook headgear, SL: self ligating, MXCI: maxillary central incisor, MXLI: maxillary lateral incisor, MXC: maxillary canine, MXP2: maxillary second premolar, MXM1: maxillary first molar, MXM2: maxillary second molar

more incisor intrusion in the implant group and more molar extrusion in the J-HG group. To investigate the effectiveness of bony anchorage during maxillary dento-alveolar retraction in adults with Class II and Class I malocclusions compared with traditional extra-oral anchorage such as headgear, Yao et al.[12] found that the skeletal anchorage group had greater anterior tooth retraction and less maxillary molar mesialisation than the headgear group. Translational movement of the incisors was more common than tipping movement, and intrusion of the maxillary dentition was greater in patients receiving miniplates compared with those receiving screw-type bony anchorage.[12] In addition, in patients with a high mandibular plane angle, those receiving skeletal anchorage had genuine intrusion of the maxillary first molar whereas those receiving headgear anchorage had extrusion of the maxillary first molars.

When comparing the orthodontic outcomes of maxillary dento-alveolar protrusion treated with headgear, miniscrews, or miniplates for maximum anchorage, Lai et al.[13] found significant intrusion of the maxillary posterior teeth in the miniplate group but not in the miniscrew and headgear groups. Greater retraction of the maxillary anterior teeth, less anchorage loss of the maxillary posterior teeth, and the possibility of maxillary molar intrusion all facilitated correction of the Class II malocclusion, especially for patients with a hyperdivergent face.

In a determination of the differences between the outcomes of treatment using micro-implant anchorage compared with headgear anchorage in adult patients with bimaxillary protrusion treated with self-ligating brackets, Chen et al.[14] reported that micro-implant anchorage did not shorten the orthodontic treatment period and that micro-implant anchorage achieved better control in the antero-posterior and vertical directions during treatment when compared with headgear anchorage. Also, it was concluded that micro-implant anchorage might result in more retraction of

Table VII. Mini-implants compared with intra oral anchorage devices.

Author and year	Study design	Sample size	Comparison	Intervention	Outcome
Upadhyay M et al. 2008	CS	30	MI and CAR	MI : 15 CAR: 15	In MI group – Distal movement of the MXM Intrusive effect on the MXM Intrusion of the MXC1 MXC1 retracted by controlled tipping and partly by translation In CAR group – Mesial movement of MXM Extrusive effect on the MXM MXC1 showed controlled tipping
Upadhyay M et al. 2008	RCT	40	MI and CAR	MI : 20 CAR: 20	In MI group – MXM distalised and intruded MXC1 retracted and intruded In CAR group – MXM mesialised and extruded MXC1 retracted and intruded
Liu YH et al. 2009	CS	34	MI and TPA	MI : 17 TPA : 17	In MI group – More retraction of MXC1 MXC1 and MXM were intruded MXM distalised In TPA group – MXC1 and MXM were extruded MXM mesialised
Liou and Chang 2010	RS	50	MI and CAR	MI : 20 CAR: 30	In MI group – Retraction at U1E (mm): 8.2 ± 2.4 Intrusion at U1E (mm): 0.4 ± 2.0 Retraction at U1A (mm): 3.0 ± 2.7 Intrusion at U1A (mm): 2.7 ± 1.8 In CAR group – Retraction at U1E (mm): 6.5 ± 2.1 Intrusion at U1E (mm): 0.0 ± 1.6 Retraction at U1A (mm): 1.3 ± 1.6 Intrusion at U1A (mm): 2.5 ± 1.4
Basha AG et al. 2010	CS	14	MI and CAR	CAR: 7 MI : 7	Anchor loss was statistically significant in CAR group (1.73 mm) Retraction Time – In CAR group: 0.92 mm per month (0.917) In MI group: 0.85 mm per month (0.923)
S. Al-Sibaie and M. Y. Hajeer 2014	RCT	56	MI and TPA	MI : 28 TPA : 28	Mean treatment duration: In MI group – 12.90 months TPA group – 16.97 months In MI group – U1E: retracted (-5.92 mm) and intruded (-1.53 mm) U1A: retracted (-4.56 mm) and intruded (-1.16 mm) MXM: distalised (0.89 mm) In TPA group – U1E: retracted (-4.79 mm) and extruded(0.92 mm) MXM: mesialised (1.50 mm) and extrusion seen

CS: clinical study, RS: retrospective study, RCT: randomised controlled trials, MI: mini implant, CAR: conventional anchorage reinforcement, TPA: transpalatal arch, MXCI: maxillary central incisor, MXM: maxillary molars, U1E: maxillary central incisor edge, U1A: maxillary central incisor apex

Table VIII. Effectiveness of mini-implants alone.

Author and year	Study design	Sample size	Study type	Intervention	Outcome
Upadhyay M et al. 2009	PS	23	Cephalometric study	MI	MXCI retracted and intruded MXM distalised and intruded
Kim SH et al. 2009	RS	17	Cephalometric study	MI	MXM showed mesial movement, extrusion and mesial tipping MXCI retracted and slight amount of extrusion seen
Liu H et al. 2011	CS	60	3D CT scan	MI	Retraction of MXU1E 5.94 ± 0.90 mm Retraction of MXU1A 1.40 ± 0.23 mm Intrusion of MXCI : 1.84 ± 0.26 Mesial drifting of MI seen
Lee KJ et al. 2011	CS	36	Cephalometric study	MI between MXP2 and MXM1 MI between MXP2 and MXP1	MI between MXP2 and MXP1 – Greater intrusion (1.59 mm) of U1E
Upadhyay M et al. 2012	PS	32	Cephalometric study	FFA group: 18 MI group: 14	In FFA group – Extrusion and mesial movement of the lower molar Lower incisor proclination In MI group – Distalisation and intrusion of the upper molar and incisor
Victor D et al. 2014	CS	20	Cephalometric study	MI group: 10 Control group: 10	In MI group – Distal tipping of molars, Intrusion of incisor tip and apex Intrusion of molar In control group – Mesial tipping molars, Extrusion of incisor tip and apex Extrusion of molars
Jee JH et al. 2014	CS	31	Cephalometric study using C implants	Conventional C-wire group : 15 Preformed C-wire group : 16	In Preformed C-wires group – Maximum retraction of the maxillary anterior teeth Maintenance of posterior occlusions without mesialisation of the molars. Lesser treatment time Easy and simultaneous levelling and space closure
Monga N et al. 2016	RS	18	Cephalometric study	MI	MXM position Sagittal – mesial movement Vertical – extrusion Angular – distal tipping MXCI position Sagittal – distal movement Vertical – intrusion Angular – distal tipping

PS: prospective study, RS: retrospective study, CS: clinical study, MI: mini implant, FFA: fixed functional appliance, MXCI: maxillary central incisor, MXP1: maxillary first premolar, MXP2: maxillary second premolar, MXM: maxillary molars, MXU1E: maxillary central incisor edge, MXU1A: maxillary central incisor apex, 3D CT: 3 dimensional computed tomography

the maxillary incisors and less anchorage loss of the maxillary first molars when compared with the use of headgear anchorage.

In a comparison of the anchorage loss in the upper first molar and retraction of the upper central incisor in cases with a Class I malocclusion between orthodontic mini-implants (OMIs) and conventional anchorage reinforcements (CARs), Lee and Kim[15] determined that the upper incisor edge retracted by 9.5 mm in a mini-implant group and 7.1 mm in a control group. The upper central incisors intruded by 0.9 mm and the upper molars intruded by 1.0 mm in the mini-implant group, whereas the upper central incisors extruded by 0.7 mm and the upper molars extruded by 0.9 mm in the conventional group. Park et al.[16] compared the effects of conventional and orthodontic mini-implant anchorage (OMI) on tooth movement and arch-dimension in the maxillary dentition in Class II division 1 patients. It was found that, in the OMI group, there was greater distal movement of the maxillary incisors and canines. A greater amount of maxillary central incisor and canine intrusion was observed with less forward movement of the posterior teeth compared with the conventional group.

The findings of the articles concluded that the use of mini-implants provides better vertical and sagittal control when compared with extra-oral anchorage reinforcements like J hook headgear and conventional headgear. Although mini-implants do not shorten treatment duration significantly, they provide greater anterior retraction and less molar mesialisation but produce molar intrusion, whereas extra-oral anchorage using headgear may result in molar extrusion and molar mesialisation.

Effectiveness of mini-implants when compared with intraoral anchorage reinforcement

The present systematic review identified six articles in which the effectiveness of mini-implants was compared with intraoral anchorage reinforcement such as transpalatal arches (TPA), Nance holding arch, or banding of the second molars. When comparing the changes in position of the molars and incisors between the implant and conventional method of anchorage reinforcement group, Upadhyay et al.[17] found that there was a net distal and intrusive movement of the molar and the maxillary incisor intruded in the implant group. The maxillary central incisors were retracted primarily by controlled tipping and partly by translation in the implant group. In the conventional anchorage group, there was net mesial and extrusive movement of the molars and incisor retraction showed significant amounts of controlled tipping, but some uncontrolled tipping was also noted.

In a RCT study, Upadhyay et al.[1] compared the dentoskeletal and soft-tissue treatment effects during en-masse retraction of anterior teeth using mini-implants as anchor units with conventional methods of anchorage such as transpalatal arches and banding of the second molars, in bimaxillary dental protrusion patients undergoing the extraction of all four first premolars. It was found that, in the implant group, the maxillary and mandibular molars were distalised by 0.78 ± 1.35 mm and 0.89 ± 1.23 mm and were intruded by 0.22 ± 0.65 mm and 0.75 ± 0.84 mm respectively. In addition, the maxillary and mandibular incisors were retracted and intruded. In the non-implant group, the maxillary and mandibular molars mesialised by 3.22 ± 1.06 mm and 2.67 ± 2.11 mm and were extruded by 0.67 ± 1.19 mm and 1.22 ± 1.59 mm, respectively.[1]

In a comparison of the differences in cephalometric parameters after active orthodontic treatment using mini-screw implants or transpalatal arches as anchorage in adult patients with bimaxillary dental protrusion needing extraction of four premolars, Liu et al.[18] reported that the maxillary incisors were retracted by 7.03 ± 1.99 mm and intruded by 1.91 ± 2.33 mm, while the maxillary molars distalised by 1.42 ± 2.55 mm and intruded by 0.06 ± 1.40 mm in the mini-screw implant group. In a TPA group, the maxillary incisors retracted by 4.76 ± 1.67 mm and extruded by 1.17 ± 1.99 mm while the molars mesialised by 1.91 ± 1.75 mm and extruded by 1.47 ± 1.15 mm. These results show that the maxillary incisors and molars intruded in the implant group and extruded in the TPA group.

In a retrospective study, when investigating apical root resorption of maxillary incisors in patients requiring en-masse maxillary anterior retraction and intrusion using miniscrews and the factors disposing a patient to apical root resorption, Liou and Chang[19] found retraction and intrusion at the incisor tip of 8.2 ± 2.4 mm and 0.4 ± 2.0 mm respectively in the mini-implant group. Furthermore, at the incisor root apex, there

was retraction and intrusion of 3.0 ± 2.7 mm and 2.7 ± 1.8 mm respectively. These values were greater when compared with the conventional anchorage group.

When measuring and comparing the difference between the rate of en-masse retraction with mini-implants and molar anchorage, Basha et al.[20] found that anchorage loss was statistically significant in a non-implant group (1.73mm) when compared with an implant group. Al-Sibaie and Hajeer[21] conducted a RCT to compare the skeletal, dental, and soft tissue treatment outcomes between sliding en-masse retraction of the upper anterior teeth employing mini-implants and a two-step sliding retraction approach employing conventional anchorage in patients presenting with a Class II division 1 malocclusion. In the mini-implant group, the upper incisor edges retracted (–5.92 mm) and intruded (–1.53 mm), while the upper incisor apices retracted (–4.56 mm) and intruded (–1.16 mm) and the upper molars were distalised (0.89 mm). In the TPA group, the upper incisor edges retracted (–4.79mm) and extruded (0.92 mm) and the upper molars were mesialised (1.50 mm) and extrusion was seen.[21]

It was clear that the use of mini-implants provided better anchorage control in the vertical and sagittal planes and produced molar distalisation along with the intrusion of the molars and incisors. Whereas conventional anchorage reinforcements such as TPAs, Nance holding arches, or the banding of second molars resulted in greater molar mesialisation and the extrusion of molars and incisors. Also, the incisors retracted mainly by controlled tipping and partially by translation when mini-implants were used.

Effectiveness of mini-implants alone

The present systematic review identified eight articles in which the effectiveness of mini-implants was evaluated for their ability to produce intrusion along with retraction. In one study, the effectiveness of mini-implants was evaluated according to the implant placement site.

A study conducted to examine the skeletal, dental, and soft tissue treatment effects of retraction of maxillary anterior teeth using mini-implant anchorage in non-growing Class II division 1 female patients by Upadhyay et al.[22] found that during anterior tooth retraction, the maxillary central incisors were retracted and intruded while the upper molars were distalised and intruded (0.45 ± 0.79 mm and 0.64 ± 0.78 mm respectively). In addition, the lower molars were mesialised and extruded (0.64 ± 1.1 mm and 0.52 ± 0.75 mm, respectively). To achieve independent en-masse retraction of the anterior teeth while avoiding the use of orthodontic appliances in the posterior segments during the retraction period, Kim et al.[23] retrospectively found that the maxillary molars showed mesial movement, extrusion and mesial tipping, while the mandibular molars showed slight extrusion. The upper incisors were retracted with a minor amount of extrusion and the lower incisor intruded slightly.

In a study to quantitatively evaluate the position of miniscrews and molars subjected to an orthodontic force (150 g) and using 3D CT registration evaluations, Liu et al.[24] found that the maxillary incisors retracted at their edge and apex by 5.94 ± 0.90 mm and 1.40 ± 0.23 mm respectively, and intruded by 1.84 ± 0.26 mm. It was also found that the miniscrews drifted mesially at the head and apex by 0.23 ± 0.08 mm and 0.23 ± 0.07 mm respectively. Lee et al.[25] evaluated the anteroposterior and vertical displacement patterns of the maxillary teeth in sliding mechanics determined by the position of interradicular miniscrews after the extraction of premolars. Implants were placed between the maxillary second premolar and the first molar (group A) and between the first and second premolars (group B). In group A, the vertical position of the incisal edge did not change significantly during the retraction period. While in group B, a significantly greater amount of intrusion (1.59 mm) was found when compared with group A. Simultaneous intrusion and retraction can be effectively obtained by using miniscrews between the premolars in extraction patients, without the need for additional intrusive mechanics.

When comparing the treatment effects of maxillary anterior tooth retraction with mini-implant anchorage in young adults presenting with a Class II division 1 malocclusion involving the extraction of the maxillary first premolars with comparative patients treated by a fixed functional appliance, Upadhyay et al.[26] reported that in the mini-implant group the upper molar and upper incisors intruded by 0.64 ± 0.78 mm and 1.32 ± 1.08 mm and distalised by 0.45 ± 0.79 mm and 5.18 ± 2.74 mm, respectively. The lower molars extruded and mesialised by 0.82 ± 0.75 mm and 0.64 ± 1.1 mm and the lower incisors distalised by 1.77 ± 2.16 mm, respectively.

Victor et al.[27] compared the torque of the incisors, the tip of the molars and vertical control during orthodontic treatment with and without mini screw implants. The results indicated that there was mild distal tipping of the molars, intrusion of the incisor tip and apex and very mild intrusion of the molar in the implant group. In the control group, there was a mesial tipping of the molars, extrusion of the incisor tip and apex and a mild extrusion of the molars.[27] When evaluating the therapeutic effects of a preformed assembly of nickel-titanium (NiTi) and stainless steel (SS) archwires (preformed C-wire) combined with temporary skeletal anchorage devices (TSADs) as the sole source of anchorage and to compare these effects with those of a SS version, of C-wire (conventional C-wire) for en-masse retraction, Jee et al.[28] found that the maxillary anterior teeth were fully retracted to close the extraction spaces. Uprighting of the maxillary anterior teeth by controlled tipping was observed. In addition, mesialisation and mesial tipping of the maxillary and mandibular molars was noted in the conventional C-wire group compared with the preformed C-wire group. There was linguoversion of the mandibular anterior teeth in both groups and extrusion of the mandibular teeth was observed in both groups, except in the anterior region in the preformed C-wire group. In relation to the soft-tissues, the upper and lower lips moved posteriorly.[28] During quantitative and qualitative assessment of anchorage loss during en-masse retraction with indirectly loaded miniscrews in patients with bimaxillary protrusion, Monga et al.[29] determined that the ratio of incisor retraction to molar protraction was 4.2 in the maxilla and 4.7 in the mandible. The first molars showed a mean extrusion of 0.20 mm in the maxilla and 0.57 mm in the mandible while the mean angular change of the first molars was -2.43° in the maxilla and -0.03° in the mandible with a mean anchorage loss in reference to the pterygoid vertical of 1.3 mm in the maxilla and 1.1 mm in the mandible. There was mesial movement with extrusion and distal tipping of the molars and distal movement with intrusion and distal tipping of incisors.

The use of mini-implants may therefore provide less molar mesialisation along with intrusion of the molars and incisors. Changing implant position by placement between the premolars resulted in simultaneous intrusion and retraction of the anterior teeth without the use of intrusive mechanics. Therefore, mini-implants proved to be more efficient for producing intrusion and retraction.

When using conventional mechanics, force application is usually parallel to the occlusal plane and, hence, the orthodontist is only required to analyse force in that plane. However, because mini-implants are usually placed apical to the occlusal plane into bone between the roots of teeth, the force applied is always at an angle (notably, the preferred location for mini-implant placement is between the roots of the second premolars and first molars) close to the mucogingival junction. However, care should be taken to ensure that they are not inserted too far apically into movable mucosa, as this can lead to failure due to persistent inflammation around the insertion site.[8]

En-masse space closure with miniscrew sliding mechanics involved orthodontic movements of the maxillary dentition simulated by the finite element method. The relationship between force direction and the movement patterns was clarified. When a power arm was lengthened, rotation of the entire dentition decreased. The posterior teeth were effective in preventing rotation of the anterior teeth. In cases of a highly-positioned miniscrew, bodily tooth movement was almost achieved. The vertical component of the force produced intrusion or extrusion of the entire dentition.[30]

Limitations

The present review had limitations. Articles in languages other than English were not included. Moreover, the number of clinical trials investigating the clinical use of orthodontic mini-implants for intrusion and retraction was limited. After application of the PRISMA guidelines, many articles were excluded and a total of 20 were ultimately selected for the review. This may be insufficient to come to a meaningful conclusion. Therefore, further investigations of the clinical effectiveness of orthodontic mini-implants should be conducted.

Conclusions

The present review highlighted the clinical effectiveness of orthodontic mini-implants for anterior intrusion and retraction. The results of the review suggest that:

1. Orthodontic mini-implants are more effective

than other conventional methods of anchorage reinforcement for anterior tooth intrusion and retraction.

2. Simultaneous intrusion and retraction can be effectively obtained by using miniscrews placed between the premolars.

Conflict of interest

None

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