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Evaluation of Skeletal Class III Treatment with Mini-Screw - A Systematic Review

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Abstract

Research conducted to identify the etiologic features of Class III malocclusion showed that this type of deformity involves not only jaws, but the total cranio-facial complex, making it a difficult anomaly to understand. Majority of patients presenting with Class III malocclusions have a combined skeletal and dental discrepancy, making the factors contributing to this anomaly, complex. In skeletal Class III cases, it is challenging to obtain an esthetically and functionally sound occlusal outcome, only with orthodontic treatment. Furthermore, owing to its high rate of relapse it is difficult to maintain a constant post treatment occlusion. The clinical success of orthodontic mini-screws is dependent on many factors such its material characteristics, biomechanics, surgical technique, clinician's experience, bone depth and quality, primary stability of the mini-screw and oral hygiene of the patient. However, despite its large-scale application in routine orthodontics, its success rate can be further improved. The present article demonstrates the effect of mini-screws on skeletal class III treatment.

Keywords: Class III malocclusion, skeletal Class III, mini-screws, complications.

INTRODUCTION

Skeletal Class III malocclusion cases present with antero-posterior, vertical, and transverse disparities in conjunction with dental discrepancies, which projects both esthetically and functionally, in the form of an obvious anterior crossbite. This poses as a challenge to orthodontist owing to its high rate of relapse following the orthodontic treatment [1]. The treatment modalities to correct skeletal class III malocclusion depends upon age of the patient, the pattern of malocclusion, and its severity, according to which the treatment plan is designed; it may involve orthopaedic interventions, along with orthodontic corrections as well as camouflaging techniques, and sometimes may also require combined surgical treatment. The number of patients seeking treatment for class III malocclusion are increasing since they are socially motivated to do so, due to increased esthetic awareness [1].

Research conducted to identify the etiologic features of Class III malocclusion showed that this type of deformity involves not only jaws, but the total cranio-facial complex [2, 3]; making it a difficult anomaly to understand. Majority of patients presenting with Class III malocclusions have a combined skeletal and dental discrepancy, making the factors contributing to this anomaly, complex. In skeletal Class III cases, it is challenging to obtain an esthetically and functionally sound occlusal outcome, only with orthodontic treatment. Furthermore, owing to its high rate of relapse it is difficult to maintain a constant post treatment occlusion [4]. Three treatment modalities have been curated to manage skeletal Class III malocclusion, they are: 1. Growth modification, which should be initiated before the pubertal growth spurt; after which its efficacy decreases and clinicians are left with only two other possible treatments [5], that is 2. Dento-alveolar

compensation and 3. Orthognathic Surgery. The treatment modalities of skeletal Class III malocclusion in an adult, is therefore orthognathic surgery conjugated with fixed orthodontic treatment. Nonetheless all treatment modalities have a similar aim which is, improvement of facial esthetics, achieve normal occlusion and improve overall self-esteem in patients [6, 7].

For the stimulation of progressive maxillary growth, moderation of mandibular growth, and to cause posterior changes in the direction of mandibular growth and mandibular position, orthopaedic force is applied to the maxillary teeth, which in turn serves as an anchorage, through which the force is delivered to the maxillary complex. This step contributes to a major fraction of this treatment [8]; however, there are some negative features to this method as well, such as unintended proclination of maxillary incisors and mesial drift of maxillary molars. Mini-screws, on the other hand, have been used to improve various types of malocclusions that pose as a challenge to cure with conventional orthodontics, and have reported to provide adequate anchorage [9, 10]. An additional factor of why use of mini-screws is considered to be successful, is because of its relative stability in young jaw bone, where in the application of orthopaedic force is directly applied to mini-screws to achieve predictable outcomes.

To avoid the untoward dento-alveolar effects of the orthopaedic device, use of Titanium mini-plates has been advocated, mainly as a method for providing skeletal anchorage for various orthopaedic devices to apply their forces directly to the maxilla. However, its use warrants two surgical procedures, one for insertion and one for removal of the miniplates. The introduction of anchorage devices (TADs), on the other hand has made achieving stable anchorage control in orthodontics, plausible when used along with fixed functional appliances [12]; especially because they can be easily placed in a single appointment, without the need for any surgical intervention. In a study by Eissa *et al*., [13] it is noted that the use of mini-screw supported Forsus, has led to correction of a class II malocclusion, but there is no literary evidence that supports its use clinically, for the correction of class III malocclusion.

The clinical success of orthodontic mini-screws is dependent on many factors such its material characteristics, biomechanics, surgical technique, clinician's experience, bone depth and quality, primary stability of the mini-screw and oral hygiene of the patient [14]. However, despite its large-scale application in routine orthodontics, its success rate can be further improved. According to research, the use of sectional appliances together with TAD in managing complex cases of post extraction space closure has been noted [15]. There are two main methods, that have demonstrated connection of mini-screws to patients' dentition, one is Direct anchorage/Direct loading of the mini-screw, where an elastic module is connected from the min-screw to a tooth, or group of teeth, that are intended to be moved; and second one that involves indirect loading of the mini-screw to restrict tooth movement, in the "anchorage segment". It is to be noted that there is an advantage to the rigid indirect setup, when insertion site is chosen [16].

Placement of mini-screws in the mandibular premolar region [17] or the retromolar region [18] is plausible. While many orthodontists have reported that distalization of the mandibular arch with mini-screws to correct a skeletal Class III malocclusion, can be beneficial [19]. The placement of mini- screws on retromolar region has shown to facilitate long span distalization of mandibular arch. The distance between the roots, however, caps the tooth movement when mini-screws are placed inter-dentally [20]. The anatomy of the mandible in the incisor plays an important role in limiting the amount retraction, as there is a risk on bone dehiscence and loss of bone support, as over re-traction of mandibular incisors could lead to poor alveolar bone integrity and support. Thus, the aim of the systematic review is to determine the outcome of Skeletal Class III patients treated with Mini-screw.

AIM AND OBJECTIVES

The aim of the systematic review is:

- To determine the outcome of Skeletal Class III patients treated with Mini-screw
- To understand the complications and challenges of mini-screw

METHODS

The present review was prepared according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA Checklist 2020).

Literature search

A computerized literature search was performed in following database including: Pubmed, the Cochrane Library, Google Scholar and Scopus databases from 1st January 2000 till May 2022. The keywords used to determine the relevant articles included: Skeletal Class III, treatment, mini-screw, orthodontics and complications.

Eligibility Criteria

Inclusion and Exclusion Criteria

The full-text articles of the relevant studies were obtained and reviewed by the reviewer independently to ensure that the studies met the inclusion criteria. The inclusion criteria were as follows:

- Studies determining the outcome of Skeletal Class III Treatment

- Randomized controlled trials, prospective and retrospective studies, cross-sectional studies, case series and case reports.
- Full-text research studies investigating the use of mini-screws in skeletal Class III patients.
- Human studies
- Studies published in English language only.

The exclusion criteria were as follows:

- Review articles, commentaries, abstracts and summary
- Studies that did not include skeletal Class III patients.
- Studies with inadequate follow-up
- Studies published in languages other than English languages in order to prevent translator bias

Study selection

References for textbook and selected articles were screened to identify any relevant studies. The author was independently involved in the process of this study and extracted the necessary information. All available titles and abstracts were identified and scanned and their relevance to the study was determined. When information from the title and abstract was unclear in determining the paper's relevance, full-text articles were thoroughly investigated by the reviewer. Additionally, papers that had cited these articles were identified through Science Citation Index (http://www.isinet.com) to identify potentially relevant subsequent primary research.

Data extraction and Quality assessment

Studies that fulfilled the inclusion criteria were processed for data extraction. The main aim of the systematic review is to evaluate the complications and limitations of mini-screws in skeletal Class III patients. Therefore, the studies were investigated for data extraction.

RESULTS

Search strategy:

Figure 1 demonstrates the process of retrieving and screening the studies for inclusion in this systematic review and meta-analysis. The search strategy yielded a total of 665 articles. After excluding the duplicate records, title and abstract screening of 571 articles was conducted. 41 full-text articles were assessed for eligibility, and finally 7 studies met the inclusion criteria and were processed for qualitative analysis.

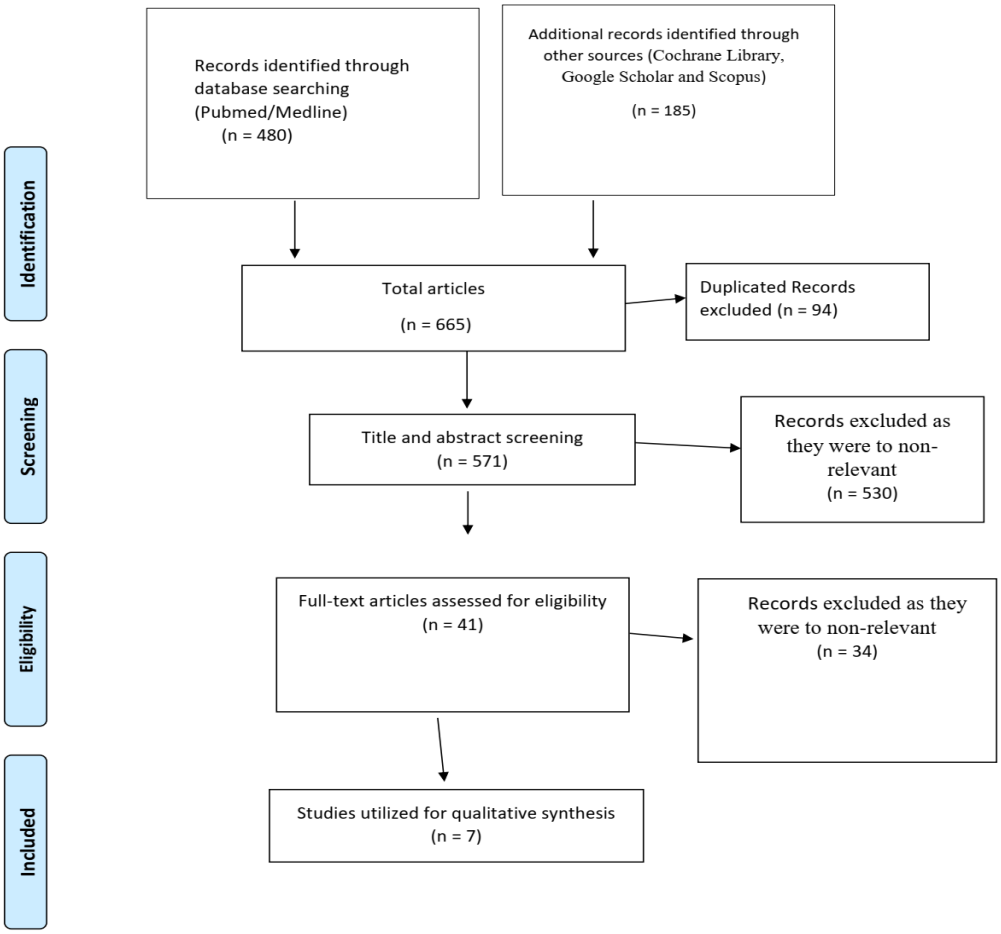

Figure 1: Flow diagram illustrating the literature search and selection criteria (according to PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analysis) (Moher *et al*., 2009)

Characteristics of Studies Included in the Review

The included studies were assessed on several factors as mentioned in Table 1. The following parameters were included: the author and year, objectives, methodology, treatment, limitation, and conclusion.

Table 1: Characteristics of Studies Included in the Review

Author, year	Aim	Methodology	Treatment	Limitation of Miniscrew
Jamilian, 2011 [21]	To evaluate and compare the effects of face mask, and mini-screw with Class III traction, on growing patients with Class III malocclusion having maxillary deficiency.	Patients were randomly grouped into two groups with 10 patients each were treated with facemask and with combination of mini-screw and Class III traction, respectively.	Both sample groups were successfully treated. Although incisor mandibular plane angle (IMPA) (the angle formed between the long axis of the lower central incisor and the plane of the mandibular arch) increased in the group with patients treated with mini-screw. While there was a decrease noted in the IMPA with the patients treated with facemask.	To combat the limitations of loosening of mini-screws, mini-screws with wider diameter and deeper insertion were used, in this study (19). However, maxillary mini-screws show decreased stability than mandibular, due to presence of less dense cortical plate, when compared to mandibular (2).
Seiryu *et al.*, 2020 [22]	To study the difference in treatment outcomes of mild skeletal Class III malocclusion when treated with facemask and facemask in combination with a mini-screw in growing patients.	24 male patients were randomly grouped into two groups, of 12 each. The first group consisted of 12 male patients that underwent treatment with facemask therapy; and was labelled as: FM group: 12 males. The second group also consisted of 12 male patients, but underwent treatment with both face mask and mini-screw. The mini screw was inserted into the palate and fixed to the lingual arch and the patients were instructed to use the facemask for 12 hours per day. It was labelled as FMþMS group: 12 male.	On Lateral cephalometric analysis it was revealed that SNA, SN-ANS, and ANB values for FMþMS group were significantly higher than those for the FM group (SNA, 1.18 SN-ANS, 1.38 ANB, 0.88). However, there was an increase noted in the proclination of maxillary incisors and its values were significantly greater in the FM group than in the FMþMS group (U1-SN, 5.08). The stability of mini-screw was noted to be of sound value, as there was no mobility and loosening of the mini-screw during treatment.	There were no negative effects to the patients during treatment. The mini-screws were stable with no mobility during treatment in the FM+MS group. It was noted that during treatment of milder skeletal Class III malocclusion, the treatment with facemask therapy along with a mini-screw exhibited fewer side effects. During the study, to avoid any harmful effects, the insertion direction for three screws in three patients was immediately changed upon CBCT examination which revealed close root proximity of the mini screw to that of the root.
Eissa *et al.*, 2018 [23]	To evaluate skeletal, dental, and soft tissue changes post the use of mini-screw anchored inverted Forsus fatigue-resistant device (FRD) in treatment of Class III malocclusion.	The controlled clinical trial, constituted of total of 16 patients (9 girls and 7 boys; age 12.45 6 0.87 years) in the test group, that were simultaneously treated with mini-screw-anchored inverted Forsus FRD where the mini-screws were inserted bilaterally between the maxillary canine and first premolar. The results were then compared with a matched control group of 16 untreated patients (8 girls and 8 boys; age 11.95 6 1.04 years).	The study revealed that the use of mini-screw-anchored inverted FRD could effectively increase progressive maxillary growth, however it did not prevent the mesial drift of the maxillary dentition. Significant lower incisor retroclination was also noted, but significant esthetic improvement of the facial profile was achieved, owing to lower lip retrusion and upper lip protrusion.	No side-effects were reported
Arveda, 2022 [24]	To describe an orthodontic treatment procedure on a young patient with a skeletal Class III malocclusion (Wits Appraisal −9	Both, Upper and lower arches were subjected to treatment using an archwire sequence of 0.16 CuNiTi, 19 × 25 CuNiTi, 19 × 25 SS over a span of 18 months.	Although the patient's skeletal class III remained, matching of maxillary and mandibular midline and crowding correction were carried out. A class I canine configuration was achieved and the overbite and overjet	The final intraoral records depicted that the patient did not present a perfect canine guide on either side. Furthermore, the final torque on the first upper premolars could have been improved.

Author, year	Aim	Methodology	Treatment	Limitation of Miniscrew
	mm), with extractions of the first lower premolars, in order to obtain a class III camouflage using direct temporary anchorage devices (TADs).		were corrected by retracting the mandibular anterior teeth, while carrying out the complete mesialization of the posterior sector into the extraction space.	
Yanagita, 2011 [25]	To observe skeletal Class III relationship (ANB angle, –3.6) with maxillary retrusion (SNA angle, 75.2).	The skeletal Class III jaw relationship improved along with reduction in Angle Class III malocclusion resulting in reduced overjet, but severe crowding with a 12-mm arch-length discrepancy of the mandible, was noted as well.	The use of mini-screws facilitated significant asymmetric tooth movement in the posterior and downward directions which in turn contributed to the camouflage of the skeletal mandibular protrusion along with total resolution of the severe crowding and lateral open bite.	Post treatment panoramic radiograph study revealed that, maxillary canines and the right molar region still showed root proximity. There was impaction of maxillary canines, as well as thinning of the supporting bone on the mesial side. It seemed likely that if the canines had been further straightened gingival recession would have occurred in these regions. In addition, root proximity was also seen on the right side of the premolar and molar region.
Jamilian, 2010 [26]	To evaluate the efficacy of extraoral appliances and identify the need of future surgical correction in patients with maxillary deficiency.	The study was conducted on patients with maxillary deficiency, and efficacy of mini-screw implants was evaluated.	Space between the permanent canines and first premolars was chosen for the insertion of mini-screw, the procedure was performed under local anaesthesia. This corrective treatment was rendered for 8 months after which, correction of malocclusion was evaluated. It was noted that there was an increase in the SNA and ANB angles by 3 degree, and an increase in the IMPA by 4 degree.	The study explored a novel treatment modality; it used mini-screw implants to treat a 12-year-old boy with a skeletal Class III malocclusion due to maxillary deficiency, and proved as an acceptable alternative to extra oral appliances such as facemasks.
Yasuda, 2014 [27]	To evaluate the efficacy of using a mini-screw implant in the treatment of a 22-year-old man presenting with a chief complaint of anterior crossbite, skeletal Class III malocclusion, along with a deviated midline.	The buccal region between the second premolar and first molar of the mandible was chosen for placement of two mini-screw implants measuring 7 mm in length, this was succeeded by a non-extraction treatment with a 0.022-in slot, preadjusted, edgewise appliance.	There was a resolution noted in the anterior crossbite, that was resolved by distal movement of the mandibular arch, but due to dento-alveolar compensation for skeletal discrepancy the maxillary incisors were proclined and the mandibular incisors were retro lined. However, an adequate molar relationship, an appropriate canine relationship, a match of dental midline, and improved facial profile were achieved.	The maxillary incisors were proclined and the mandibular incisors were retro lined.

Limiting Factors

Root Damage from Mini-screws

One of the limiting factors in the placement of mini screws is the root damage that occurs when mini screw is implanted, making choosing of the location for its implantation tricky [28]. Hence use of a surgical template is proposed by Suzuki and Suzuki [23], to prevent root damage during the placement of mini-

screw. Presently, CBCT can also be used to evaluate the root –to-root distance and thickness of the cortical plate, to ensure proper placement [29]. In our clinic, peri-apical radiographs are taken prior to, and post mini-screw placement, even though there is limited information about the direct contact between mini-screw and root, the radiographs provide useful information in suggesting whether removal and replacement of mini-screw is required or not. In case of injury to the root by the placement of mini-screw, an immediate removal of the mini-screw ensures limited injury and its confinement just to the dentin or cementum. However, if there is injury to the pulp, normal healing is compromised [30, 31]. Hence, extra-alveolar placement of mini screw is recommended, to prevent root damage and ensure a high success rate of treatment rendered [32, 33].

Fracture of the Mini-screw

When utilizing mini-screws, another problem to consider is implant fracture [34]. Mini-screw fracture was detected at insertion torque values of between 108.9 and 640.9 Nm, according to Buchter *et al*., [35]. Wilmes *et al*., [36] found that mini-screw fracture happened at insertion torque values of between 108.9 and 640.9 Nm. Low success rates have been linked to insertion torques of 100 Nm or greater [37]. Fracture prevention requires predrilling in individuals with dense bone and the use of mini-screws with a diameter of greater than 1.5 mm [38]. The use of a trephine bur to remove a fractured mini-screw removes a substantial quantity of surrounding bone, hence it is preferable to extract the surrounding bone with a carbide bur and then remove the damaged TAD with a Howe plier [39].

Ingestion of a Miniscrew

A patient may swallow a mini-screw that loosens while he or she is eating or sleeping. The mini-screw's sharp point may become caught in their stomach, although it is usually expelled spontaneously [40].

DISCUSSION

The present study shows the clinical significance of mini-screws in skeletal Class III patients. Certain complications such as root damage, fracture of the screw, and ingestion of screws are limitations that restrict its use were observed in several studies included in the present review paper [23, 28-32, 40]. The main downside of mini-screws is that they are frequently placed interradicularly, which might increase the risk of root injury and, more critically, can make arch movement difficult since root interference and failure will eventually occur [39]. Similar findings were seen in another study [41]. Also, when employed with intermittent inter-arch elastic traction, a single mini-screw is more prone to failure [34, 35]. The stress distribution on each individual screw is substantially less when two or more mini-screws are consolidated with stainless steel wires or plates, enhancing their success rate. However, screws used in tandem in the alveolus are uncommon because finding enough interradicular space in two neighbouring interdental sites might be challenging. Because of transverse maxillary deficit, maxillary expansion is often included in Class III treatment, but in most cases, expansion is assumed to activate the circum-maxillary sutures, making them more receptive to maxillary protraction pressures. In order to remove a fractured mini-screw a study recommended to extract the surrounding bone with a carbide bur and then remove the damaged TAD with a Howe plier [39]. Similarly, to improve the maxillary sutural response, some authors have gone so far as to alternate the use of maxillary expansion and contraction (Alt RAMEC) [42].

One of the studies mentioned that mini-screws with a diameter of greater than 1.5 mm can prevent fracture [38]. Recent studies have mentioned the use of palatal mini-screws to support repetitive expansion and contraction should lessen the danger of cyclic loading causing root damage to the dentition [43]. When the mini-screw-supported maxillary expansion is paired with miniplates in the anterior jaw, recent studies have indicated significant success [44, 45]. The findings were comparable to those obtained using a bone-borne protraction facemask [46]. Since mini-screws were initially intended to endure regular orthodontic stresses, the indirect anchorage was used in this investigation to prevent subjecting the mini-screws to a direct orthopaedic load, which would raise the chance of failure [12]. Similarly, a study explored a novel treatment modality; it used mini-screw implants to treat a 12-year-old boy with a skeletal Class III malocclusion due to maxillary deficiency, and proved as an acceptable alternative to extra oral appliances such as facemasks [26]. Another study mentioned the use of mini-screws facilitated significant asymmetric tooth movement in the posterior and downward directions which in turn contributed to the camouflage of the skeletal mandibular protrusion along with total resolution of the severe crowding and lateral open bite [25].

Skeletal anchoring has revolutionized the orthopaedic treatment of Class III malocclusion in growing children in recent years. Without the dental side effects of conventional tooth-borne facemask therapy, such as mesial migration of the maxillary posterior teeth and flare of the maxillary incisors, it enables real orthopaedic repair of the maxillary deficit. Some authors have placed protraction facemasks right on top of front maxillary miniplates. In contrast to the dental side effects associated with traditional facemask therapy, their findings indicated considerable skeletal adjustments [31].

In the mixed dentition, growth modification is frequently carried out. In this age group, interradicular mini-screw placement is unexpected. First, it is known

that children's alveolar processes fail at higher rates than those of adults. Due to the existence of growing teeth, there are few locations where mini-screws can be safely inserted. The application of mini-screws is suitable in an adult Class III patient who refused to have an orthognathic surgical surgery and had a lateral open bite, considerable crowding, and midline deviation. Even under ideal conditions, it is challenging to resolve such a complex issue with traditional Class III treatment. For aesthetic reasons, in a study the patient preferred lingual bracket therapy [17]. The skeletal mandibular protrusion was hidden by the mini-screw treatment, which also completely eliminated the acute crowding and the lateral open bite. Mini-screw treatment allowed for significant asymmetric tooth movement in the posterior and downward directions [17].

There are two parts to the forces produced by elastics. One force component moves the maxilla forward in a horizontal direction, which is advantageous in cases of maxillary insufficiency. The second element shifts the posterior maxillary teeth downward in a vertical direction. When the vertical face height is increased, this could result in adverse tooth movements, but it is not a concern in individuals with low or medium face heights. In high-angle situations, several design modifications to the device, like the insertion of a posterior bite-plane, may be taken into consideration. Otherwise, as the force has a substantially vertical component, these mechanics should be avoided in high-angle scenarios. The mini-screws could also loosen after insertion, so it is important to strengthen stability by reducing vibration and deepening the insertion. Since the cortical plate in the maxilla is narrower and less dense than that in the mandible, maxillary mini-screws should be placed carefully [47, 48]. The idea of anchorage as it relates to conventional tooth movement and orthodontic treatment planning has undergone major alterations as a result of the development and use of mini-screws in orthodontics [49]. They did away with the requirement for extraoral orthodontic devices like J-hook headgear, ensuring that treatment outcomes would be independent of patient participation and so increasing the possibility of achieving consistent and good outcomes.

The present study demonstrates that placement of mini screws causes the root damage that occurs when mini screw is implanted, making choosing of the location for its implantation tricky. Common complications that restrict the use of miniscrews include root damage, fracture of the screw, and ingestion of screws. Further large-scale studies should be conducted to determine the importance of mini-screws in management of Skeletal Class III patients.

CONCLUSION

Given the significance of mini-screws, the location of the mini-screws impacts the outcome of the surgical intervention. Certain complications such as root damage, fracture of the screw, and ingestion of screws are limitations that restrict its use were observed in several studies included in the present review paper. Future studies should implement large-sample size for using mini-screws in skeletal Class III patients to understand its challenges for dentists and patients in a better manner

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