Stainless steel vs. titanium miniscrew implants: Evaluation of stability during retraction of maxillary and mandibular anterior teeth

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Abstract:

OBJECTIVES: This study was aimed to compare the stability of stainless steel and titanium miniscrew implants of the same diameter and length during en masse retraction of maxillary and mandibular anterior teeth.

MATERIALS AND METHODS: Forty miniscrew implants (1.3 mm diameter and 8 mm length) were placed in 10 patients (20 titanium and 20 stainless steel). Stability was checked at insertion (T0), at one month (T1), and at sixth months (T2) and the amount of retraction was recorded in millimeters.

RESULTS: Titanium and stainless steel implants were equally stable at the time of insertion. At T1, three titanium miniscrew implants showed grade 2 mobility, whereas seven stainless steel miniscrew implants showed grade 2 mobility. For T2, none of the titanium miniscrew implants had grade 2 mobility while four stainless steel miniscrew implants resulted in grade 2 mobility. Both had an equal frequency of grade 3 and grade 4 mobility. However, the difference in the stability was not statistically significant. No statistical significance was found when the amount of retraction achieved by titanium and stainless steel miniscrew implants was compared between the maxillary and mandibular arches.

CONCLUSION: Both titanium and stainless steel miniscrew implants provide good anchorage and remain stable during en masse retraction of maxillary and mandibular anterior teeth. Thus, both miniscrews are clinically effective.

Keywords: Miniscrew implant, retraction, stability, stainless steel, titanium

Introduction

Anchorage control is fundamental to orthodontic therapy and directly affects the treatment results. The term orthodontic anchorage describes the nature and degree of resistance to displacement provided by an anatomic unit and is essential for the maximization of tooth movement and minimization of undesired effects.[1] Conventionally, extra-oral and intra-oral auxiliaries such as the Nance holding arch, head gears, and transpalatal arch are used to reinforce the anchorage provided by the anchor tooth or anchorage unit.[2] However, all of these methods have disadvantages such as complicated designs, the need for exceptional patient cooperation, and elaborate wire bending.[3] Thus, some anchorage loss or mesial movement of maxillary molars is usually observed with conventional orthodontic anchorage, which is considered a significant potential side effect of orthodontic mechanotherapy.[3] Temporary anchorage devices have opened a new horizon in orthodontics. The primary
advantages of miniscrew implants are their ability to be relatively stationary in the bone, their ability to increase anchorage capacity, and the absence of adverse effects or complications that could affect the health or change the treatment outcome. Furthermore, orthodontic miniscrews have advantages such as simple insertion and removal, increased patient comfort, and a favorable cost-benefit ratio.

Miniscrew implants provide absolute anchorage for bodily movements of the anterior teeth during en masse retraction in the management of protrusion. Miniscrews are made of biocompatible elements such as titanium alloys and surgical stainless steel. Titanium shows properties of corrosion resistance. However, compared to stainless steel, titanium is costlier, and thus, in developing countries, the use of titanium miniscrews is relatively less, which in turn can impact the treatment quality. Moreover, despite its low cost, stainless steel possesses good mechanical properties like stiffness, ductility, and elasticity, and thus meets the minimum criteria to be used as a mini-implant. One of the most important factors for the success of an orthodontic miniscrew is its stability until the desired movement is achieved. This study aimed to compare the stability of stainless steel and titanium miniscrew implants of the same diameter and length during en masse retraction of maxillary and mandibular anterior teeth.

**Material and Methods**

The present study was approved by the institutional ethics committee and review board letter no. SU/2017/1226(36) dated 18/12/2017. The study was conducted in the Department of Orthodontics and Dentofacial orthopedics, Santosh Dental College and Hospital, Ghaziabad, Uttar Pradesh, India.

Forty miniscrew implants (1.3 mm diameter and 8 mm length) were placed in ten patients. In each patient, stainless steel miniscrew implants were placed in maxillary and mandibular arches; moreover, in the same patient, titanium miniscrew implants were also placed in different quadrants of the maxillary and mandibular arches. To prevent selection bias, implants were allocated using a computer-generated randomized block number table.

**Inclusion criteria**

Inclusion criteria included Angle’s Class I bimaxillary protrusion cases and Angle’s Class II malocclusion where maximum anchorage was required as per the treatment plan and first premolar extraction was mandatory for resolving proclination; patients aged between 13 and 35 years; patients with permanent dentition and normal to good oral hygiene.

**Exclusion criteria**

1. Patients with deciduous or mixed dentition
2. Minimum and moderate anchorage cases
3. Non-extraction cases

All patients were pre-examined using a standard protocol that included facial and intraoral photographs, dental modal analysis, panoramic radiographs, and cephalometric analysis. Patients were enrolled according to the inclusion criteria after obtaining informed consent. All the patients were treated with a 0.022 inch slot MBT (McLaughlin, Bennett and Trevisi) prescription pre-adjusted edgewise appliance system. The treatment plan included retraction of the maxillary and mandibular anterior teeth using miniscrews (diameter 1.3 mm and 8 mm in length) placed in the alveolar bone between the second premolar and first molar for orthodontic anchorage.

The initial leveling and aligning of the upper and lower arches were performed using sequential nickel-titanium (NiTi) wires and the diameters of the wires were progressively increased from 0.016 NiTi to 0.019 × 0.025 NiTi. After leveling and aligning in the maxillary and mandibular arch, miniscrews were placed in the alveolar bone between the second premolar and first molar.

The screws were loaded one week after insertion and retraction was carried out on a rectangular 0.019 × 0.025 stainless steel wires with the help of a NiTi closed coil spring. The NiTi closed coil spring was attached to the miniscrew with the help of a ligature wire, which was tied to a hole present in the miniscrew head portion, and the other side was attached to the crimpable hook present on the archwire. A force of 250 gm was measured using a dontrix gauge and applied on each side. The patients were followed-up to evaluate the stability at different intervals, on insertion (T0), at one month (T1), and at sixth months (T2) [Figure 1], and retraction in mm was recorded every month for six months.

**Figure 1:** Loading of the Miniscrew Implant with the help of Crimpable Hooks and Closed Coil Spring
**Grading system for miniscrew stability**  
Grading was performed with the help of an explorer, tweezer, and periodontal probe.  
Grade 1: 0 mm mobility  
Grade 2: 0–1 mm mobility  
Grade 3: 1–2 mm mobility  
Grade 4: >2 mm mobility/in case the screw comes out.

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS) version 24 (IBM Corp., Armonk, NY, USA). Continuous data were compared between the two groups using paired t-test, and categorical variables were compared using the Chi-square or Fisher’s exact tests.

**Results**

The titanium and stainless steel miniscrew implants were equally stable at the time of insertion, as shown in Table 1. Table 2 shows the stability of the miniscrew implants one month after insertion, in which titanium miniscrew implants were more stable than stainless steel miniscrew implants. Of the 20 titanium miniscrew implants, only three showed grade 2 mobility, while seven out of 20 stainless steel miniscrew implants resulted in grade 2 mobility. Table 3 shows the stability of the miniscrew implants six months after insertion, in which titanium miniscrew implants were more stable than stainless steel miniscrew implants. Of the 20 titanium miniscrew implants, none exhibited grade 2 mobility, whereas four out of 20 stainless steel miniscrew implants resulted in grade 2 mobility. Both had an equal frequency of grade 3 and grade 4 mobility.

No statistical significance was found when the amount of retraction achieved by titanium and stainless steel miniscrew implants was compared between the maxillary and mandibular arches [Graphs 1 and 2].

**Discussion**

Achieving absolute anchorage has been a very important topic of interest in orthodontics. When orthodontic forces are applied, all teeth are subjected to Newton’s third law of action and reaction. During orthodontic treatment, the desired movement of the teeth causes undesirable displacement of the anchor teeth, ultimately hindering the required tooth movement. Therefore, the orthodontist must always aim to prevent such effects.

The success of orthodontic treatment can be hindered due to anchor loss, which can affect the anteroposterior correction of the malocclusion, thus, compromising the treatment goal of achieving proper facial esthetics. Control of anchor loss is mandatory when correction of

| Table 1: Stability of Titanium and Stainless Steel Miniscrew Implant at the Time of Insertion (T0) |
| --- |
| Mobility | Titanium Miniscrew Implant | Stainless Steel Miniscrew Implant | Total Miniscrew Implants |
| Grade 1 | 20 (50%) | 20 (50%) | 40 (100%) |
| Grade 2 | 0 (0%) | 0 (0%) | 0 (0%) |
| Grade 3 | 0 (0%) | 0 (0%) | 0 (0%) |
| Grade 4 | 0 (0%) | 0 (0%) | 0 (0%) |
| Total | 20 | 20 | 40 |

Chi-square=4.615, P=0.273

| Table 2: Stability of Titanium and Stainless Steel Miniscrew Implant after One Month of Insertion (T1) |
| --- |
| Mobility At One Month (T1) | Titanium Miniscrew Implant | Stainless Steel Miniscrew Implant | Total Miniscrew Implants |
| Grade 1 | 17 (56.67%) | 13 (43.33%) | 30 (100%) |
| Grade 2 | 3 (30%) | 7 (70%) | 10 (100%) |
| Total | 20 | 20 | 40 |

Chi-square=2.133, P=0.33

| Table 3: Stability of Titanium and Stainless Steel Miniscrew Implant after Six Months of Insertion (T2) |
| --- |
| Mobility At Six Months (T2) | Titanium Miniscrew Implant | Stainless Steel Miniscrew Implant | Total Miniscrew Implants |
| Grade 1 | 15 (57.69%) | 11 (42.31%) | 26 (100%) |
| Grade 2 | 0 (0%) | 4 (100%) | 4 (100%) |
| Grade 3 | 4 (50%) | 4 (50%) | 8 (100%) |
| Grade 4 | 1 (50%) | 1 (50%) | 2 (100%) |
| Total | 20 | 20 | 40 |

Chi-square=4.615, P=0.187
severe crowding, excessive overjet, gap, and bimaxillary protrusion is required. Thus appliances, such as the transpalatal bar, the Nance holding arch, and extraoral traction devices are usually used to reinforce molar anchorage. Other methods to stabilize the molar position include multiple anchorage segments to form a large unit to counterbalance the force and application of differential movement.

Owing to the limitations of conventional intraoral or extraoral anchorage aids, miniscrews have become widely popular in recent years for reinforcing anchorage in orthodontic treatment. Dental implants placed in the alveolar bone are resistant to orthodontic forces. Initially, only osseointegrated implants were introduced to provide a stable anchorage. Osseointegrated implants have shortcomings in terms of cost-effectiveness and delayed loading.

Surgical miniscrews were introduced to overcome the disadvantages of conventional dental implants. In 1993, Creekmore and Eklund used a surgical miniscrew below the nasal cavity. In 1997, Kanomi specifically designed a miniscrew for orthodontic use. Costa et al. described a screw with a special bracket-like head that could be used for both direct and indirect anchorage. These screws had a smaller diameter than the osseointegrated implants. The special advantages of orthodontic miniscrews include easy placement and retrieval, immediate loading, and cost-effectiveness. Owing to these advantages, miniscrews have gained considerable popularity.

Miniscrews are made of biocompatible elements such as titanium alloys and surgical stainless steel. Apart from biocompatibility, corrosion resistance is another advantage of titanium. However, compared to stainless steel, titanium is more costly and relatively less affordable and this is the reason, why in developing countries, the use of the titanium miniscrews is relatively less, which in turn impacts the treatment quality. Stainless steel on the other hand, in spite of its low cost, possesses good mechanical properties like stiffness, ductility, and elasticity, and thus meets the minimum criteria to be used as a mini-implant.

Miniscrews are very useful for high anchorage cases, which usually require complex orthodontic tooth movements and where the chances of anchor loss are greater. Miniscrew implants have multiple uses in orthodontics, such as the retraction of anterior teeth, correction of open bites, distalization and intrusion of teeth, the eruption of impacted teeth, space closure, total arch distalization, deep bite correction, and uprighting of posteriors.

Primary stability or initial stability, evaluated at T0, is a term used to describe the mechanical stability of the miniscrew implant in the bone immediately after placement. It is considered a prerequisite for successful implantation. It was assessed by applying a force and a couple at the bracket level, or by applying the force at the level of the center of resistance of the anterior segment.

The screws were placed in the alveolar bone between the second premolar and first molar in both the maxillary and mandibular arches at an ideal angulation of the miniscrew implant placement, that is, 30–40° in the maxilla and 10° to 20° in the mandible. Insertion of the miniscrew perpendicular to the dental axis can cause damage to adjacent dental roots due to the increased probability of the miniscrew being placed at the narrowest inter radicular space. However, inserting a screw at an angle leads to greater surface contact between the bone and miniscrew implants.

The most important criterion for the success of an orthodontic miniscrew is its stability until the desired movement is achieved. Therefore, in the present study, we compared the stability of stainless steel and titanium miniscrews of the same length and diameter used as anchorage for en masse retraction of maxillary and mandibular anterior teeth.

After miniscrew (1.3 mm diameter and 8 mm length) placement, the initial stability of the miniscrew was evaluated. Patients were prescribed antibiotics and analgesics for three days and 2% chlorhexidine mouthwash for two weeks to maintain good oral hygiene.

Anchorage loss can frequently occur in patients requiring simultaneous retraction of the six anterior teeth. However, with the help of a miniscrew implant, simultaneous retraction of six anterior teeth with no anchorage loss can be achieved in a single step, with the use of a pre-adjusted appliance.

In the case of anterior teeth protrusion, en masse retraction of the six anterior teeth can reduce the treatment duration and allow for an early change of the facial profile, which in turn, enhances patient cooperation. In contrast to tipping and uprighting techniques, bodily movement during retraction provides a more favorable tissue response and allows the extraction space to be closed in a single step. However, compared with tipping, the anchorage requirement for bodily retraction is much higher. During retraction, bodily movement can be achieved by applying a force and a couple at the bracket level, or by applying the force at the level of the center of resistance of the anterior segment.
implants. A stability check of titanium and stainless steel miniscrew implants one month after insertion showed that titanium miniscrew implants were more stable than stainless steel miniscrew implants. Further, titanium miniscrew implants were more stable than stainless steel miniscrew implants even six months after insertion. However, the difference in stability was not statistically significant, and both stainless steel and titanium miniscrew implants proved to be equally stable if used as anchorage for retraction of maxillary and mandibular anterior teeth. These findings contrast with those reported by Ashith et al., who reported significantly higher success rates for titanium implants than that for stainless steel implants.

In this study, retraction in millimeters was recorded every month for six months. There was no significant association between retraction achieved by titanium and stainless steel miniscrew implants.

Therefore, both stainless steel and titanium miniscrew implants proved to be equally stable if used as anchorage for retraction of the maxillary and mandibular anterior teeth, and the difference in parameters such as retraction was statistically non-significant.

**Conclusion**

Both titanium and stainless steel miniscrew implants provide good anchorage and remain stable during the retraction of the maxillary and mandibular anterior teeth. Thus, both miniscrews are clinically effective.

**Declaration of patient consent**

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published, and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Schatzle M, Männchen R, Zwahlen M, Lang NP. Survival and failure rates of orthodontic temporary anchorage devices: A systematic review. Clin Oral Implants Res 2009;20:1351-9.
2. Proffit WR. The second stage of comprehensive treatment: Correction of molar relationship and space closure. In: Proffit WR, Fields HW Jr, editors. Contemporary Orthodontics. 3rd ed. St. Louis: Mosby-Yearbook; 1997. p. 573-7.
3. Upadhyay M, Yadav S, Nagaraj K, Patil S. Treatment effects of mini-implants for en-masse retraction of anterior teeth in bimaxillary dental protrusion patients: A randomized controlled trial. Am J Orthod Dentofacial Orthop 2008;134:18-29.
4. Liu EJ, Pai BC, Lin JC. Do miniscrews remain stationary under orthodontic forces? Am J Orthod Dentofacial Orthop 2004;125:42-7.
5. Papageorgiou SN, Zogakis IP, Papadopoulos MA. Failure rates and associated risk factors of orthodontic miniscrew implants: A meta-analysis. Am J Orthod Dentofacial Orthop 2012;142:577-95.
6. Fritz U, Ehmer A, Diedrich P. Clinical suitability of titanium microscrews for orthodontic anchorage-preliminary experiences. J Orofac Orthop 2004;65:410-8.
7. Kim TW, Baek SH, Kim JW, Chang YI. Effects of microgrooves on the success rate and soft tissue adaptation of orthodontic miniscrews. Angle Orthod 2008;78:1057-64.
8. Cornelis MA, Scheffler NR, De Clerck HJ, Tulloch JB, Behets CN. Systematic review of the experimental use of temporary skeletal anchorage devices in orthodontics. Am J Orthod Dentofacial Orthop 2007;131 (4 Suppl):552-8.
9. Melsen B, Bosch C. Different approaches to anchorage: A survey and an evaluation. Angle Orthod 1997;67:23-30.
10. Vanden Bulcke MM, Burstone CJ, Sachdeva RC, Dermaut LR. Location of the centers of resistance for anterior teeth during retraction using the laser reflection technique. Am J Orthod Dentofacial Orthop 1987;91:375-84.
11. Branemark PI, Adell R, Breine U, Hansson BO, Lindström J, Ohlsson A. Intra-osseous anchorage of dental prostheses. I. Experimental studies. Scand J Plast Reconstr Surg 1969;3:81-100.
12. Creekmore TD, Eklund MK. The possibility of skeletal anchorage. J Clin Orthod 1983;17:266-9.
13. Kanomi R. Mini-implant for orthodontic anchorage. J Clin Orthod 1997;31:763-7.
14. Costa A, Raffaini M, Melsen B. Miniscrews as orthodontic anchorage: A preliminary report. Int J Adult Orthod Orthognath Surg 1998;13:201-9.
15. Buchté A, Wiechmann D, Koerdt S, Wiesmann HP, Piko J, Meyer U. Load-related implant reaction of mini-implants used for orthodontic anchorage. Clin Oral Implants Res 2005;16:473-9.
16. Gottman I. Characteristics of metals used in implants. J Endod 1997;11:383-9.
17. Roberts WE, Marshall KJ, Mozary PG. Rigid endosseous implant utilized as anchorage to protract molars and close an atrophic extraction site. Angle Orthod 1990;60:135-52.
18. Papadopoulos MA, Tarawneh F. The use of mini-screw implants for temporary skeletal anchorage in orthodontics: A comprehensive review. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;103:e6-15.
19. Park YC, Lee SY, Kim DH, Jee SH. Intrusion of posterior teeth using mini-screw implants. Am J Orthod Dentofacial Orthop 2003;123:690-4.
20. Huang LH, Shotwell JL, Wang HL. Dental implants for orthodontic anchorage. Am J Orthod Dentofacial Orthop 2005;127:713-22.
21. Jing Y, Han X, Guo Y, Li J, Bai D. Nonsurgical correction of a Class III malocclusion in an adult by miniscrew-assisted mandibular dentition distalization. Am J Orthod Dentofacial Orthop 2013;143:877-87.
22. Kuroda S, Katayama A, Takano-Yamamoto T. Severe anterior open-bite case treated using titanium screw anchorage. Angle Orthod 2004;74:558-67.
23. Aljhani A, Zawawi KH. The use of mini-implants in en masse retraction for the treatment of bimaxillary dentoalveolar protrusion. Saudi Dent J 2010;22:35-9.
24. Arora A, Gupta SD, Prakash A, Kumar P. Success rate of different micro implant system. Int J Med Dent 2014;4:39-42.
25. Nosouhian S, Rismanchian M, Sabzian R, Shadmehr E, Badrian H, Davoudi A. A mini-review on the effect of mini-implants on contemporary orthodontic science. J Int Oral Health 2015;7(Suppl 1):83-7.

26. Leo M, Cerroni L, Pasquantonio G, Condò SG, Condò R. Temporary anchorage devices (TADs) in orthodontics: Review of the factors that influence the clinical success rate of the mini-implants. Clin Ter 2016;167:e70-7.

27. Kyung HM, Park HS, Bae SM, Sung JH, Kim IB. Development of orthodontic micro-implants for intraoral anchorage. J Clin Orthod 2003;37:321-8.

28. Elias CN, de Oliveira Ruellas AC, Fernandes DJ. Orthodontic implants: Concepts for the orthodontic practitioner. Int J Dent 2012;2012:1-7.

29. Poggio PM, Incorvati C, Velo S, Carano A. “Safe zones”: A guide for miniscrew positioning in the maxillary and mandibular arch. Angle Orthod 2006;76:191-7.

30. Ashith MV, Shetty BK, Shekatkar Y, Mangal U, Mithun K. Assessment of immediate loading with mini-implant anchorage in critical anchorage cases between stainless steel versus titanium miniscrew implants: A controlled clinical trial. Biomed Pharmacol J 2018;11:971-6.