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Risk factors and success rates associated with orthodontic mini-implants: a literature review

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Abstract

Success rates and failure risk factors are among the most common concerns a dental professional has regarding mini-implants. This paper reports the results of a literature review whose objective was to examine average success rate as well as failure risk factors concerning patient, clinicians and mini-implants. The variables associated with risk factors that significantly influence mini-implants success rates are jaw insertion, insertion site, insertion torque, keratinized tissue band (which is associated with hygiene), proximity of the tooth root, cortical bone thickness, and the patient's age. It has been shown that orthodontic mini-implants have a modest failure rate of 13.5%, and an average success rate of 86.22%, demonstrating its clinical utility.

Key words: Orthodontics; Risk factors; Dental implants

Fatores de risco e taxas de sucesso associadas aos mini-implantes ortodônticos: revisão de literatura

Resumo

As preocupações mais frequentes, para o profissional, acerca dos mini-implantes são as taxas de sucesso e os fatores de risco para falhas. O objetivo deste trabalho é realizar uma revisão de literatura abordando a taxa média de sucesso, bem como os fatores de risco para falhas divididos em três categorias: em relação ao paciente, em relação ao profissional e em relação ao dispositivo. As variáveis associadas aos fatores de risco, que influenciam significativamente as taxas de sucesso destes dispositivos foram: maxilar de inserção, idade, sítio de inserção, faixa de tecido ceratinizado (que está associado à higiene), proximidade com a raiz dentária, espessura do osso cortical e torque de inserção. Foi demonstrado que os mini-implantes ortodônticos têm uma modesta taxa de falha de 13,5%, assim como taxa média de sucesso de 86,22%, indicando sua utilidade clínica.

Palavras-chave: Ortodontia; Fatores de risco; Implantes dentários

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Introduction

Anchorage is defined as resistance to unwanted tooth movement [1]. In orthodontics, it is defined as resistance to any tooth movement inside the bone tissue that has not been programmed by biomechanics. Skeletal anchorage is the absolute absence of movement in the anchor unit as a result of the reaction forces applied to the tooth movement [1]. This kind of anchorage can only be achieved by devices attached to the bone. Such devices include orthodontic mini-implants [2].

Mini-implants have become popular not only because they can be easily placed and removed, but also because of their low cost and minimal need for patient compliance [3]. Mini-implants clinical effectiveness is based on their ability to maintain close contact with the bone (Kim et al. 2008 *apud* Papadopoulos et al. 2011). Thus, they remain stable during the orthodontic treatment while resisting to the reaction forces [3], minimizing anchorage loss.

Despite the excellent clinical results obtained from the use of mini-implants for orthodontic anchorage, several complications occurring during the treatment with those devices have been reported [3,4]. Mini-implants failure results in their inability to act as absolute anchorage that defeats the forces of reaction requiring their removal or replacement [5].

This article points out failure risk factors and divides them into three categories: in relation to the patient, in relation to the clinician, and in relation to the device (mini-implant) itself.

According to most studies evaluated, mini-implants failure risk factors related to the patient include jaw location (mandible or maxilla), cortical bone thickness, the insertion side (right or left), gender and age. In relation to the dental professional, this literature review has revealed that some factors are associated with the operator's clinical experience, insertion torque and failure at the time of insertion as to the proximity of the tooth root [6]. As to risk factors in relation to mini-implants, this review has pointed factors associated with length and diameter of the threads and factors associated with the type of mini-implant used, either self-drilling or self-tapping (also called pre-drilled) mini-implants [6].

Therefore, the purpose of this article is to review the literature regarding mini-implants average success rates, and failure risk factors cited in the studies reviewed.

Literature Review

One of the most important prerequisites for the success of an orthodontic treatment is a suitable anchorage unit [7]. Since the number of adult patients in need for orthodontic treatments has increased in recent decades [8], the challenges a clinician must face to obtain optimal dental anchorage have increased because anchorage quality is often weakened due to periodontal disease and tooth loss [7]. The use of permanent dentition for orthodontic anchorage, therefore, is usually limited in those cases, and extra-oral appliances are rejected for aesthetic reasons [8]. That is why mini-implants have been used as an alternative solution to orthodontic anchorage reinforcement [9] since their use reduces the need for patients' compliance [5,7].

The failure criteria in the reviewed studies were defined as (1) serious clinical mobility [10], which requires replacement of the mini-implant (2), spontaneous loss of the device or (3) its loss at the time of examination to assess mobility. Failure was defined as the loss of the mini-implant within a period of less than eight months after insertion and before completion of the orthodontic treatment. If a mini-implant is lost, there are two options: reinstalling a new one in the same area after 4-6 weeks or immediately placing another one in the adjacent region [10,11].

The absence of attached gingiva at the site of mini-implants insertion is considered one of the main risk factors associated with failure of this anchorage resource [4,9,10, 12-16]. The type of peri-implant soft tissue, as well as its health and thickness, can also affect anchorage [4]. Mini-implants inserted in non-keratinized alveolar mucosa have higher failure rates than those inserted in attached mucosa [12]. Miyawaki et al. [15] analyzed data from 51 patients with 134 mini-implants of three different types and 17 miniplates and concluded that the mini-implant diameter of 1 mm or less, inflammation in the peri-implantar tissue and mandibular plane are associated with high failure rates when the mini-implants are inserted in the buccal posterior mandibular bone.

A critical success (or failure) factor is a meticulous oral hygiene. A careful oral hygiene in the mini-implants sites should be emphasized for long-term success [17]. It is widely recognized that mouthwash with chlorhexidine 0.2 can be used for prevention and control of both inflammation and infection [3]. Proper home care by the patient is as important as proper placement by the orthodontist [4].

It has been reported that the success rate of mini-implants in the mandible are significantly lower when compared to the maxilla in studies in humans and animals [10,13,18], although the opposite has been observed for conventional implants (prosthetic) [13]. Another study [14] also found that mini-implants placed in the maxilla have shown success rates of 10% higher than those inserted in the mandible. This is in line with the meta-analysis results [5] that have shown the largest failure rates in the mandibular bone (19.3%) compared with the maxillary bone (12%). These data indicate that mini-implants failure in the mandible were 1.5 (one and half times) larger than in the maxilla.

Cheng et al. [13] suggested that mini-implants placed in the alveolar mucosa significantly increase the risk of infection and failure, which is in agreement with another author [14] who states that the mandibular bone may be more susceptible to infection due to its narrow strip of inserted gingiva, and mini-implants are inserted in the area of non-keratinized mucosa. According to the same author [14], higher success rates for the mandibular region, such as the ones found in a few other studies (Hedayati et al. 2007 and Upadhyay et al. 2008 *apud* Papadopoulos et al. 2011) were expected due to the fact that the lower jaw has a thicker and denser cortical bone. The highest failure rate in this bone can be attributed to its increased bone density, which requires higher values of placement torque [5]. In addition to the low availability of attached mucosa, the mandibular bone is denser. So overheating [5,8,13] is more likely to occur during mini-implant insertion particularly with self-drilling mini-implants [13].

Moreover, mini-implants anchorage has shown to be more effective in adults [19], which is consistent with other studies that have found higher failure rates in younger patients [14,18,20,21]. Failure in growing patients may be related to immaturity of the bone [22]. However, other studies attribute this to the fact that adults have a significantly thicker cortical bone at specific sites of the maxilla and mandible compared to the bone of younger patients (Fayed et al. 2010 *apud* Papadopoulos et al. 2011). Once the mini-implant stability is provided by mechanical retention, bone density and cortical bone thickness appear to play a major role [18]. This fact may be related to bone metabolism in growing patients and low bone maturation [21].

A classic study [21] aimed to determine mini-implants success rates in adolescents in order to verify the need for a latency period prior to the application of orthodontic load, and to determine the optimal insertion torque to improve success rates in adolescents. The study group comprised 57 patients, aged 11.7 to 36.1 years, in whom 169 mini-implants were inserted. When the mini-implant remained under force for 6 months or more it was considered successful. Success rates were: (1) 63.8% in the early loading group, that is, less than 1-month latency period (prior to load application) in adolescents; (2) 97.2% in the delayed loading group over a three-month latency period in adolescents; (3) 91.9% in the adult group. The success rate in the early loading group of adolescents was significantly lower than in the other groups. Although the insertion torque has not been set, a latency period of 3 months before load application is recommended in order to increase the success rate of mini-implants inserted in the alveolar bone of adolescent patients, since a three-month latency prior to application of significant load improved the mini-implants success rate in adolescents from 63% to 97%.

Different success rates have been shown in different studies as to the ideal mini-implant insertion site. Kuroda et al. 2007 [23] emphasizes that the area between the first and second premolars has higher success rates compared to the area between the first and second molars. This is in agreement with a study [20] demonstrating that the area between the first and second mandibular premolars showed a higher success rate (89.0%) and the area between the first and second molars showed the lowest success rate (69.1%). Such findings also agree with a second study in which the area between the second premolars and the first molars showed significantly lower success rates compared to the area between the first and second premolars in the mandible [24]. A third study [9] found that the mini-implants inserted in the mandibular right side between the first and second molars had the lowest success rate (87.71%) when compared to other sites (P=0.05).

According to the author [14], female patients had higher success rates (85.7%) compared to males (79.4%). The female patients had one and a half times more likely to get better results on the initial stability when compared to male patients without presenting a statistically significant pattern (P=0.26). Mini-implants success rate was higher in females according to another author as well [11]. In female patients, especially younger ones, the lower density and less cortical bone thickness may be offset by the high value of the insertion torque made possible by the mini-implant conical shape. However, an excessively high insertion torque can induce microfractures in the cortical bone around the mini-implant and eventually lead to bone remodeling, resulting in the loss of the mini-implant [11]. A study [18] found that gender, type of malocclusion, length, load pattern, and duration of the healing phase showed no significant influence on the failure rate, which confirms the results of other studies [13,15,20,24-27] and a meta-analysis [5]. Also, there was no statistically significant difference in relation to the insertion site and gender in some studies [28], which is in agreement with other authors [15,29].

As to factors related to location, the literature review has shown that mini-implants success rates are not associated with which insertion side, either right or left [9] is chosen, which is in agreement with other studies [5,11,20,24,26]. These studies have found that there were no statistically significant differences between the insertion sides and success rates.

On the other hand, the key that determines stationary anchor is bone density. Mini-implant failures are often the result of low bone density due to inadequate cortical thickness. Bone D1-D3 is ideal for the insertion of self-drilling mini-implants, which will result in greater stationary anchorage with application of orthodontic loading. Inserting mini-implants in bone type D4 is not recommended due to high failure rates [30,31]. A previous study [27] investigated the relationship between the cortical bone thickness (CBT) and success rates of mini-implants placed in the posterior buccal alveolar bone for orthodontic anchorage and came to the conclusion that the ideal site should be an area with cortical thickness of 1mm or more. Deguchi et al. [16] used computed tomography to investigate the CBT in various sites and concluded that the safest site for a mini-implant is the first molars' mesial or distal surfaces.

Other authors [15,27] have also found a relationship between mini-implants success rate and CBT. Mechanical reciprocity between bone quantity and mini-implant stability may be related to this clinical threshold (1 mm) for successfully implanting 1.5-2.0 mm diameter mini-implants [28]. This study [28] used computerized tomography to evaluate the CBT insertion sites in a greater number of patients than that used by Motoyoshi et al. [27] and investigated the relationship between CBT and mini-implants success rates. Biomechanical influences on the bone around the mini-implants using finite elements and the differences in the distribution of stress were examined according to the differences in the CBT in order to verify the clinical threshold that results in the success of mini-implant insertion. The success rate for the mini-implants was significantly higher for CBT $\geq$1.0 mm when compared to CBT <1.0 mm [28], which is in agreement with Motoyoshi et al. [27]. Based on these findings, the process of a mini-implant failure starts with bone resorption from a higher position to a lower one in the cancellous bone, resulting in support loss ensured by the spongy bone under the cortical bone. Occasionally, the mini-implant may not resist to the orthodontic forces and end up getting lost [28].

On the whole the clinician's experience did not affect the initial stability of mini-implants, although success rates have slightly increased [14]. The number of mini-implants insertion prior procedures, per clinician was not associated with primary stability to the limit of 40 times; more than 40 prior procedures helps to increase primary stability due to the practitioner's experience, but with no statistically significant association [14].

A valid method for assessing mini-implants primary stability quantitatively is through insertion torque measurement. To this end, previous studies [27,29] have found that the recommended torque for mini-implants success is 5-10 Ncm for devices with 1.6 mm diameter. In another study, the insertion and removal torques approached 8 and 4 N on average, respectively, when 1.6 mm diameter and 8 mm long mini-implants were installed in the buccal posterior alveolar bone [32]. Therefore, according to this author, a torque of 4 N is sufficient to retain the ability to anchor mini-implants [32]. For clinical application, initial drilling is required in all areas of high bone density, which comprise the entire mandibular bone, the middle regions of the upper alveolar ridge, and the palate. This is also true when self-drilling implants are used. It has been recommended that clinicians choose a drill with the mini-implant diameter minus 0.5 mm (1.1 mm for 1.6 mm mini-implants and 1.5 mm for 2.0 mm mini-implants for example).

Interradicular placement of orthodontic mini-implants risks trauma to the periodontal ligament and the tooth root. Mini-implants may remain clinically stable but not absolutely stationary under load application. Unlike osseointegrated conventional implants, mini-implants achieve primary stability through mechanical retention. Therefore, they are not entirely stable because of lack of proper osseointegration, and movements of 1 to 1.5 mm can be expected.

As a general rule, it is advisable to leave a space of 2 mm from the tooth root and nerves, especially when they are inserted in the interdental area [33]. If the insertion results in injury [5] to adjacent structures (periodontal ligament, tooth root, nerves, blood vessels or maxillary sinus), mini-implants should be removed and inserted in a different site. Mini-implants that did not touch the adjacent roots have achieved the highest success rates: 90%. On the other hand, those ones that had their whole body in contact with the lamina dura have shown the lowest success rates: 62.5%. The mini-implant proximity to the tooth's root is considered as the greatest risk factor for failure of this device as skeletal anchorage [23]. It is recommended that mini-implants be placed at an angle of 20 to 40 degrees to the tooth's root. This procedure will reduce the risk of touching the root (Kyung HM et al. 2003 *apud* Kuroda, Yamada et al. 2007 [23]).

In another study, mini-implants were positioned at an angle of 30-40 degrees to the long axis of the teeth in the maxilla and at 10 to 20 degrees in the posterior mandible. The miniscrews inserted in the retromolar area and in the distobuccal region of the second molars were placed at an angle of 90° in relation to the bone surface. Insertion angulation is necessary in order to reduce the contact with the tooth roots without reducing the length of the screw. A longer mini-implant should provide greater stability, and angulation allows greater contact with the bone when compared to a mini-implant placed perpendicularly to the bone.

It is important to place the mini-implants as far from the roots as possible by using smaller diameters and lengths. Studies [14,16,34] based on CT suggest that mini-implants with a diameter of 1.3 mm to 1.5 mm and length 6 mm to 8 mm are recommended in order to provide skeletal anchorage in interradicular areas. Deguchi et al. 2006 *apud* Motoyoshi et al. 2007 [21] found that the acceptable length for a safer insertion without risk of touching the tooth roots is approximately 6-8 mm. So, choosing the mini-implant diameter for different sites is critical [17]. A statistically significant difference was found [10] between the failure rates of 1.6 mm diameter mini-implants (13%) and 1.1 mm diameter mini-implants (30.4%) while mini-implants length showed no statistically significant differences. In the maxilla, it is recommended a mini-implant diameter equal to or smaller than 1.4 mm. In the lower jaw, it is recommended a mini-implant with a diameter greater than 1.4 mm for better anchorage [17].

The mini-implant geometry as well as the surgical technique directly influence stress distribution in the peri-implant bone. Most mini-implant losses occur as a result of excessive stress on the bone-implant interface. Self-drilling mini-implants have shown several advantages over self-tapping (pre-drilled) ones. The simplicity of the insertion procedure is due to the fact that it does not require initial drilling. In addition, self-drilling mini-implants have a higher bone-to-implant contact (mechanical grip) compared to self-tapping (pre-drilled) ones (Heidemann et al. 2001 *apud* Kravitz et al. 2007 [4]). Although self-drilling mini-implants allow a greater initial stability compared to pre-drilled ones, osseointegration is significantly lower. This fact is of clinical importance because mini-implants have not been designed to remain in the bone and should be easily removed from the patient's mouth without risk of fracture [35].

Conclusion

Recently, some studies have assessed both success and failure rates of mini-implants and associated risk factors due to their use as temporary anchorage devices (TADs) for orthodontic purposes [9]. Mini-implants success rates in the studies included in a meta-analysis [19] ranged from 71.4% to 100%. According to the studies included in this Article (4,6,10,13,14,17,20,25,27,36,37), the success rates were 70.73%, 79%, 83.8%, 83.6%, 87.4%, 87.7% 89.9%, 89%, 90.80%, 91.6% and 86.8%, among others. The lowest success rate of 70.73% was reported by a study that evaluated the success of 6 mm long mini-implants in adolescents aged 14 years and 10 months.

The effectiveness of mini-implants as anchorage devices was higher when the treatment reached more than 12 months [19]. This can be attributed to the fact that although mini-implants are not osteointegrable, a phenomenon of osseointegration can occur after a long treatment period, which may result from the mineral deposit on their surface (Eliades et al. 2009 *apud* Papadopoulos et al. 2011). This partial osseointegration can provide additional stability, increasing the effectiveness of the anchorage promoted by the mini-implant.

Ninety per cent of the failures occurred within the first 4 months, having losses occurred more frequently within the first month (32.5%), and 80% of the failures occurred within the first 4 months [20]. Therefore, if a mini-implant remains more than 4 months under application of orthodontic force, it can be considered that stability has been achieved and the procedure has been successful [24].

Finally, this study has shown that orthodontic mini-implants have a modest failure rate of 13.5% while success rates range from 70.73% to 91.6%. The average success rate was 86.22%, high enough to demonstrate their clinical utility.

References

1. Daskalogiannakis J. Glossary of orthodontic terms. Leipzig: Quintessence Publishing Co; 2000.
2. Tsui WK, Chua HDP, Cheung LK. Bone anchor systems for orthodontic application: a systematic review. Int J Oral Maxillofac Surg 2012; 1-12.
3. Papadopoulos MA, Tarawneh F, The use of miniscrew implants for temporary skeletal anchorage in orthodontics: A comprehensive review. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;103:e6-e15.
4. Kravitz ND, Kusnoto B. Risks and complications of orthodontic miniscrews (4). Am J Orthod Dentofacial Orthop 2007;131:S43-S51.
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(5):577-95.
6. Schätzle M, Männchen R, Zwahlen M, Lang NP. Survival and failure rates of orthodontic temporary anchorage devices: a systematic review. Clin Oral Impl Res 2009;20:1351-9.
7. Wilmes B, Drescher D. Impact of bone quality, implant type, and implantation site preparation on insertion torques of mini-implants used for orthodontic Anchorage. J Oral Maxillofac Surg 2011;40:697-703.
8. Nanda R, Uribe FA. Dispositivos de Ancoragem Temporários na Ortodontia. Rio de Janeiro: Santos; 2010.
9. Antoszewska J, Papadopoulos MA, Park H-S, Ludwig B. Five-year experience with orthodontic miniscrew implants: A retrospective investigation of factors influencing success rates. J Orthod Dentofacial Orthop 2009;158:e1-e10.
10. Wiechmann D, Meyer U, Büchter A. Success rate of mini- and microimplants used for orthodontic anchorage: a prospective clinical study. Clin Oral Impl Res 2007;18:263-7.
11. Baek S-H, Kim B-M, Kyung S-H, Lim JK, Kim YH. Success Rate and Risk Factors Associated with Mini-Implants Reinstalled in the Maxilla. Angle Orthod 2008;78(5):895-901.
12. Ladeia Jr L, Ladeia LE. Mini-implantes: um guia teórico-prático de instalação e biomecânica ao ortodontista e implantodontista. Nova Odessa: Napoleão; 2011.
13. Cheng S-J, Tseng I-Y, Lee J-J, Kok S-H. A Prospective Study of the Risk Factors Associated with Failure of Mini-implants Used for Orthodontic Anchorage. Int J Oral Maxillofac Implants 2004;19(1):100-6.
14. Lim H-J, Eun C-S, Cho J-H, Lee K-H, Hwang H-S. Factors associated with initial stability of miniscrews for orthodontic treatment. J Orthod Dentofacial Orthop 2009;136:236-42.
15. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Takano-Yamamoto T. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. J Orthod Dentofacial Orthop 2003;124:373-8.
16. Deguchi T, Nasu M, Murakami K, Yabuhi T, Kamioka H, Takano-Yamamoto T. Quantitative evaluation of cortical boné thickness with computed tomographic scanning for orthodontic implants. J Orthod Dentofacial Orthop 2006;129:72.e7-72.e12.
17. Wu T-Y, Kuang S-H, Wu C-H. Factors Associated With the Stability of Mini-Implants for Orthodontic Anchorage: A Study of 414 Samples in Taiwan. J Oral Maxillofac Surg 2009;67:1595-9.
18. Chen Y-J, Chang H-H, Huang C-Y, Hung H-C, Lai E H-H, Yao C-C J. A retrospective analysis of the failure rate of three different orthodontic skeletal anchorage systems. Clin Oral Impl Res 2007;18:768-75.
19. Papadopoulos MA, Papageorgiou SN, Zogakis IP, Clinical Effectiveness of Orthodontic Miniscrew Implants: a Meta-analysis. J Dent Res 2011; 90(8):969-75.
20. Moon C-H, Park H-K, Nam J-S, Im J-S, Baek S-H. Relationship between vertical skeletal pattern and success rate of orthodontic mini-implants. J Orthod Dentofacial Orthop 2010;138:51-7.
21. Motoyoshi M, Matsuoka M, Shimizu N. Application of orthodontic miniimplantsin adolescents. Int JOral Maxillofac Surg 2007;36:695-9.
22. Ono A, Motoyoshi M, Shimizu N. Cortical bone thickness in the buccal posterior region for orthodontic mini-implants. Int J Oral Maxillofac Surg 2008;37:334-40.
23. Kuroda S, Yamada K, Deguchi T, Hashimoto T, Kyung H-M, Takano-Yamamoto T. Root proximity is a major factor for screw failure in orthodontic anchorage. J Orthod Dentofacial Orthop 2007;131(4 Suppl 1):s68-s73.
24. Moon C-H; Lee D-G; Lee H-S; Im J-S; Baek S-H. Factors Associated with the Success Rate of Orthodontic Miniscrews Placed in the Upper and Lower Posterior Buccal Region. Angle Orthod 2008;78:101-6.
25. Park H-S, Jeong S-H, Kwonc O-W. Factors affecting the clinical success of screw implants used as orthodontic anchorage. J Orthod Dentofacial Orthop 2006;130:18-25.
26. Lee S-J, Ahn S-J, Lee JW, Kim S-H, Kim T-W. Survival analysis of orthodontic mini-implants. J Orthod Dentofacial Orthop 2010;137(2):194-9.
27. Motoyoshi M, Yoshida T, Ono A, Shimizu N, Effect of Cortical Bone Thickness and Implant Placement Torque on Stability of Orthodontic Mini-implants. Int J Oral Maxillofac Implants 2007;22:779-84.
28. Motoyoshi M, Inaba M, Ono A, Ueno S, Shimizu N. The effect of cortical bone thickness on the stability of orthodontic mini-implants and on the stress distribution in surrounding bone. Int J Oral Maxillofac Surg 2009; 38:13-8.
29. Motoyoshi M, Hirabayashi M, Uemura M, Shimizu N. Recommended placement torque when tightening an orthodontic mini-implant. Clin Oral Impl Res 2006;17:109-14.
30. Misch, Carl E. Implantes Dentais Contemporâneos. 3ª ed. Rio de Janeiro: Elsevier; 2008.
31. Mish CE. Density of bone: effect on treatment plans, surgical approach, healing, and progressive boné loaning. InJ Oral Implantol 1990;6:23-31.
32. Motoyoshi M, Uemura M, Ono A, Okazaki K, Shigeeda T, Shimizu N. Factors Affecting the long-term stability of orthodontic min-implants. J Orthod Dentofacial Orthop 2010;137:588.e1-588.e-5.
33. Liou EJW, DDS, MS, Pai BCJ, DDS, Lin JCY, DDS. Do miniscrews remain stationary under orthodontic forces? J Orthod Dentofacial Orthop 2004;126:42-7.
34. Tseng Y-C, Hsieh C-H, Chen C-H, Shen Y-S, Huang I-Y, Chen C-M. The application of mini-implants for orthodontic Anchorage. Int J Oral Maxillofac Surg 2006;35:704-7.
35. Suzukia EY, Suzukia B. Placement and removal torque values of orthodontic miniscrew implants. J Orthod Dentofacial Orthop 2011;139:669-78.
36. Kim YH, Yang S-M, Kim S, Lee JY, Kim KE, Gianelly AA, Kyung S-H. Midpalatal miniscrews for orthodontic anchorage: Factors affecting clinical success. J Orthod Dentofacial Orthop 2010;137:66-72.
37. Garfinkle JS, Cunningham Jr LL, Beeman CS, Kluemper GT, Hicks EP, Kim M-O. Evaluation of orthodontic mini-implant anchorage in premolar extraction therapy in adolescents. J Orthod Dentofacial Orthop 2008 133(5):642-53.