Research Article

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Correlation between Miniscrew Stability and Bone Mineral Density in Orthodontic Patients

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ABSTRACT

Background: The aims of this study were to correlate the clinical stability of titanium miniscrews when used as orthodontic anchorage for en-mass retraction and to assess bone quality.

Material and Method: Study consisted of 30 patients were chosen and their bone density was assessed via denta scan. Clinical stability was assessed after 45 days.

Result: Among the study population, 8 were less than 18 year of age, 16 were between 19-21 year of age, and 6 were more than 21 year of age. Out of 60 miniscrews which is placed on the maxillary arch, 48 of them were clinically stable after 30 days, and the BMD value of those clinically stable miniscrews was more than 200(HU). 12 miniscrews loosened before 30 days and the BMD value of those miniscrews was less than 200(HU).

Conclusion: It was demonstrated that miniscrew implants have a lower failure rate of 20%, indicating their usefulness in clinical practice. There was a significant relationship between BMD and the success rate of miniscrew, shows population having more than 200 HU of bone density having great chances of success of their miniscrew stability.

Keywords: Micro Implant , Bone mineral density, Denta scan, Region of Interest.

INTRODUCTION

Orthodontic anchorage is defined as "Resistance to unwanted tooth movement."[1] Dentists use appliances to produce desired movements of teeth in the dental arch. According to Newton's third law of motion, every action has an equal and opposite reaction; this means that, inevitably, other teeth move if the appliance engages them. Anchorage is the resistance to the force provided by other teeth or devices. In orthodontic treatment, reciprocal effects must be evaluated and controlled. The goal is to maximize desired tooth movement and minimize undesirable effects.[2]

Conventional orthodontic anchorage often results in anchorage loss, which is considered a significant potential side effect of orthodontic mechanotherapy. More than 2 mm of anchorage loss can undermine treatment efficacy, especially in critical situations. Titanium implants developed osseous contact, and continuously loaded implants remained stable. [3] Orthodontic miniscrew implants have been popularized because of their simplicity of placement and removal, low cost, and minimal need for patient compliance. The value of miniscrew implants is in the prerequisite that they remain relatively stationary in the bone, their ability to increase anchorage capacity, and the absence of

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adverse effects or complications that could endanger health or treatment outcome.[4]

The host factor is related to the quantity and quality of the bone where the screw is placed. Cortical bone thickness (CBT) (quantity) can affect the initial stability of a screw.[5] Finite element analysis showed that, when a lateral force is applied to the screw, most of the force is concentrated on the cortical bone. It was reported that bone density differs according to sex, age, and physical condition. CT was recently suggested to successfully measure bone mineral density (BMD) in orthopedics. BMD has been used as a parameter to establish a treatment plan to ensure the stability of implants in dentistry.[6]

Computed tomography (CT) is an effective method for bone mineral density (BMD) measurement of specific regions of interest (ROI). A main advantage is that the resulting image is not influenced by adjacent structure superimposition.[7] Its high sensitivity for tissue differentiation allows for a detection threshold of 1% or lower in density difference.[8]

BMD quantitative values in Hounsfield units (HU) for 4 regions are 0.850 HU (anterior mandibular region), 500 to 800 (posterior mandibular and anterior maxillary regions), and 0 to 500 (posterior maxillary region).[9] Because a positive correlation of the preoperatory quantitative-assessed CT mandibular BMD with torque intensity during implant placement has been found, CT-measured BMD can be used to estimate primary implant stability.[10]

In this study we aimed to correlate the clinical stability of titanium miniscrews used for orthodontic anchorage with the quality of bone using multi-slice CT images (DENTA SCAN).

The Objective of the study was

a) To asses bone mineral density of site of Miniscrew placement

b) To assess the correlation between the success rate of Miniscrew and bone mineral density.

MATERIAL AND METHODS

The study protocol was presented in front of Institutional Ethical Committee **(DGCI Registration no: ECR/575/Inst/MP/2014)** the study was approved **(Project code 2014ORT02)** by the Research Approval Committee of People's College of Dental Sciences & Research Centre. The study has been conducted in full accordance with the World Medical Association Declaration of Helsinki. A single examiner performed all the examinations throughout the study. The investigator was trained and calibrated in the Department of Orthodontics & Dentofacial Orthopedics People's College of Dental Sciences and Research Centre. The data consisted of 15 patients, with the age group ranging from 12 year to 32 years (5 males and 10 Females). All of these patients underwent Fixed Orthodontic Treatment with Miniscrew placed for Orthodontic anchorage.30 Miniscrew implants (Titanium Miniscrew) of 1.5x 9 mm (S.K surgical) on both right and left sides were used for anchorage purpose.

Inclusion criteria:

a) Good oral health.
b) Indication for maxillary premolar extraction & canine distallization
c) No chronic renal failure & hormonal disorder particularly thyroid, parathyroid & adrenal impairment.
d) No regular use of tobacco, smoking or alcohol drinking.
e) No regular use of drugs such as steroid, barbiturate, anticonvulsant & thyroid hormone replacement.

Exclusion criteria:

a) Patient with poor periodontal condition.
b) Patient with severe bone loss.
c) Patient with known medical condition e.g. subacute bacterial endocarditis, diabetes, valvular disease, anemia etc.

Denta scan software was used for tomogram reconstruction.[11] For paraxial reconstruction, the following reference measures were used: length, 16.0mm; distance, 1.0 mm; thickness, 1.0 mm. Panoramic reconstruction allowed identification of the section representing the interradicular septal region to be studied. Through paraxial reconstruction the site for miniscrew placement

was identified, and the largest possible ROI encompassing buccal cortical and medullary bone was outlined. BMD per area (cm2), in Hounsfield units, was calculated by using the software. The values obtained expressed the mean density of the area under study.[12] Temporary anchorage devices (TADS) are also known as mini screws and are used to facilitate the movement of teeth through what is called Skeletal Anchorage. TAD appliances are placed directly into the jaw bone then teeth are pulled towards the TAD via elastic or spring traction.[13]

All screw was examined for clinical stability after the insertion and application of orthodontic loading 1 month after force application. The examination of stability was done by manual examination for mobility. Each response variable was dichotomous; the value was recorded as of 0 if miniscrew loosened (failed) and the value of 1 if it is not loosen. All the data was recorded on excel sheet and subjected to statistical analysis. Data was analyzed for clinical stability SPSS (**Statistical Package for the Social Sciences**) version 22.0, for the purpose of data analysis. p (probability) value ≤ 0.05 was taken to be statistically significant and ≤ 0.01 was considered statistically highly significant.

RESULTS

TABLE 1 shows frequency distribution of age and gender among study groups: Out of 30 study population, 8 (26.7%) were less than 18 year of age, 16 (53.3%) were between 19-21 year of age, and 6 (20%) were more than 21 year of age. A total of 10 males (33.7%) and 20 females (66.7%) were present in study groups.

TABLE 2 shows analysis of clinical stability of miniscrew among study group: Out of 60 miniscrews, 48 miniscrews (80%) were clinically stable whereas 12 miniscrews (20%) were clinically loosened.

TABLE 3 shows Comparison of Age, Gender with Clinical Stability of miniscrews: Among study group people with less than 18 years of age, 8 miniscrews were found clinically stable whereas 8 miniscrews was found clinically loosened. Among age group between 19-21 years, 28 miniscrews were found clinically stable whereas 4 miniscrews was found clinically loosened. Among age group more than 21 year of age 12 miniscrews were found to be clinically stable whereas none of the miniscrews was found clinically loosened. There was statistically significant ($p < 0.01$) difference between the age group and clinically stability of the miniscrews.

While comparing the gender to the clinical stability of miniscrew, out of 60 miniscrews 20 miniscrews where clinically stable while none of the miniscrews where loosened among the males whereas in the females 28 miniscrews where clinically stable while 12 miniscrews found loosened.

TABLE 4 shows Correlation between Stability of miniscrew and BMD of the maxillary jaw: Spearman correlation showed that BMD of the maxillary arch and stability of the miniscrews are significant ($p<0.01$) with each other.

TABLE 5 shows Stability of miniscrew at T0 and T1: At T0 (on the day of miniscrew placement and before force application) 100% of clinical stability of miniscrew were noted while At T1 (30 days after miniscrews placement and after force application) 80% of clinical stability of miniscrews were noted.

TABLE 6 shows Miniscrews Failure Correlation with Bone Density: Out of 60 miniscrews which is placed on the maxillary arch 48 of them were clinically stable after 30 days, and the BMD value of those clinically stable miniscrews was more than 200(HU). 12 miniscrews loosened after 30 days and the BMD value of those miniscrews was less than 200(HU).

DISCUSSION

Mini-implants, also called mini-screws or temporary anchorage devices (TAD), are very small screw-like gadgets used more widely in orthodontic treatments. They are becoming popular because they provide good anchorage, which means that they are fixed to bone and then linked to a tooth or a segment of teeth to slowly move them during treatment.[14] Miniscrews as anchorage auxiliary devices in orthodontic treatment have advantages and efficacy. Despite the tremendous success of mini-implants in facilitating treatment outcomes,

However, they exhibit a relatively high failure rate. After placement, approximately 13.5%[15] of Orthodontic microscrews lose stability and no

longer serve as anchorage for tooth movement, which translates into clinical failure. This failure is greater than that of dental implants[16] and possibly discourages some clinicians from utilizing this important resource. Orthodontic microscrews failure may be multifactorial and the factors most frequently studied are classified into categories of related factors: 1) the patient, 2) the clinician, 3) the form and site of insertion, 4) the treatment, 5) complicating factors, and 6) the microscrew. Amongst these categories, some variables deserve special attention from the orthodontists because they are related to the necessary knowledge for the orthodontic diagnosis (facial pattern),[17,18] orthodontic mechanics upper/lower jaw,[19,20] insertion side,[19,21] type of desired movement,[18,22,23] and for the installation of the microscrew (caliber of the microscrew).[24]

The present study was done to determine the clinical success rate of orthodontic miniscrew implants by investigating the initial (from insertion till force application) and long term stability and to evaluate the various factors associated with stability of miniscrew implants. In the present study age, sex, placement site & operator experience were used & the overall success rate of the present study is 80 %.

In the present study, BMD values of right side of the maxillary arch was ranged from 154.82 to 912.41 HU (mean, 403.07 ± 227.11) while BMD values of left side of the maxillary arch was ranged from 128.12 to 929.09 HU (mean, 414.93 ± 254.17). This was similar to the study done by Santiago RC[12] et al in which the BMD values ranged from 167 to 660.8 HU (mean, 420.63 HU). The specific regions between the maxillary second premolars and first molars had a mean close to the maximum value of the scale of Norton and Gamble for the posterior region of the maxilla (0-500 HU), a finding that underscores its significant quality.[12]

Out of 30 study population, 8 (26.7%) was less than 18 years of age, 16 (53.3%) was between 19 -21 years of age while 6 (20%) was more than 21 years of age. This is contrasting to the study done by Lim HJ [25] et al, where majority of the study population was more than 21 years of age group. Age affects the properties of bone in humans. In general, with age there is an increase in the mineral content of the bone tissue, which achieves its best strength and stiffness at maturity.[26]

In the present study, the study population comprised of 10 male and 20 female this is accordance to the study done by Chang C[27] et al where majority of the of the study population was female whereas study done by Santiago RC[12] et al, majority of the study population was male.

Out of 60 miniscrews, 48 miniscrews was clinically stable whereas 12 miniscrews clinically loosened after 30 days of placement this is accordance to the study done by Chang C et al[27] where out of 224 miniscrews, 205 was clinically stable whereas 19 miniscrews clinically loosened. Miniscrew placement in interradicular areas requires appropriate radiologic planning, including a surgical guide with periapical radiographs for determination of a safer placement site.[12] In this study, surgery performed by the same professional and adequate planning seemed to be decisive factors for clinical success of the miniscrew implants, in accordance with methods previously used elsewhere. Although a waiting time of 2 weeks is advised between miniscrew placement and load application (range, 50-300 gf) to allow for tissue cicatrization, primary mechanical retention allows for immediate device activation. In this study, a 200-g load was immediately applied after the placement of 30 miniscrews, without apparent interference with stability and clinical success. Because inflammation control is fundamental for miniscrew stability, all subjects were advised to use strict oral hygiene practices, and they also received oral anti-inflammatory drugs for 5 days after the surgical procedure. [12]

In the present study, while comparing Age with clinical stability of the miniscrew, out of 16 miniscrews which are placed in less than 18 years of age group, 8 miniscrews was clinically stable whereas 8 miniscrews loosened clinically. In between 19 to 21 years of age group, out of 32 miniscrews, 28 miniscrews was clinically stable whereas 4 miniscrews was loosened clinically. Whereas more than 21 years of age group, out of 12 miniscrews, all the miniscrews was clinically stable ($\chi^2 = 6.56$). In the present study as the patients age increased, the success rate increases which is similar to the study done by Hoi-Jeong Lim[25] where they found that children have a high possibility of

loosening, and it would be better not to use miniscrew as the first choice of anchorage for them but variation of bone quality must be expected in older subjects. But studies had done by Lamberg – Allardt CJ et al[30] and Lin JT et al[29] is in contrast with present study which can be explained on the basis of decreased calcium metabolism with age, especially in women.

While comparing gender with clinically stability of the miniscrews, out of 20 miniscrews, which is placed in males, all miniscrews were clinically stable whereas out of 40 miniscrews, which is placed in females 28 miniscrews, was clinically stable while 12 miniscrews loosened ($\chi^2 = 3.75$). In the present study male subjects had a higher success rate than did the female subjects which is in agreement with the studies by Hoi- Jeong Lim[25] & Motoyoshi et al[30] where male subjects had a higher success rate than did a females, this finding may be related to the hormonal peculiarities in females and generally higher bone mass in males. An earlier study including the measurement of the bone mineral contents in the jaws and forearms have disclosed lower bone mineral densities in females in comparison with males and larger bone mineral content loss in elderly females throughout adult life.[31] Although Cheng et al[32] and Miyawaki et al[17] found no difference between male and female subjects; either in relation to (T0) to (T1).

There was statistically significant association ($p < 0.05$) was present between age, gender with clinical stability of the miniscrew. In the present study Spearman correlation showed that BMD in the maxillary arch was significantly associated ($p < 0.05$) with clinical stability of the miniscrew. The stability of mini-implants depends on mechanical factors such as device design and dimensions but also on biological factors such as bone quality, bone quantity and time before loading.[17,33]

Two hypotheses were formulated to explain the results of the present study. The first is that the presence of a cortical thickness of 1 mm in all of the specimens had an important influence on miniscrew stability, masking the influence of bone mineral density and trabecular density. Cortical thickness has been related to primary stability of miniscrews and implants. The second hypothesis is that the difference in bone quality verified statistically may not be clinically relevant. A bigger difference between BMD and TBA (Trabecular bone area) values in bones could perhaps reflect differences in mini-implant stability.[34]

In the present study there was 100% clinically stability was present among study population at T0, on the day of miniscrew placement (Before force application) while 80% clinically stability was present among study population at T1, 30 days after miniscrew placement (After force application). While comparing miniscrews stability with BMD, out of 60 miniscrews, 48 miniscrews had BMD value more than 200 HU and these miniscrews was clinically stable whereas 12 miniscrews had BMD value less than 200 HU and all of them was clinically loosened in the first week which is in agreement with the study done by Cheol–Hyun Moon[35] where dislodgement of the OMI occurred most frequently in the first week and more than 90% of the failures occurred within the first 4 month.

CONCLUSION

significant relationship was found between BMD and the success rate of miniscrew, shows population having more than 200 HU of bone density having great chances of success of their miniscrew stability.

Fig 1: Patient is positioned in Multislice C.T scan machine.

Fig 2: Denta scan software was used for tomogram reconstruction.

Fig 3: Paraxial reconstruction the site for miniscrew placement was identified, and the largest possible ROI(Region of Interest) encompassing buccal cortical and medullary bone was out

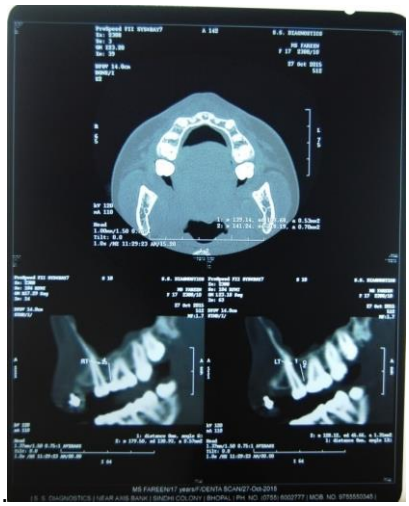

Fig 4: BMD per area (cm2), in Hounsfield units, was calculated by using the software. The values obtained expressed the mean density of the area under study

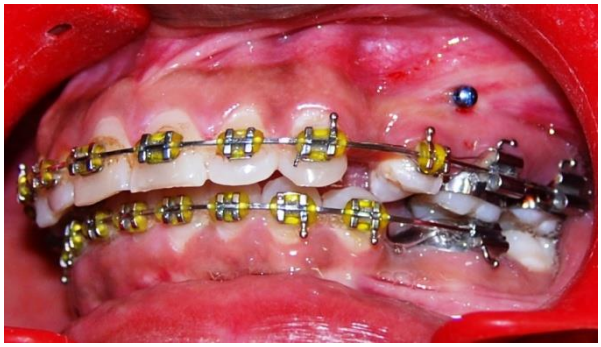

Fig 5: Minicrew were placed between the roots of premolar and mesiobucaal root of 1st molar on both the side in upper arch.

Table 1: Frequency Distribution of Age and Gender among Study Subjects.

	Frequency	Percentage
Age		
Less than 18 years	8	26.7
In between 19-21years	16	53.3
More than 21 years	6	20
Gender		
Male	10	33.3
Female	20	66.7

Table 2: Analysis of Clinical Stability of miniscrew among study group.

Clinical Stability	Frequency	Percentage
Presence	48	80
Absence	12	20
Total	60	100

Table 3: Comparison of Age, Gender with Clinical Stability of miniscrew.

	Stability		Chi-Square	p-Value
	Present	Absent		
Age				
Less than 18 years	8	8	13.12	0.00*
19-21	28	4		
More than 21 years	12	0		
Gender				
Male	20	0	7.5	0.00*
Female	28	12		

* p-value<0.05

Table 4: Correlation between Stability of miniscrew and BMD of the maxillary jaw.

	Stability	BMD
Stability	1	0.00**
BMD	0.00**	1

Spearman Correlation

** p-value<0.01

Table 5: Stabilityof miniscrew at T0 and T1

	At T0, on the day of miniscrew placement (Before Force application)	At T1, 30 days after miniscrew placement (After Force application)
Stability	100 %	80 %

Table 6: Miniscrew Failure Correlation with Bone Density.

	Bone Density in HU		Chi-Square	p-Value
	Less than 200	More than 200		
Miniscrew Stability				
Success	0	48	60.0	0.00**
Failure	12	0		

** p-value<0.0

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

REFERENCES

1. Proffit W. Mechanical principles in orthodontic force control. In: Proffit W, Fields HW, editors. Contemporary orthodontics. 2nd ed. Saint Louis: Mosby; 1993; 289-315.

2. Lien-Hui Huang, Jeffrey Lynn Shotwell, Hom-Lay Wang. Dental implants for orthodontic anchorage. Am J Orthod Dentofacial Orthop 2005; 127(6):713-22.

3. Roberts WE, Smith RK, Zilberman Y, Mozsary PG, Smith RS. Osseous adaptation to continuous loading of rigid endosseous implants. Am J Orthod 1984; 86:95-111.

4. Liou EJW, Pai BCJ, Lin JCY. Do miniscrews remain stationary under orthodontic forces? Am J Orthod Dentofacial Orthop 2004; 16:42-7.

5. Motoyoshi M, Yano S, Tsuruoka T, Shimizu N. Biomechanical effect of abutment on stability of orthodontic mini-implant. A finite element analysis. Clin Oral Implants Res 2005; 16:480-5.

6. Beer A, Gahleitner A, Holm A, Tschabitscher M, Homolka P. Correlation of insertion torques with bone mineral density from dental quantitative CT in the mandible. Clin Oral Implants Res 2003; 14: 616-20.

7. Kuroda S, Yamada K, Deguchi T, Hashimoto T, Kyung HM, Yamamoto TT. Root proximity is a major factor for screw failure in orthodontic anchorage. Am J Orthod Dentofacial Orthop 2007; 131(Suppl):S68-73.

8. Kravitz ND, Kusnoto B. Risks and complications of orthodontic miniscrews. Am J Orthod Dentofacial Orthop 2007; 131: S43-51.

9. Ebbesen EN, Thomsen JS, Beck-Nielsen J, Nepper-Rasmussen HJ, Mosekilde LI. Vertebral bone density evaluated by dual-energy x-ray absorptiometry and quantitative computed tomography in vitro. Bone 1998; 23:283-90.

10. Cummings SR, Bates D, Black DM. Clinical use of bone densitometry: scientific review. JAMA 2002; 288:1889-97.

11. Reynolds RA. CT scanning for dental implantology. RAD Magazine, 25, 285, 44-46.

12. Cesar Santiago, Fernanda Oliveira de Paula, Marcelo Reis Fraga et al. Correlation between miniscrew stability and bone mineral density in orthodontic patients. Am J Orthod 2009.16(2):243-250.

13. Miniscrew. Available on URL: http://www.junction-orthodontics.com/hot-topics/tads-temporary-anchorage-devices-mini-screws. Accessed on November 22th 2015.

14. Mini-implants. Available on URL:http://www.studiodentaire.com/en/treatments/mini-implant-mini-screw-tad.php. Accessed on November 26th 2015.

15. Papageorgiou SN, Zogakis IP, Papadopoulos M. Failure rates and associated risk factors of orthodontic miniscrew implants: A metaanalysis. Am J Orthod Dentofacial Orthop 2012; 142:577-595.

16. Jung RE, Pjetursson BE, Glauser R, Zembic A, Zwahlen M, Lang NP. A systematic review of the 5-year survival and complication rates of implant-supported single crowns. Clin Oral Imp Res 2008; 19:119-130.

17. Miyawaki S, Koyama I, Inoue M, Mishima K, Sugahara T, Yamamoto TT. Factors associated with the stability of titanium screws placed in the posterior region for orthodontic anchorage. Am J Orthod Dentofacial Orthod , 2003;124:373-8.

18. Antoszewska J, Papadopoulos MA, Park, HS, Ludwig B. Five-year experience with orthodontic miniscrew implants: A retrospective investigation of factors influencing success rates. Am J Orthod Dentofacial Orthop 2009; 136:158.e1-158.e10.

19. Park HS, Jeong SH, Kwon OW. Factors affecting the clinical success of screw implants used as orthodontic anchorage. Am J Orthod Dentofacial Orthop 2006; 130:18-25.

20. Brettin BT, Grosland NM, Qian F, Southard KA, Stutz TD, Morgan TA, et al.. Bicortical vs monocortical orthodontic skeletal anchorage. Am J Orthod Dentofacial Orthop 2008; 134:625-635.

21. Shinohara A, Motoyoshi M, Uchida Y, Shimizu N. Root proximity and inclination of orthodontic mini-implants after placement: cone-beam computed tomography evaluation. Am J Orthod Dentofacial Orthop. 2013; 144(1):50-6.

22. Kuroda S, Sugawara Y, Deguchi T, Kyung HM, Takano-Yamamoto T. Clinical use of miniscrew implants as orthodontic anchorage: success rates and postoperative discomfort. Am J Orthod Dentofacial Orthop 2007; 131: 9–15.

23. Chen YJ, Chang HH, Lin HY, Lai EH, Hung HC, Yao CC. Stability of miniplates and miniscrews used for orthodontic anchorage: experience with 492 temporary anchorage devices. Clin Oral Implants Res 2008; 19:1188-1196.

24. Cho UH, Yu W, Kyung HM. Root contact during drilling for microimplant placement. Angle Orthod 2010; 81:130-136.

25. Lim HJ, Eun CS, Cho JH, Lee KH, Hwang HS. Factors associated with initial stability of miniscrews for orthodontic treatment. Am J Orthod Dentofac Orthop, 2009; 136:236–242.

26. Zioupos P, Smith CW, An YH. Factors affecting mechanical properties of bone. In: An Y H, Draughn R A (eds.). Mechanical testing of bone and the bone-implant interface, CRC Press 1999, Boca Raton, pp. 65–85.

27. Chang C, Liu SS, Roberts WE. Primary failure rate for 1680 extra-alveolar mandibular buccal shelf mini-screws placed in movable mucosa or attached gingiva. Angle Orthod, 2015; 85(6):905-10.

28. Lamberg-Allardt CJ, Outila TA, Kärkkainen MU, Rita HJ, Valsta LM. Vitamin D deficiency and bone health in healthy adults in Finland: could this be a concern in other parts of Europe? J Bone Miner Res, 2001; 16(11):2066-73.

29. Lin JT, Lane JM. Osteoporosis a review. Clinical Orthop Relat Res 2004; 425: 126-34.

30. Ono A, Motoyoshi M, Shimizu N. Cortical bone thickness in the buccal posterior region for orthodontic mini-implants. Int J Oral Maxillofac Surg, 2008; 37:334–340.

31. Ikumi N, Tsutsumi S. Assessment of correlation between computerized tomography values of the bone and cutting torque values at implant placement: a clinical study. Int J Oral Maxillofac Implants. 2005 Mar-Apr; 20(2):253-60.

32. Cheng SJ, Tseng IY Lee JJ, KoK SH. A prospective study of the risk factors associated with failure of mini – implants used for orthodontic anchorage. Int J Oral Maxillofac Implants, 2004; 19:100-6.

33. Deguchi T, Takano-Yamamoto T, Kanomi R, Hartsfield JK, Roberts WE, Garetto LP. The Use of Small Titanium Screws for Orthodontic Anchorage. Journal of Dental Research. 2003; 82(5):377-81.

34. Marquezan M, Souza MM, Araújo MT, Nojima LI, Nojima Mda C. Is miniscrew primary stability influenced by bone density? Braz Oral Res, 2011; 25(5):427-32.

35. Moon CH, Lee DG, H. Lee HS, Im JS, Baek SH. Factors associated with the success rate of orthodontic miniscrews placed in the upper and lower posterior buccal region. Angle Orthod, 2008; 78:101–106.