# Cbct Evaluation Of Bicortical Thickness Of The Mid Palate For Micro-Osteo Perforation In Patients Undergoing Treatment With Miniscrew Assisted Rapid Palatal Expansion.

Running title: CBCT evaluation of bicortical thickness in the mid palate for micro-osteo perforation.

Akshay Mohan[1], S.Harish Babu[2], Arvind.S[3], Ashwin Mathew George[4]

***ABSTRACT: Objective: To evaluate the anatomical variations in bicortical thickness of the mid palatine region in order to calibrate the maximum depth of micro osteoperforation permissible at various sites along the midpalate.***

***Design: This was a retrospective cone-beam computed tomography study***

***Setting: The study was conducted in Department of Orthodontics and Dentofacial Orthopedics***

***Methods: CBCT images of 60 subjects between the age of 14-28 years were taken up for evaluation from the records of the dental hospital. The sixty scans were from 37 males and 23 females. The CBCT images of subjects were evaluated by two investigators to assess the bicortical thickness of bone in the midpalatal region using fixed reference points and planes. Mean and standard deviation of bicortical thickness at various fixed landmarks were calculated. One-way ANOVA was done to check for variation of bicortical thickness among various sites in males and females. Intra operator reliability was checked by the paired T- test and Kappa statistics were used to evaluate inter-operator reliability between the observations by two observers (A.M, H.B).***

***Results: A mean value of 8.93+/-1.67mm, 6.37+/-1.56mm, 4.42+/-1.40mm, 3.11+/-1.21mm, 2.47+/-0.95mm, 2.07+/-0.93mm was obtained for reference points A, B, C, D, E and F respectively in males. It was observed that a mean value of 7.93+/-1.56mm, 5.48+/-1.39mm, 3.66+/-1.01mm, 2.81+/-1.06mm, 2.35+/-1.08mm, 2.09+/-1.18 mm was obtained for points A, B, C, D, Eand Frespectively in females. Statistically significant difference was observed between the six points (ANOVA test; p value- 0.00). The Intra operator reliability was assessed using a paired T-test and was estimated to be 0.93 and the inter-operator reliability by Kappa statistics was 0.321.***

***Conclusion: The bicortical thickness of the mid palate varies showing more thickness anteriorly and progressively getting thinner posteriorly. The anterior segment showed more variations in the thickness compared to the posteriors. Micro osteoperforation of palate can***

***be done upto a depth of 8.93 mm in males and 7.93mm in females and a minimum depth of 3.11 mm in males and 3.66mm in females is possible in the anterior half of the palate.***

***Keywords: Cone-Beam Computerized Tomography, Maxillary Expansion, Orthodontics, Palate***

## 1. INTRODUCTION

Rapid maxillary expansion has been a treatment option in patients with transverse discrepancies and a method of achieving skeletal expansion in prepubertal patients up to early adolescence(1). With the modus operandi of disrupting mid palatine and circum maxillary sutures, many RME appliances have managed to achieve transverse maxillary expansion along with an increase in nasal airway. Achieving these changes is not without concomitant changes such as alveolar bone bending, buccal inclination of posterior teeth and unfavorable periodontal changes in some cases.

Mini implants have proven to be a versatile anchorage device to provide bone borne anchorage in treatment of transverse discrepancies (2). Miniscrew assisted rapid palatal expansion has now made it possible to treat transverse discrepancies despite age and with minimal detrimental changes to posterior teeth (3). The challenge faced in miniscrew assisted rapid palatal expansion is to reduce the resistance offered by the sutures without causing failure of mini implants. Resistance offered by sutures will lead to increased loading on the mini implants during activation leading to pain and failure of the mini implant.

Major areas of resistance to MARPE are mid palatine suture and the pterygomaxillary articulation(4)(5). With increasing age the interdigitation at sutures increases making the site more rigid(6)(7). The concept of regional acceleratory phenomenon (RAP) can be used for such clinical challenges by using mild surgical trauma induced by corticotomy, corticision, piezocision or micro osteoperforation to produce localized inflammation(8). With the mid palatine suture being the only sight easily accessible for intervention, minimally invasive procedures like micro osteoperforation can be used to disrupt the mid palatine suture to make it more pliable to expansion forces.

Micro osteoperforation of varying depths performed at edentulous ridges using either burs or mini implants and have been known to produce accelerated tooth movement(9). The Mid palatine region is an eligible site for micro osteoperforation as it is a natural resistance to any transverse skeletal expansion(10). Micro osteo perforation along the mid palatal suture which will induce rapid acceleratory phenomenon which would accelerate the bone turnover and reduce the regional bone density leading to transient osteopenia and thus bringing out changes in the transverse dimension(13)(8)(14). Before micro osteoperforation is performed on the palate, it is imperative to know the anatomical bone thickness in the mid palate which inherently shows a certain amount of anatomical variations(11)(12).

It should be noted here that varying soft tissue thickness across the palatal contour can also influence the length of the mini implant to be chosen as it is desirable to have the entire threaded portion of the mini implant in the bone(15).

Previous studies with CBCT have studied bone thickness at various sites on the hard palate to assess the right length of the mini implant required for anchorage(16)(17)(18). This study aims to evaluate the bicortical thickness of the mid palatine region for the purpose of micro osteoperforation and to study the variations in these values anteroposteriorly as well as among the genders.

## 2. MATERIALS AND METHODS

This retrospective cross-sectional study involved evaluation of 60 CBCT images of patients who reported to the Department of Orthodontics and Dentofacial Orthopedics over a period of one month. Sample size for the present study was determined as 49 with a power of 95% and an alpha error of 0.05. This study design was approved by the institutional ethical committee (SDC/SIHEC/2020/DIASDATA/0619-0320). Among subjects who reported to the hospital for dental treatment of impacted teeth, mandibular trauma, orthognathic surgery, temporomandibular joint abnormalities, external and internal tooth resorption etc., good quality CBCT scans belonging to the age group 14-28 years, with correct head positions were chosen(19). CBCT scans with poor quality, patients with a history of cleft palate, maxillary palatal trauma or palatal bone disorders, CBCT scans which were not sharp due to patient movements or any other conditions which made it difficult to identify the landmarks were excluded from the study. A total of 100 consecutive CBCT records were collected from a one-month period, 60 CBCT scans were selected based on inclusion and exclusion criteria. The sixty CBCTscans from 37 males and 23 females were selected for the study. All the patients were within the age group 14-28 years with a mean age of 19.4 $\pm$ 3 years. Selected scans were numbered one to sixty based on their chronological order**.** The two examiners (A.M) and (H.B) analyzed the CBCT scans and categorized them according to the gender.

All scans included in the study were taken using Orthophos XG 3D (Dentsply Sirona,UK) machine with the settings: 85KV, 10 mA, exposure time 15 seconds, voxel 0.4mm and FOV 15x12cm. The selected CBCT scan images were converted to DICOM (Digital Imaging and Communication in Medicine) format. The analysis of the computed images was performed using Galileo's Sidexis Viewer 1.9, Dentsply Sirona imaging software.

The orientation and position was verified and corrected by orienting the sagittal cross sectional slice of every subject such that the palatal plane is positioned parallel to the positional indicator of the software. In the axial and coronal cross-sectional slice, the vertical positional indicator line was oriented parallel to an imaginary line passing along the midpalatal suture. Following orientation, the sagittal view was selected for evaluation of the bone thickness at the midpalate.

On the mid sagittal slice, a reference plane was constructed from cephalometric Point A to posterior nasal spine (PNS). Following which a point 10 mm from the A point was marked

along the A point-PNS line. The maxillary region was divided into five equal sections B, C, D, E and F at 3mm interval posterior to point A along the point A-PNS line, while the palatal region was divided into two equal sections (P1, P2). Lines perpendicular to the A-PNS line were constructed at points B, C, D, E and F (Figure 1). The distance between the outer margin of the cortices adjoining towards the nasal floor and the oral cavity were measured.

The measurements from CBCT scans were performed by two examiners (A.M) and (H.B). Re-evaluation was done in case of disparity among the observations of two examiners and the observations were reconfirmed by (A.S.K). To avoid the errors due to fatigue not more than six CBCT's landmarks were analyzed per day. After a week of completing the initial measurements, five radiographs were randomly selected out of 60 previously selected CBCT scans and the measurements were repeated to check for intra-operator errors using the paired T-test. The statistical analysis was carried out using Statistical Package for Social Sciences version 20.0 (SPSS Inc., Chicago, IL, USA). Mean and standard deviation of bone thickness at various points in males and females were performed. One-way ANOVA was done to check for variation of bicortical thickness among various sites in males and females. Intra operator reliability was checked by the paired T- test. Kappa statistics were used to evaluate inter-operator reliability between the observations by two observers (A.M, H.B).

## 3. RESULT

The mean, standard deviation and significance of bicortical thickness of midpalate at various points in males and females was evaluated. A mean value of 8.93+/-1.67 mm, 6.37+/-1.56mm, 4.42+/-1.40mm, 3.11+/-1.21mm, 2.47+/-0.95mm, 2.07+/-0.93mm was obtained for reference points A, B, C, D, E respectively in males. ANOVA test reported a p-value of 0.00 which was lesser than 0.05 indicating that there was statistically significant difference among the six reference points. No significance difference was observed between reference points D and E; E and F (p-value >0.05) (Figure 2). It was observed that a mean value of 7.93+/-1.56mm, 5.48+/-1.39mm, 3.66+/-1.01mm, 2.81+/-1.06mm, 2.35+/-1.08mm, 2.09+/-1.18 mm was obtained for points A, B, C, D, E respectively in females. ANOVA test reported a p-value of 0.00 which was lesser than 0.05 indicating that there was a statistically significant difference among the 6 reference points. No significance difference was observed between reference points C and D; D and E ; D and F; E and F (p-value >0.05) (Figure 3). There is a decrease in mid palatal thickness observed in males and females aswe go posteriorly and a statistically significant difference was observed between the six points(ANOVA test; p value-0.00). The Intra operator reliability was assessed using a paired T-test and was estimated to be 0.93 and the inter-operator reliability by Kappa statistics was 0.321.

## 4. DISCUSSION

Micro osteoperforation on alveolar ridges are known to induce regional acceleratory phenomenon and have been used to accelerate tooth movement (20). Varying amounts of interdigitation and ossification have been observed in the midline of the hard palate making the mid palatine suture an area of resistance to rapid palatal expansion(7). Abdul-Aziz et al. in his study used regional acceleratory phenomena to accelerate palatal expansion on the

buccal alveolar plate. Micro osteo perforation along the mid palatal suture induces osteopenia and creates regional acceleratory phenomenon in the mid palatal area thus reducing any resistance provided by this anatomic structure. Micro osteoperforation induced regional acceleratory phenomenon can be brought about by various methods including high speed round burs or miniscrews(21)(22)(23)(Figure 4,5). For such an intervention to be effective without any iatrogenic harm a thorough understanding of the regional anatomic structure is imperative. This study was undertaken to evaluate the bicortical thickness of the hard palate in its midline along its entire length in order to calibrate the maximum depth of micro osteoperforation permissible at various sites along the midpalate.

The results of the study have shown that the maximum amount of bicortical thickness was found in the anterior half of the palate at 8.93 mm and was found at Point A which was 10mm from the incisal papilla in males. Whereas the maximum bicortical thickness was 7.93 mm found at point A which was 10mm from the incisal papilla in females. A statistically significant variation in this thickness was found in the anterior half of the palate with the minimum thickness being upto 3.11 mm in males and 3.66 mm in females. A similar study by Lyu X et al.(16) have shown that the hard tissue at the palate was thickest at the first premolar plane, followed by at the second premolar plane, first molar, and second molar planes. According to Kang et al.(24) the midpalatal area within 1 mm of the midsagittal suture had the thickest bone available and the thickness tended to decrease posteriorly. The findings of Lyu et al. and Kang et al. were in agreement with our study results and the minor variation in the results could be attributed to study methodology.

## 5. CONCLUSION

From the results of the study it can be concluded that statistically significant variations in bicortical thickness of the hard palate have been observed in the anterior region while the posterior region of the hard palate showed insignificant variations in thickness of the hard palate.

This result would imply that the micro osteoperforation of palate can be done upto a depth of 8.93 mm in males and 7.93mm in females and a minimum depth of 3.11 mm in males and 3.66mm in females is possible in the anterior half of the palate which was found to have statistically significant variations in thickness. The more posterior points did not show any significant variations in thickness with point E and F showing 2.47 mm and 2.07mm respectively in males and with point D, E, F showing 2.81mm, 2.35mm and 2.09mm thickness respectively in females.

## 6. LIMITATIONS

The limitation of the present study is that it is a retrospective cross sectional unicentric study done on a smaller section of the population.

*Acknowledgment*

The authors would like to acknowledge Dr ShanthaSundari K.K for her valuable contribution towards the study.

*Declaration Of Interest Statement*

The Author(s) declare(s) that there is no conflict of interest.

*Appendices*

Abbreviations

CBCT: Cone beam computed tomography

MARPE: Miniscrew assisted rapid palatal expansion

RME: Rapid maxillary expansion

ANS: Anterior nasal spine

PNS: Posterior nasal spine

RAP: Regional acceleratory phenomenon

SPSS: Statistical package for the social sciences

A.M: Akshay Mohan

H.B: Harish Babu

A.S.K: Arvind Sivakumar

## 7. REFERENCE

[1] Hershey HG, Stewart BL, Warren DW. Changes in nasal airway resistance associated with rapid maxillary expansion. Am J Orthod. 1976 Mar;69(3):274–84.

[2] Villegas C, Uribe F. A New and Innovative TAD System for Improved Stability and Versatility [Internet]. Temporary Anchorage Devices in Clinical Orthodontics. 2020. p. 455–65. Available from: http://dx.doi.org/10.1002/9781119513636.ch44

[3] Brunetto DP, Sant'Anna EF, Machado AW, Moon W. Non-surgical treatment of transverse deficiency in adults using Microimplant-assisted Rapid Palatal Expansion (MARPE). Dental Press J Orthod. 2017 Feb;22(1):110–25.

[4] MacGinnis M, Chu H, Youssef G, Wu KW, Machado AW, Moon W. The effects of micro-implant assisted rapid palatal expansion (MARPE) on the nasomaxillary complex—a finite element method (FEM) analysis [Internet]. Vol. 15, Progress in Orthodontics. 2014. Available from: http://dx.doi.org/10.1186/s40510-014-0052-y

[5] Cantarella D, Dominguez-Mompell R, Mallya SM, Moschik C, Pan HC, Miller J, et al. Changes in the midpalatal and pterygopalatine sutures induced by micro-implant-supported skeletal expander, analyzed with a novel 3D method based on CBCT imaging. Prog Orthod. 2017 Nov 1;18(1):34.

[6] Tausche E, Hansen L, Hietschold V, Lagravère MO, Harzer W. Three-dimensional evaluation of surgically assisted implant bone-borne rapid maxillary expansion: a pilot

study. Am J Orthod Dentofacial Orthop. 2007 Apr;131(4 Suppl):S92–9.

[7] Angelieri F, Cevidanes LHS, Franchi L, Gonçalves JR, Benavides E, McNamara JA Jr. Midpalatal suture maturation: classification method for individual assessment before rapid maxillary expansion. Am J Orthod Dentofacial Orthop. 2013 Nov;144(5):759–69.

[8] Babanouri N, Ajami S, Salehi P. Effect of mini-screw-facilitated micro-osteoperforation on the rate of orthodontic tooth movement: a single-center, split-mouth, randomized, controlled trial. Prog Orthod. 2020 Mar 9;21(1):7.

[9] Alqadasi B, Aldhorae K, Halboub E, Mahgoub N, Alnasri A, Assiry A, et al. The Effectiveness of Micro-osteoperforations during Canine Retraction: A Three-dimensional Randomized Clinical Trial. J Int Soc Prev Community Dent. 2019 Nov;9(6):637–45.

[10] Lee SC, Park JH, Bayome M, Kim KB, Araujo EA, Kook Y-A. Effect of bone-borne rapid maxillary expanders with and without surgical assistance on the craniofacial structures using finite element analysis. Am J Orthod Dentofacial Orthop. 2014 May;145(5):638–48.

[11] Yadav S, Sachs E, Vishwanath M, Knecht K, Upadhyay M, Nanda R, et al. Gender and growth variation in palatal bone thickness and density for mini-implant placement. Prog Orthod. 2018 Nov 5;19(1):1–10.

[12] Wang Y, Qiu Y, Liu H, He J, Fan X. Quantitative evaluation of palatal bone thickness for the placement of orthodontic miniscrews in adults with different facial types. Saudi Med J. 2017 Oct;38(10):1051–7.

[13] Frost HM. The regional acceleratory phenomenon: a review. Henry Ford Hosp Med J. 1983;31(1):3–9.

[14] Suzuki SS, Braga LFS, Fujii DN, Moon W, Suzuki H. Corticopuncture Facilitated Microimplant-Assisted Rapid Palatal Expansion. Case Rep Dent. 2018 Dec 6;2018:1392895.

[15] Baumgaertel S. Hard and soft tissue considerations at mini-implant insertion sites. J Orthod. 2014 Sep;41 Suppl 1:S3–7.

[16] Lyu X, Guo J, Chen L, Gao Y, Liu L, Pu L, et al. Assessment of available sites for palatal orthodontic mini-implants through cone-beam computed tomography [Internet]. Vol. 90, The Angle Orthodontist. 2020. p. 516–23. Available from: http://dx.doi.org/10.2319/070719-457.1

[17] Manjula WS, Murali RV, Kumar SK, Tajir F, Mahalakshmi K. Palatal bone thickness measured by palatal index method using cone-beam computed tomography in nonorthodontic patients for placement of mini-implants. J Pharm Bioallied Sci. 2015 Apr;7(Suppl 1):S107–10.

[18] Ryu J-H, Park JH, Thu TVT, Bayome M, Kim Y, Kook Y-A. Palatal bone thickness compared with cone-beam computed tomography in adolescents and adults for mini-implant placement [Internet]. Vol. 142, American Journal of Orthodontics and Dentofacial Orthopedics. 2012. p. 207–12. Available from: http://dx.doi.org/10.1016/j.ajodo.2012.03.027

[19] Grauwe AD, De Grauwe A, Ayaz I, Shujaat S, Dimitrov S, Gbadegbegnon L, et al. CBCT in orthodontics: a systematic review on justification of CBCT in a paediatric population prior to orthodontic treatment [Internet]. Vol. 41, European Journal of

Orthodontics. 2019. p. 381–9. Available from: http://dx.doi.org/10.1093/ejo/cjy066
[20] Agrawal AA, Kolte AP, Kolte RA, Vaswani V, Shenoy U, Rathi P. Comparative CBCT analysis of the changes in buccal bone morphology after corticotomy and micro-osteoperforations assisted orthodontic treatment - Case series with a split mouth design. Saudi Dent J. 2019 Jan;31(1):58–65.
[21] Bolat E. Micro-Osteoperforations. In: Işık Aslan B, Deniz Uzuner F, editors. Current Approaches in Orthodontics. IntechOpen; 2019.
[22] Alansari S, Teixeira CC, Sangsuwon C,Alikhani M. Introduction to Micro-osteoperforations. In: Clinical Guide to Accelerated Orthodontics. Springer, Cham; 2017. p. 33–42.
[23] Alikhani M, Sangsuwon C, Alansari S, Teixeira CC. Planning MOPs in Your Daily Practice. In: Clinical Guide to Accelerated Orthodontics. Springer, Cham; 2017. p. 117–32.
[24] Kang S, Lee S-J, Ahn S-J, Heo M-S, Kim T-W. Bone thickness of the palate for orthodontic mini-implant anchorage in adults [Internet]. Vol. 131, American Journal of Orthodontics and Dentofacial Orthopedics. 2007. p. S74–81. Available from: http://dx.doi.org/10.1016/j.ajodo.2005.09.029

| **Points** | **Mean(mm)** | **Standard deviation(mm)** | **p-value** |
|---|---|---|---|
| A(10mm) | 8.93 | 1.67 | 0.000 |
| B(13mm) | 6.37 | 1.56 | |
| C(16mm) | 4.42 | 1.40 | |
| D(19mm) | 3.11 | 1.21 | |
| E(22mm) | 2.47 | 0.95 | |
| F(25mm) | 2.07 | 0.93 | |

Table 1: The table depicts the mean, standard deviation and significance of bicortical thickness of midpalate at various points in males. A mean value of 8.93+/- 1.67 mm, 6.37+/-1.56mm, 4.42+/-1.40mm, 3.11+/-1.21mm, 2.47+/-0.95mm, 2.07+/-0.93mm was obtained for points A, B, C, D, E, F respectively. ANOVA test reported a p-value of 0.00 which was lesser than 0.05 indicating that there was statistically significant difference among the six reference points. No significance difference was observed between reference points D and E; E and F (p-value >0.05).

| **Points** | **Mean** | **Standard deviation** | **p-value** |
|---|---|---|---|
| A(10mm) | 7.93 | 1.56 | 0.000 |
| B(13mm) | 5.48 | 1.39 | |
| C(16mm) | 3.66 | 1.01 | |
| D(19mm) | 2.81 | 1.06 | |
| E(22mm) | 2.35 | 1.08 | |
| F(25mm) | 2.09 | 1.18 | |

Table 2: The table depicts the mean, standard deviation and significance of bicortical thickness of midpalate at various points in females. A mean value of 7.93+/-1.56mm, 5.48+/-1.39mm, 3.66+/-1.01mm, 2.81+/-1.06mm, 2.35+/-1.08mm, 2.09+/-1.18 mm was obtained for points A, B, C, D, E, F respectively. ANOVA test reported a p-value of 0.00 which was lesser than 0.05 indicating that there was statistically significant difference among the six reference points. No significance difference was observed between reference points C and D; D and E; D and F; E and F (p-value >0.05).

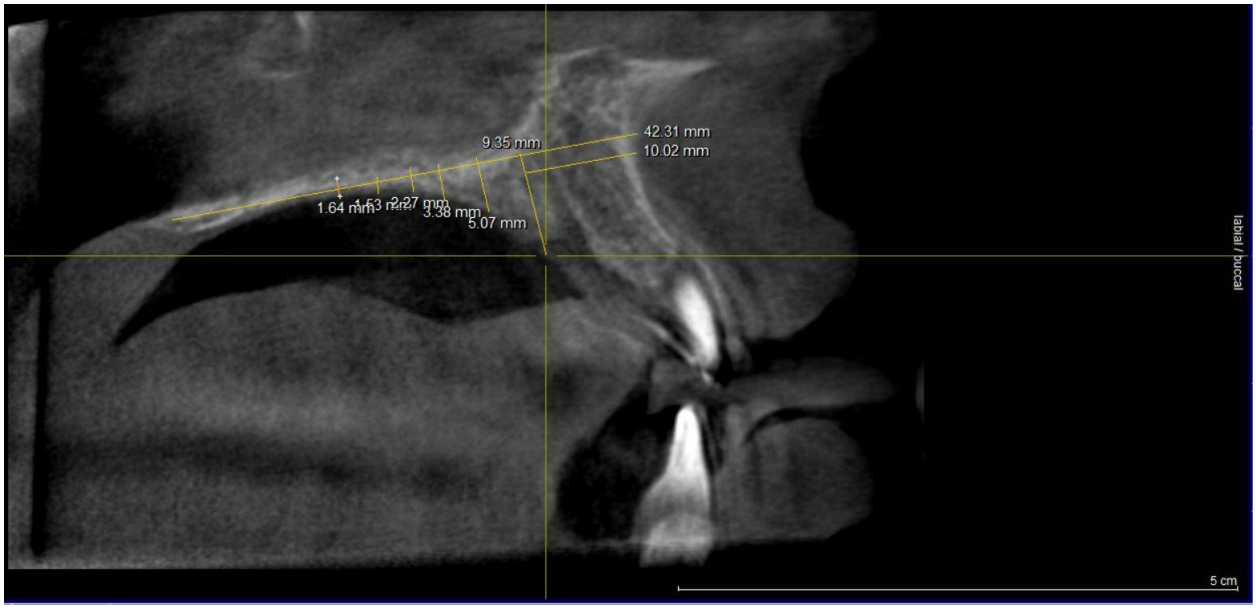


Figure 1: In each sagittal image bicortical thickness was measured at 6 points i.e A (10mm), point B(13mm), point C(16mm), point D(19mm), point E(22mm), point F(25mm) points with intervals of 3mm perpendicular to reference line connecting incisive foramen and PNS.

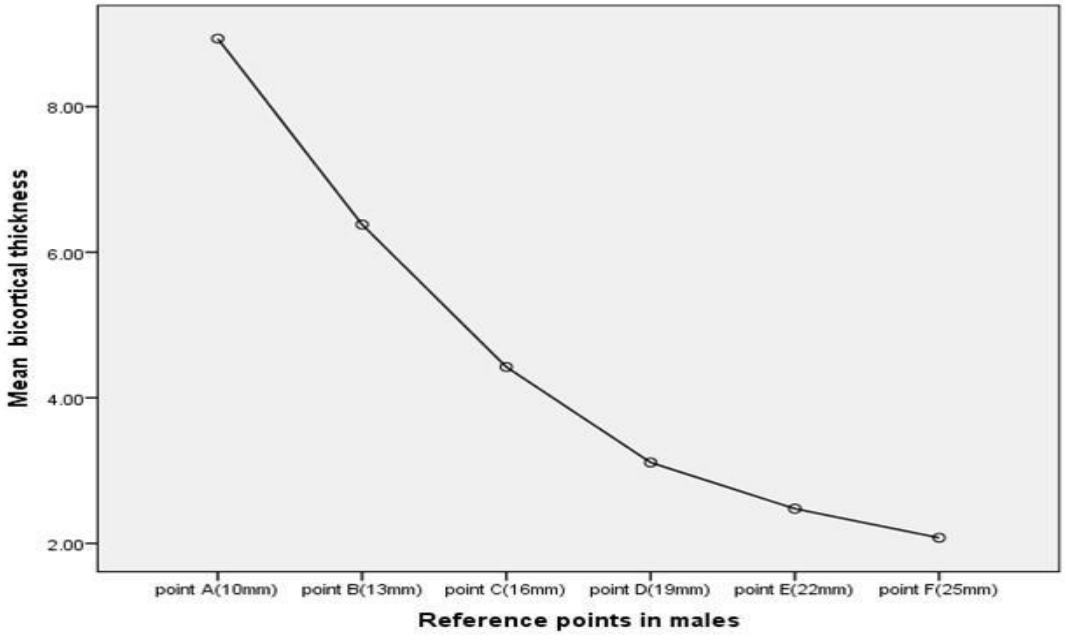


Figure 2: The graph represents the mean bicortical thickness of midpalate in males for the six reference points i.e. point A (10mm), point B (13mm), point C (16mm), point D (19mm), point E (22mm), Point F (25mm). X-axis represents the various points of mid palate and Y-axis represents the bicortical thickness. There is a decrease in mid palatal thickness observed as we go posteriorly and statistically significant difference was observed between the six points (ANOVA test; p value- 0.00).

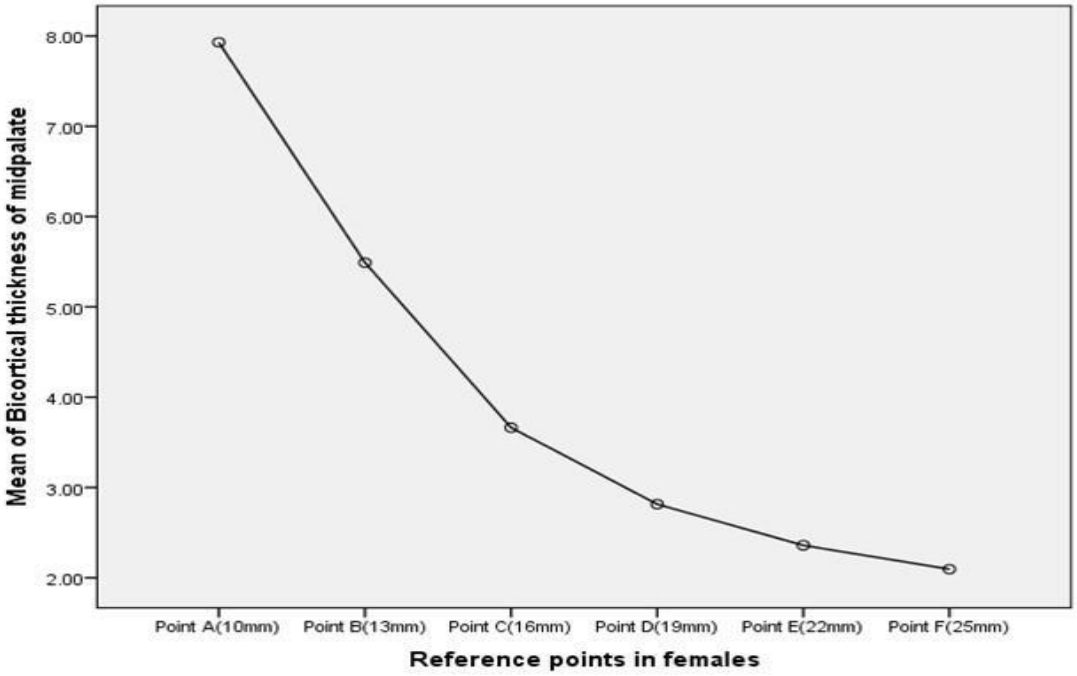


Figure 3: The graph represents the mean bicortical thickness of midpalate in females for the six reference points i.e. point A (10mm), point B (13mm), point C (16mm), point D (19mm), point E (22mm), point F (25mm). X-axis represents the various points of mid palate and Y-axis represents the bicortical thickness. There is a decrease in mid palatal thickness observed as we go posteriorly and statistically significant difference was observed between the six reference points (ANOVA test; p value- 0.00).

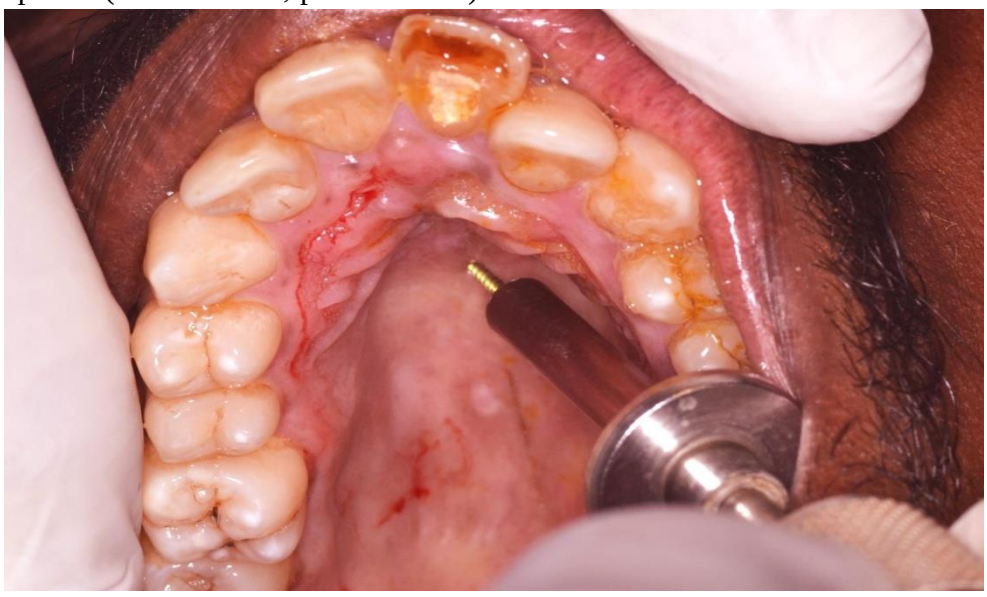

Figure 4: Micro osteoperforation induced regional acceleratory phenomenon can be brought about by miniscrews.

Figure 5: Bleeding points observed after micro osteoperforation procedure on the mid palate using miniscrews.