sciendo DOI: 10.2478/aoj-2012-0003

The safety zone for mini-implant maxillary anchorage in Mongoloids

Mang Chek Wey, Chung Nam Shim, Meng Yit Lee, Marhazlinda Jamaluddin and Wei Cheong Ngeow
Faculty of Dentistry, University of Malaya, Kuala Lumpur, Malaysia

Aim: This study aimed to establish a safety zone for the placement of mini-implants in the buccal surface between the second maxillary premolar (PM2) and first maxillary molar (M1) of Mongoloids.
Methods: Thirty-two digital orthopantomograms of Mongoloids were selected and the interdental distance between the second premolar and first molar at 2, 5, 8 and 11 mm from the cemento-enamel junction (CEJ) was measured. The distance between the PM2 and M1 root apices and from the apices to the maxillary sinus was also determined.
Results: The average width (mm) at 2 mm was 2.58 ± 0.53; 5 mm was 3.47 ± 0.61; 8 mm was 4.00 ± 0.74, 11 mm was 4.36 ± 0.71 and the distance between the apices was 7.49 ± 0.79. Only half of the samples were measured at 11 mm, as many of the root apices were superimposed over the maxillary sinus. The measurement (mm) from PM2 root apex to the sinus was -0.18 ± 1.56, from the mesiobuccal root apex of M1 (MB1) to the sinus was -1.94 ± 1.70 and from the midpoint between their apices to the sinus was -2.96 ± 2.06 (superimposed on the sinus).
Conclusion: The safest area to place mini-implants between the second premolar and the first molar in the maxilla of Mongoloids is between 5 to 8 mm above the CEJ.
(Aust Orthod J 2012; 17-21)

Received for publication: July 2010
Accepted: January 2012

Mang Chek Wey: weymc@um.edu.my; Chung Nam Shim: chrisshim3000@hotmail.com; Meng Yit Lee: myitzz@yahoo.com; Marhazlinda Jamaluddin: marhazlinda@um.edu.my; Wei Cheong Ngeow: ngeowy@yahoo.com

Introduction

Titanium mini-implants have proven to be advantageous in orthodontics for the management of skeletal anchorage.[1] A minimum mesiodistal interdental bone width of 3.1 mm is considered safe for the placement of a mini-implant possessing a maximum diameter of 1.2 to 1.3 mm.[2] Mini-implants with a 1.5 mm diameter are considered safe if at least 3.5 mm of space is available in the interdental bone.[2] The increased usage of mini-implants has created a need for improved precision in their placement. The clinician must be aware of the risks as complications can arise from improper mini-implant placement and usage.[3-5] Significant complications which may arise during insertion are trauma to a neighbouring root and surrounding periodontium or perforation into the maxillary sinus. Therefore, a thorough understanding of regional anatomical structures is imperative for optimal success. Interdental mini-implant placement demands careful radiographic planning which may include the use of a radiographic guide, together with panoramic and periapical films, to determine optimal position. Previous reports have suggested the use of surgical splints or stents,[6] or other specific guides fabricated on models replicated with cone-beam computerised tomography.[7]

It has been found that the Caucasian population has the greatest amount of interdental bone in the maxillary buccal region between the second premolar and the first molar, 5 to 8 mm apical to the alveolar crest.[2,8,9] However, differences have been found between Caucasian and Asian tooth morphology,[10] which may possibly influence the amount of interdental bone available for mini-implant insertion. As previous studies determining the safety zone of mini-implants were conducted on Caucasian populations, it is the purpose of the present study to investigate the safety zone for mini-implant insertion between the maxillary second premolar and first molar of Mongoloid subjects.

Materials and methods

Five hundred and seven digital panoramic radiographs of Mongoloid subjects (i.e. Chinese or Malay patients), taken using the Sirona Orthophos® XG 5 (Sirona, Bensheim, Germany), between March to June 2008 were screened using the following selection criteria:

1. High quality radiographs with reliable geometric accuracy and good image contrast.
2. The fully-erupted presence of all maxillary permanent teeth from right to left second molars.
3. The absence of radiolucent or radiopaque lesions in the arch.
4. The absence of radiographic over-exposure or processing artefacts.
5. The absence of deep caries, root canal treatment or various large restorations with possible associated periapical radiolucencies.
6. The absence of supernumerary or unerupted teeth, as these might obscure the appearance and measurement of the interdental area.
7. The absence of overlapping or spacing between contact points of second premolar and first molar crowns.

The subjects' rights were preserved and informed consent was obtained when the radiographs were taken. Consecutive images of 32 panoramic radiographs which fulfilled the selection criteria were saved and exported to Adobe Photoshop® CS3 version 10.0 (Adobe System Incorporated, San Jose, CA, USA). The cemento-enamel junction (CEJ) of the upper second premolar and first molar were identified. A line was drawn from the distal aspect of the CEJ of the second premolar to mesial aspect of the CEJ of the first molar (Figure 1). A second line, which bisected the angle between the best-fit tangents of the root of the second premolar and mesiobuccal (MB) root of the first molar, was drawn from the centre of the line joining the CEJ of both teeth. Perpendicular lines to the bisecting line were drawn at 2, 5, 8 and 11 mm and between the apices of the second premolar and mesiobuccal root (MB) of the first molar. Distances were measured along these lines to obtain the interdental gap between the teeth at the designated locations.

Using a line that connected the apices of the second premolar and the MB root of the first molar (Figure 2), three measurements to obtain the perpendicular distance between three selected points of interest to the maxillary sinus were made. These three points were the apex of the second premolar, the apex of the MB root of the first molar and a midpoint of the distance between the two apices.

In order to ensure consistency, two researchers underwent inter-examiner calibration prior to the commencement of the study. Intra-examiner reliability assessment was determined by the measurement of six interdental widths at three levels (2, 5 and 8 mm) from right and left maxilla and randomly repeated two weeks later.

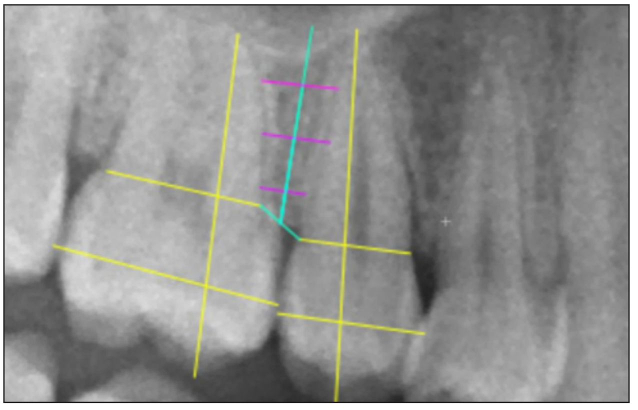

Figure 1. A best-fit tangent, made along the distal root of the second premolar and the mesiobuccal root of the first molar, was used to record the bisecting angle between these two lines for interdental measurements at the levels of 2, 5, 8 and 11 mm.

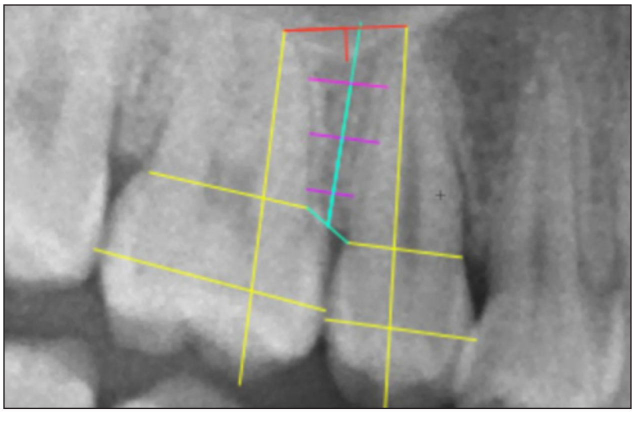

Figure 2. A line was drawn from root apex of #15 to mesiobuccal root apex of #16 for the midpoint measurement to maxillary sinus.

Data analysis was performed using the Statistical Package for Social Science (SPSS) software (Version 12.0; SPSS Inc, Chicago, IL, USA). Descriptive statistics were applied where appropriate. Results were tabled as means with standard deviations (SD), in addition to highlighting the minimum and maximum measurements and distances. The reliability of the measurements between examiners was analysed using the intra-class coefficient correlation. A paired *t*-test was used to compare the measurements between the left and right sides. In addition, the 95 per cent confidence interval of the interdental width at the level of 2, 5, 8 and 11 mm from CEJ were obtained from one sample *t*-test.

Results

The intra-class correlation coefficient used to compare the six randomly repeated measurements revealed acceptable correlations between examiners for all measurements, except for the measurement obtained at the 5 mm level in the right maxilla.

Significant correlations were found between the findings on the left and right side for the measurement at 2, 5 and 8 mm apical to the CEJ with $p < 0.05$ (Table I). Therefore, the means of these measurements were combined as the final result and for subsequent analysis. Correlations for the measurements at 11 mm above the CEJ and the distance between the apices were not statistically significant ($p > 0.05$).

The magnification factor of the radiographic machine as reported by the manufacturer was 1:1.19, and so measurements were adjusted accordingly. The actual measurements as well as the adjusted results are as shown in Tables II and III.

The widest interdental bone width was found to be at 8 mm apical to the CEJ and measured to be 4.00 ± 0.74 mm (Table II). At 5 mm from the CEJ, the mean interdental bone width was 3.47 ± 0.61 mm. At the 95 per cent confidence interval, the interdental bone width at 5 mm ranged from 3.32 mm to 3.62 mm. At 8 mm from the CEJ, the mean interdental bone width was 4.00 ± 0.74 mm. At the 95 per cent confidence interval, the interdental bone width at 8 mm was from 3.80 mm to 4.20 mm.

It was determined that the average position of the root apices of the second premolar and the MB root of the first molar had the maxillary sinus superimposed at the 11 mm level (Table III).

Discussion

The present study was undertaken using digital panoramic radiographs as a review of the literature revealed that, apart from Schnelle et al.[9] who examined panoramic films, many previous interdental studies used either conventional computerised tomography (CT), micro CT,[11-13] CBCT[2,14] or decalcified specimens.[15] Therefore, in order to complement previous findings, it was decided to use panoramic radiographs; this was more representative of clinical practice as most orthodontic patients would routinely undergo panoramic radiographic investigation. Earlier studies found that results obtained using dental panoramic

Table I. Mean, correlation and level of significance between measurements from the left and right maxilla.

Interdental level	Sample size (N)	Mean (SD), mm	Correlation	Significance (*p*)
Left 2 mm	32	3.06 (0.60)	0.60	0.00*
Right 2 mm	32	3.08 (0.67)		
Left 5 mm	30	4.18 (0.73)	0.46	0.01*
Right 5 mm	30	4.04 (0.69)		
Left 8 mm	25	4.83 (0.85)	0.44	0.03*
Right 8 mm	25	4.62 (0.92)		
Left 11 mm	14	5.23 (0.58)	0.43	0.13
Right 11 mm	14	4.94 (0.93)		
Left apices	32	9.11 (1.52)	0.29	0.11
Right apices	32	8.72 (1.33)		

* $p < 0.05$

Table II. Interdental width between the second premolar and the mesiobuccal root of the first molar at level 2, 5, 8, 11 mm above cemento-enamel junction, and between the root apices.

Interdental width		Measurement (mm)		Minimum/Maximum (mm)		Average (mm)	
		Measured value	Adjusted data	Measured value	Adjusted data	Measured value	Adjusted data
2 mm (N = 64)	Left	3.06 ± 0.60	2.57 ± 0.50	1.95 / 4.20	1.64 / 3.53	3.07 ± 0.63	2.58 ± 0.53
	Right	3.08 ± 0.67	2.59 ± 0.56	1.75 / 4.60	1.47 / 3.87		
5 mm (N = 62)	Left	4.18 ± 0.72	3.51 ± 0.61	2.75 / 5.90	2.31 / 4.96	4.13 ± 0.72	3.47 ± 0.61
	Right	4.08 ± 0.72	3.43 ± 0.61	2.20 / 2.55	1.85 / 2.14		
8 mm (N = 56)	Left	4.92 ± 0.88	4.13 ± 0.74	3.40 / 6.90	2.86 / 5.80	4.76 ± 0.88	4.00 ± 0.74
	Right	4.61 ± 0.88	3.87 ± 0.74	2.65 / 6.30	2.23 / 5.29		
11 mm (N = 37)	Left	5.25 ± 0.54	4.41 ± 0.45	4.20 / 6.15	3.53 / 5.17	5.19 ± 0.85	4.36 ± 0.71
	Right	5.13 ± 1.08	4.31 ± 0.91	3.75 / 7.05	3.15 / 5.92		
Apices (N = 64)	Left	9.11 ± 1.52	7.66 ± 1.28	5.55 / 13.35	4.66 /11.22	8.91 ± 0.94	7.49 ± 0.79
	Right	8.71 ± 1.33	7.32 ± 1.12	6.65 / 10.75	5.59 / 9.03		

Table III. The mean and standard deviation of the distance from the root apices of the second premolar and first molar to the maxillary sinus (negative value denotes apparent involvement of the maxillary sinus).

Distance	Measured distance (mm) (Magnified)		Actual distance (mm) (Calculated)	
	Mean	Standard Deviation	Mean	Standard Deviation
Second premolar to maxillary sinus	-0.21	1.86	-0.18	1.56
First molar to maxillary sinus	-2.31	2.03	-1.94	1.70
Midpoint between the apices of the first molar's mesiobuccal and second premolar roots and maxillary sinus	-2.96	2.45	-2.96	2.06

radiographs were comparable to those obtained using CBCT.[16] The results gained from the assessment of panoramic films slightly underestimated the widths measured by CBCT and so there was less concern for over-reporting of interdental distance.

Studies on Caucasians have shown that the greatest interdental bone width was buccally located between the maxillary second premolar and the first molar, 5 to 8 mm apical to the alveolar crest.[2,8,9] While Poggio et al.[2] measured the interdental width above the alveolar crest, the present study employed the CEJ as a landmark which approximated the alveolar crest in periodontally-healthy patients. It was considered that the use of the CEJ landmark would reduce the confounding influence of bone loss and ensure the predictability of interdental widths in patients with healthy or diseased periodontal status. Furthermore, the CEJ was a landmark which could be easily clinically located.

The present results obtained for Mongoloid subjects were found to be similar to those for Caucasians reported by Poggio et al.[2] The area between 5 mm (mean 3.47 ± 0.61 mm) to 8 mm (mean 4.00 ± 0.74 mm) apical to the CEJ of the adjacent first molar and second premolar teeth would appear safe and appropriate for mini-implant placement due to the adequacy of interdental bone width.

It has been further reported that the greatest amount of interdental bone is approximately 11 mm from the alveolar crest in the mandibular buccal region.[2,8,9] The present study determined that, at 11 mm above the CEJ, not all maxillary premolars and molars had sufficient interdental bone width for the insertion of a mini-implant due to the encroachment of the maxillary sinus. Only half of the subjects in the present study had measurable and adequate interdental bone at this level. While there appeared to be sufficient room between the root apex of the second premolar and the MB root of the first molar, it is not recommended that mini-implants be placed at, or beyond, the 11 mm CEJ level in the maxillary posterior segment.

Conclusion

Mini-implants may be safely placed in the area 5 to 8 mm apical to the CEJ of the second premolar and first molar in the maxillary buccal region of Mongoloid subjects. Additional investigations and extra precautions are needed if mini-implants are to be inserted 11 mm above the CEJ of these teeth, due to the proximity of the maxillary sinus.

Acknowledgments

We would like to acknowledge the contribution of Dr Mei Ling Wong in the initial design of the study, and Professor Phrabhakaran a/l K. N. Nambiar, for his kind assistance and permission to undertake this work at the Radiology Unit, University of Malaya.

Corresponding author

Dr Mang Chek Wey
Department of Children's Dentistry and Orthodontics
Faculty of Dentistry
University of Malaya
50603 Kuala Lumpur
Malaysia

Email: weymc@um.edu.my

References

1. Kravitz ND, Kusnoto B. Risks and complications of orthodontic miniscrews. Am J Orthod Dentofacial Orthop 2007;131(4 Suppl):S43-51.
2. 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.
3. Cope JB. Temporary anchorage devices in orthodontics: a paradigm shift. Semin Orthod 2005;11:3-9.
4. Kravitz ND, Kusnoto B. Risks and complications of orthodontic miniscrews. Am J Orthod Dentofacial Orthop 2007;131:S43-51.
5. Ohnishi H, Yagi T, Yasuda Y, Takada K. A mini-implant for orthodontic anchorage in a deep overbite case. Angle Orthod 2005;75:444-52.
6. Kitai N, Yasuda Y, Takada K. A stent fabricated on a selectively colored stereolithographic model for placement of orthodontic mini-implants. Int J Adult Orthodon Orthognath Surg 2002;17:264-6.
7. Kim SH, Choi YS, Hwang EH, Chung KR, Kook YA, Nelson G. Surgical positioning of orthodontic mini-implants with guides fabricated on models replicated with cone-beam computed tomography. Am J Orthod Dentofacial Orthop 2007;131:S82-9.
8. Carano A, Velo S, Incorvati C, Poggio P. Clinical application of the Mini-Screw-Anchorage-System (M.A.S.) in the maxillary alveolar bone. Prog Orthod 2004;5:212-30.
9. Schnelle MA, Beck FM, Jaynes RM, Huja SS. A radiographic evaluation of the availability of bone for placement of miniscrews. Angle Orthod 2004;74:832-7.
10. Lavelle CL. Maxillary and mandibular tooth size in different racial groups and in different occlusal categories. Am J Orthod 1972;61;29-37.
11. Park HS. An anatomic study using CT images for the implantation of micro-implants. Korean J Orthod 2002;32:435-41.
12. Ishii T, Nojima K, Nishii Y, Takaki T, Yamaguchi H. Evaluation of the implantation position of mini-screws for orthodontic treatment in the maxillary molar area by a micro CT. Bull Tokyo Dent Coll 2004;45:165-72.
13. Deguchi T, Nasu M, Murakami K, Yabuuchi T, Kamioka H, Takano-Yamamoto T. Quantitative evaluation of cortical bone thickness with computed tomographic scanning for orthodontic implants. Am J Orthod Dentofacial Orthop 2006;129:721.e7-12.
14. Kim GT, Kim SH, Choi YS, Park YJ, Chung KR, Suk KE, Choo HR, Huang JC. Cone-beam computed tomography evaluation of orthodontic miniplate anchoring screws in the posterior maxilla. Am J Orthod Dentofacial Orthop 2009;136:628.e1-10.
15. Heins PJ, Wieder SM. A histologic study of the width and nature of inter-radicular spaces in human pre-molars and molars. J Dent Res 1986;65;948-51.
16. Madrigal C, Ortega R, Meniz C, López-Quiles J. Study of available bone for interforaminal implant treatment using cone-beam computed tomography. Med Oral Patol Oral Cir Bucal 2008;13:E307-12.