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DIGITAL RADIOGRAPHIC EVALUATION OF THE INTERRADICULAR BONE FOR MINISCREW IMPLANT PLACEMENT IN DIFFERENT MALOCCLUSIONS.

Dental Science

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ABSTRACT

Aim & Objective: To determine and understand the influence of different dentoskeletal patterns on the availability of interradicular bone for the placement of miniscrew implants in class I,class II and class III malocclusions.
Material and methods: Radio-visiographs (RVGs) of 60 subjects with skeletal Class I, II, or III patterns were obtained using paralleling technique method. In each patient Thirteen chosen interradicular sites were examined. For each interradicular site, interradicular bone width were measured at 3, 5, 7, 9, and 11 mm from the alveolar crest using Kodak Dental Imaging Software. The readings were compared using three way factorial ANOVA, Turkey test was applied when ANOVA yielded significant results.
Results: The "safest zone" to place the miniscrew implants in the maxilla, is between the second premolar and the first molar, followed by the two premolars in the posterior region. In the anterior region the safe zone is between the central incisors at 9 mm and 11 mm, depending upon the purpose of the miniimplant. In the mandible, the safest zone for the placement of miniscrew implant was found to be between the two premolars and the first and the second molars at 9 mm and 11 mm. Significant differences in interradicular spaces among the skeletal patterns were observed. Maxillary interradicular spaces, particularly between the first and second molars, in the subjects with skeletal Class III patterns, were greater than those in the subjects with skeletal Class II and Class I patterns. In contrast, in the mandible, interradicular spaces between the two premolars in subjects with skeletal Class II patterns were greater than those in the subjects with skeletal Class III and Class I patterns.
Conclusion: For all skeletal patterns, the safest zone in the interradicular space of the maxilla was the space between the central incisors followed by second premolar and the first molar and first and second premolars. In the posterior mandible, the safer zones were located between the first and second premolars and between the first and second molars.

KEYWORDS

Miniscrew; Radiovisiograph (RVG), Interradicular bone; Orthodontics.

INTRODUCTION

Anchorage is the cornerstone of the orthodontic force system. The need for orthodontic treatment requiring minimal patient compliance has encouraged research into the use of multiple strategies to reinforce anchorage.[1] Traditionally, anchorage was reinforced by increasing the number of teeth in the anchorage unit, by using the oral musculature, or by using extraoral appliances. Compared to other methods of skeletal anchorage, Miniscrew implants (MSI) have emerged as particularly efficient during orthodontic treatment. [2]

Despite their tremendous success in facilitating treatment outcomes the implant failure rates are widely variable and could be as high as 10-30 %.[4] Optimal positioning has always been critical to the success of the miniscrew implants. most common site for MSI placement is the interradicular alveolar bone. in recent years numerous sites have been used by clinicians for the placement of miniscrews. [5-6] .The limiting factor in placement of miniscrews is the restriction posed by the narrowness of the available interradicular bone width. Potential complications of root injury include, severe pain, and sensitivity, loss of tooth vitality, osteosclerosis, and dentoalveolar ankylosis. A 1mm safety clearance between the miniscrew and the root surface on either side has been recommended in the tooth bearing area to prevent the screws from causing injury to roots.[7-8] The screws placed in the unattached gingiva can lead to periodontal soft tissue complications like tissue inflammation, minor infection, and peri-implantitis because of difficulty in maintaining proper oral hygiene. Placement in the attached gingiva or the border between attached and unattached gingiva is therefore preferable.[9-10]

When using temporary anchorage devices (TAD), examination of typical orthodontic records i.e. radiographs, models, photographs and clinical examination is the starting point. Radiographs provide a topographical survey of relevant anatomic structures. Traditionally OPG and IOPA have been used for precise placement of miniscrew implants. A panoramic radiograph is required to estimate the bone quality, root angulations and proximity position of vital anatomical structures. However, vertical and horizontal magnifications are inherent in panoramic radiography. Vertical maginification in panoramic radiographs has been reported to be approximately 18-21 %, whereas horizontal magnification is even more unreliable.[3] IOPA overcomes some of the drawbacks of the orthopentamogram in relation to the clarity in various areas of the mouth. Ideally a three dimensional radiograph such as cone beam computed tomography (CBCT) is desired. Unfortunately the access to and the expense of CBCTs or such radiographic devices, for most instances of miniscrew insertion does not seem to be feasible. RVGs could be a potential replacement to these radiographic techniques by virtue of the ease in use and availability in dental clinics and cost/benefit ratio.

Several studies using OPG, IOPA, and CBCT have been performed to assess the safe locations in the interradicular spaces for miniscrew implant placement. However, in these studies the assessment of the safe locations was performed in samples with minor malocclusion in different populations. No study has been done to understand the influence of different dentoskeletal pattern on the availability of interradicular bone width.

AIM and Objectives :-

1. Evaluation of interradicular spaces in the anterior and posterior regions at thirteen sites in different dentoskeletal patterns (Skeletal class I, II & III) in the Indian population for the placement of miniscrew implants (MSIs) using digital radiographs (RVGs).
2. Determination of the interradicular bone width at various levels in relation to the Cementoenamel junction (CEJ) i.e. at 3, 5, 7, 9 & 11 mm. Studies have shown that larger diameter MSIs have better prognosis therefore, to find the best location for placing MSIs of wider diameter in the interradicular bone.
3. Compare the interradicular bone width within each group and between the different dentoskeletal patterns to assess the characteristic dentoalveolar compensation on the availability of the interradicular spaces.

MATERIALS & METHODS

Materials required to perform the study is as follows: a) Material for lateral cephalogram procurement and measurement: Lateral

Cephalogram of the patients,Acetate paper, protractor, set square, ruler, 0.35 mm pencil, b) Materials for RVG images procurement and measurement:

RVG unit, Paralleling device, Kodak Dental software for RVG.

Measurements:-

Lateral cephalograms were used to determine the dentoskeletal patterns of the subjects.

Lateral cephalometric measurements were obtained,

1. SNA angle: angle formed by the SN line and the NA line.
2. SNB angle: angle formed by the SN line and the NB line;
3. ANB angle: angle formed by the NA line and the NB line;
4. Wit's appraisal

The average values of ANB taken in groups: class I – 0-3 degrees
Class ll- 3.5 to 6 degress
Class lll- -1 to -3 degrees.

Imaging And Measurement Of The Interradcular Sites On Rvg Images:

The paralleling technique method was used to obtain standarised radiographs using the RVG machine with the attached x ray unit. The obtained images were now used for the measurements. A perpendicular line was drawn from the alveolar crest to the desired levels (3, 5, 7,9,11 mm). The horizon made by drawing horizontal lines between the lamina dura of the adjacent teeth at 3,5,7,9 and 11 mm depths from the alveolar crest. These measurements were made perpendicular to the vertical line extended from the alveolar crest. To eliminate the intra observer bias 5 different site and the average value was recorded. *(figure 1a-1c)*

Statistical analysis

The statistical analyses were performed using the SPSS V21 program. Mean and standard deviation of the measurements were calculated. Three- way Factorial ANOVA was used to compare the means of measurements between different skeletal patterns. Post hoc multiple comparisons were also performed with Tukey test when ANOVA yielded significant results indicating that there was a difference. Results were considered statistically significant at P< .05.

RESULTS

SAMPLE CHARACTERSTICS:

The data collected from the sample of 60 patients (subdivided into three groups A,B,C) was compared at 13 different sites and at 5 different levels from the CEJ, for each site. The following results were obtained from the study. Three- way Factorial ANOVA was used to compare the means of measurements between different skeletal patterns. Post hoc multiple comparisons were also performed with Turkey test when ANOVA yielded significant results indicating that there was a difference. Results were considered statistically significant at *P< 0.01 and P<0.05*.

Interradicular measurements:

The values obtained after the measrurements at the different sites at the 3,5,7,9,11 mm(Fig 1a,b,c) distance from the CEJ has been tabulated in the Table no.1.

At the 3 mm level, in the maxilla, the greatest interradicular width was found in the second premolar and first molar region with a mean value of 2.48 + 0.49. In the mandible, the greatest amount of interradicular bone at the 3 mm level was found between the first and the second premolars with a mean value of 2.67 + 0.84. In the maxilla, there was no significant difference amongst the different malocclusions (dentoskeletal patterns) found at this level. In the mandible there was a significant difference (P<0.01) in the availability of bone between the two premolars, the greatest amount was found in the Class II subjects followed by Class III .Significant difference (P<0.05) was found in the first and second molar region between Class III and Class I At the 5 mm, in the maxilla, the greatest amount of interradicular bone was found between the second premolar and the first molar with a mean value of 2.87mm + 0.64. In the mandible the greatest amount of interradicular bone was found between the two premolars with a mean of 3.31mm + 0.99. In the maxilla there was a significant difference (P< 0.01) between Class II and Class I and (P<0.05) between Class II and Class III subjects. In the mandible, there was a significant difference (P< 0.01) found at the first molar and second molar region between Class I , Class II and Class III subjects.

At 7 mm level, in the maxilla the greatest interradicular width was found between the two central incisors with a mean value of 3.24 mm + 0.93. In the mandible the greatest amount of interradicular width was found in between the first and the second premolars (3.85 mm + 1.07) .In the maxilla, there was a significant difference (P<0.01) found between Class II and Class III subjects. The three groups also showed variations in the width of interradicular bone in the first and second molar region with the greatest width available in Class III subjects followed by Class I and Class II subjects. In the central incisor region significant difference (P< 0.01) was found between Class I and Class II. The greatest value was observed in Class III subjects (3.60 + 0.99mm) (Table 1).

TABLE 1

The table below shows the descriptive values of the observations at different positions, depths and of different Groups, along with their corresponding results on Tukey's Post Hoc Analysis between different Groups

		Measurement Level Depth															Tukey Test Significance of P														
		3 mm			5 mm			7 mm			9 mm			11 mm			3 mm			5 mm			7 mm			9 mm			11 mm		
Location		A	B	C	A	B	C	A	B	C	A	B	C	A	B	C	A-B	A-C	B-C	A-B	A-C	B-C	A-B	A-C	B-C	A-B	A-C	B-C	A-B	A-C	B-C
Maxilla																															
16/17	Mean	2.31	1.86	2.31	2.39	1.93	2.39	2.60	2.00	2.68	2.54	2.39	3.05	2.93	2.89	3.53									x			x		x	x
	SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-															
15/16	Mean	2.55	2.19	2.58	2.59	2.48	2.95	2.87	2.77	3.45	3.04	3.41	3.80	3.57	4.09	4.45									x		x			xx	
	SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-															
14/15	Mean	2.49	2.21	2.42	2.70	2.56	2.83	3.01	2.81	3.21	2.93	2.94	3.61	3.46	3.36	4.16											x	x		x	xx
	SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-															
11/21	Mean	2.31	2.44	2.61	2.30	2.90	3.11	2.78	3.35	3.60	3.11	3.80	4.05	3.36	4.28	4.41				x		xx		xx		x	xx		xx	xx	
	SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-															
24/25	Mean	2.45	2.15	2.12	2.68	2.61	2.68	2.98	2.89	2.92	3.15	3.09	3.27	3.30	3.54	3.87															
	SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-															
25/26	Mean	2.20	2.66	2.60	2.69	3.00	2.94	2.83	3.34	3.46	3.01	3.53	3.98	3.24	4.46	4.73								x			xx		xx	xx	
	SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-															
26/27	Mean	1.98	1.65	2.16	1.85	1.52	2.36	2.08	1.55	2.56	2.35	1.91	3.03	2.76	2.55	3.39						xx			xx		x	xx		x	xx
	SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-															
Mandible																															
36/37	Mean	2.08	2.83	2.90	2.50	3.24	3.29	2.87	3.67	3.65	3.44	4.32	4.12	3.84	5.11	4.77	x	xx		x	x		xx	x		xx	x		xx	xx	
	SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-															
35/36	Mean	2.76	2.40	2.19	3.00	2.59	2.57	3.34	2.66	2.78	3.94	3.03	3.27	4.36	3.75	4.08							x			xx	x		x		
	SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-															
34/35	Mean	2.38	3.14	2.50	3.08	3.82	3.06	3.53	4.45	3.60	3.87	4.94	4.15	4.28	5.43	4.82	x		x	x		x	xx		xx	xx		x	xx		x
	SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-															
46/47	Mean	1.95	2.78	2.91	2.47	3.18	3.32	3.24	3.60	3.65	3.60	4.38	4.24	3.91	5.44	4.87	xx	xx		x	xx					x	x		xx	xx	
	SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-															
45/46	Mean	2.63	2.39	2.74	2.64	2.72	3.08	2.95	2.88	3.24	3.42	3.31	3.82	4.05	4.19	4.59															
	SD	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-															
44/45	Mean	2.42	3.04	2.33	2.98	3.65	2.78	3.54	4.13	3.19	4.00	4.63	3.49	4.39	5.15	3.85	x		x	x		xx			xx	x		xx	x		xx

At the 9 mm level, in the maxilla the greatest amount of interradicular width was observed in between the two central incisors (3.65 + 1.11) .In the mandible the greatest amount of interradicular width was observed between the two premolars (4.31mm + 1.14) and the first and the second molars (4.06mm + 1.42). The interradicular widths when compared amongst the three groups showed significant difference (P<0.01). The greatest interradicular width was observed in between the two central incisors in Class III subjects followed by Class II subjects mm) and Class I subjects. The greatest amount of interradicular width in the posterior region also yielded significant difference (P<0.01) in the second premolar and first molar region. The greatest value was observed in Class III subjects followed by Class II subjects and Class I subjects. In the first and the second molar region P< 0.01 difference was observed between Class II and Class III subjects. In the mandible, the greatest amount of interradicular width is found in between the two premolars in the Class II subjects followed by Class III followed by Class I subjects. The greatest amount of interradicular width in the first and the second molar region was found in Class II subjects followed by class III.

At the 11 mm level, in the maxilla the greatest interradicular width was found between the second premolar and first molar (4.03mm + 1.31. In the mandible the greatest amount of interradicular width was observed in between the two premolars (4.84 mm + 1.23. In the maxilla the greatest amount if interradicular bone was found in the second premolar and first molar region in class III subjects followed by class II subjects and class I subjects.The area between the two premolars showed a significant difference (P<0.01) between Class I and Class III subjects. Interradicular area between the two central incisors showed the significant different (P<0.05) between the Class I , Class II and Class III subjects. In the mandible, the greatest amount of interradicular bone width was observer in the first molar and second molar region with significant difference (P<0.05) between Class I, Class II and Class III subjects. The area between the second premolar and the first molar was greatest in Class III subjects followed by Class II and Class I subjects.

DISCUSSION

In the present study, subjects with well-defined skeletal patterns (Classes I, II, and III) were studied for understanding influence of different skeletal patterns and their characteristic dentoalveolar compensation on the availability of interradicular spaces.

In this study, Radiovisiography (RVG) has been used to evaluate the width of the interradicular bone for placement of miniscrew implants for orthodontic anchorage. Dental radiographs have commonly been used to investigate the hard tissues in dentoalveolar regions. Schenelle et al[3] reported the evaluation of the availaible bone for miniscrew placement using panoramic radiographs. However, vertical and horizontal magnifications are inherent in panoramic radiography. Vertical maginification in panoramic radiographs has been reported to be approximately 18-21 %, whereas horizontal magnification is more unreliable. And taking a CT scan for each patient for the same purpose is not feasible because of the cost/benefit ratio and the amount of radiation exposure. Therefore, we selected direct digital radiography with paralleling cone technique which reduces the magnification and angulation errors. To reduce the errors multiple readings (5) at each level by two observers were recorded and the mean was considered as the final reading.

For all skeletal patterns, the safest zone in the interradicular space of the maxilla was the space between the two central incisors, and the space between the second premolar and the first molar. Deguchi et[10] al recently reported that the distance between the second premolar and the mesial root of the first molar at the 6 mm was greater than that of the first molar and the second molar in the maxilla. They concluded that the reason for the high success rate of miniscrew placement in the maxillary premolar area is due to easy access, easy placement surgery and low frequency of root proximity. In the mandible, the safest zones were located between the first and second premolars and between the first and second molars. These results are in agreement with those of previous studies that assessed the interradicular spaces in subjects with minor or no malocclusion. Lee et al[13] in their study using computed tomography also reported that the greatest interradicular distance in the mandible was found between the first and the second premolars, followed by the second premolar and the first molar, followed by first and second molars. There were larger mean differences found between the first and second premolars at every vertical level than the other sites. In the present study, maxillary interradicular spaces, particularly between the second premolars and first molars, and the first and the second molars, in the subjects with skeletal class III were greater than those in the subjects with skeletal class II and class I patterns. In the mandible the interradicular spaces between the first and the second molars were greater in the skeletal Class II subjects than those in skeletal class III subjects, whereas the interradicular distance between the second premolar and the first molar was greatest in the class II subjects followed by class III and class I subjects (at 9mm and 11 mm). The interradicular spaces between the two premolars were greatest in class II subjects followed by class III and class I subjects. These results are contradictory to the previous study conducted by Chaimanee et al[8], they found that the maxillary interradicular spaces, particularly between the first and second molars, in the subjects with skeletal Class II patterns, were greater than those in the subjects with skeletal Class III patterns. In contrast, in the mandible, interradicular spaces in the subjects with skeletal Class III patterns were greater than those in the subjects with skeletal Class II patterns. The possible explanations for this variation of greater interradicular availability of interradicular bone in the mandible for the Class II subjects:

- As we know that the skeletal class II patterns can be a combination of retrognathic mandible and a prognathic maxilla, a normal maxilla and retrognathic mandible and prognathic maxilla and a normal mandible. So, in the Class II subjects with a normal mandible need not necessarily show lesser interradicular spaces than the Class III subjects. The results obtained in the present study show that the values obtained in the Class II and Class III subjects were not very significantly different. It could be a possibility that the subjects in our study had prognathic maxilla and near normal mandibles.
- Tsunori et al[14] reported that the interaction of the muscles of mastication and the craniofacial skeleton plays an important role in the control of craniofacial growth. They reported that there was a significant and complex relationship between structures of the mandibular body and facial type.
- Lee et al[13] reported that the amount of interradicular space can be affected by the shape and length of adjacent roots and their arrangements, ie, tips and torques. When the root shape is conical or pipette shaped, the operator can take advantage of the larger interdental space in the middle or apical portion. Therefore irrespective of the type of dentoskeletal pattern the interradicular space is majorly governed by the root anatomy and their arrangement.
- Fayad et al[16] showed that the eruption of maxillary third molars played an important role in the sagittal inclination of adjacent molars. Therefore, the presence of third molars influences the inclination of the maxillary molars and may play an important role in the availibilty of the interradicular space. Further studies are necessary to investigate the influence of the third molars on the availability of the interradicular space.
- The variations in the finding could also be a result of the ethnic variability, as previous studies were done in other ethnic groups not on the Indian population.

In our study, assessment of interradicular distance was performed by using the alveolar crest as a reference point as it is relatively simple and reliable, and provides a clinical guideline for miniscrew placement as reported by previous studies.

In our study, areas greater than 3 mm interradicular bone width, in the maxilla, were found only at 9- and 11-mm depths from the alveolar crest between the first molar and second premolars, an area likely to be covered by movable mucosa. Schnelle et al[3] & Deguchi et al speculated that the soft tissue irritation and inflammation by the implant is inevitable and suggested the placement of implant at the attached gingiva to reduce the risk of peri implantitis and consequent implant failure. Morarend et al[17] reported the advantage of placing the implant at the attached gingiva. They stated that in addition to providing an environment of reduced inflammation the coronal placement of miniscrews might be biomechanically advantageous because they are closer to the centre of resistance of the teeth. Poggio et al reported that the insertion of miniscrews in the maxillary molar region above 8 mm from the alveolar crest must be avoided because of the presence of the sinus. Doldo T et al[18] also reported that apical level between first and second molar on vestibular side was unsuitable for placement of miniimplants due to the risk of perforating the maxillary sinus, since bone cortex thickness is unpredictable in this area. Some of the clinical reports present in the literature seem to overlook this anatomic variation.

In the mandible as reported by Doldo T, the unsuitable areas for miniscrew implant placement irrespective of the adequate amount of interradicular width are the apical level between the first and the second premolars due to the presence of the foramen mentalis. The maxillary interradicular spaces, particularly between the second premolars and first molars, and the first and the second molars, in the subjects with skeletal class III were greater than those in the subjects with skeletal class II and class I patterns. In the mandible the interradicular spaces between the first and the second molars were greater in the skeletal Class II subjects than those in skeletal class III subjects, whereas the interradicular distance between the second premolar and the first molar was greatest in the class I subjects followed by class III and class II subjects (at 9mm and 11 mm), which is a significant finding and this reading was not observed in any of the previous studies.

In the present study, only the effect of different skeletal patterns and their characteristic dentoalveolar compensation on the availability of interradicular spaces were analyzed. The results obtained were nearly similar to the previous studies which have been done using CBCT. Inspite of the fact that RVGs are cost effective and easily available one of the limitation of RVGs are that they provide limited, two dimensional representations of three dimensional anatomic structures. So the RVGs can be a reliable tool for assessment of interradicular bone but 3-D imaging techniques like CBCT are more accurate and precise.

CONCLUSION

For all skeletal patterns, the safest zone in the interradicular space of the maxilla was the space between the central incisors followed by second premolar and the first molar. In the posterior mandible, the safer zones were located between the first and second premolars and between the first and second molars.

Significant differences in interradicular spaces among the skeletal patterns were observed.

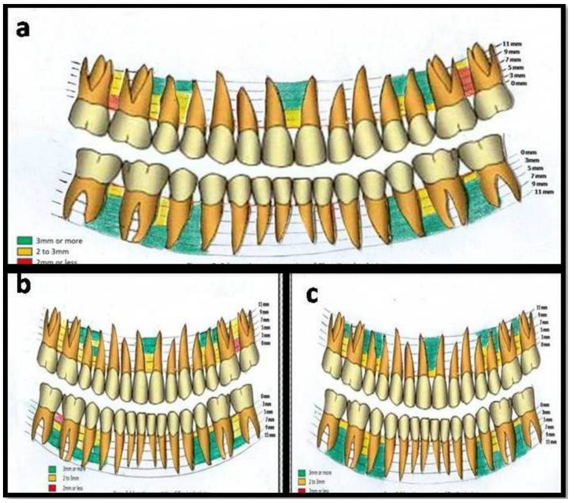

FIGURE 1 : Interradicular measurements at different levels.

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