The optimal position for insertion of orthodontic miniscrews

O posicionamento ótimo para inserção de miniimplantes ortodônticos

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Abstract

Purpose: Miniscrews feature several advantages over other devices used to achieve anchorage; however, using computed tomography (CT) scans to determine the appropriate areas to place these devices for all patients can be expensive. This study aimed to determine the optimal interradicular spaces for miniscrew placement in the mandible and maxilla.

Methods: Using CT images from 12 adult patients, mean interradicular distance and standard deviation values were obtained at heights of 2, 5, 8 and 11 mm from the alveolar bone crest. The means were compared with mean data from the literature.

Results: Considering a height of 3 mm, the most favorable mandibular interradicular distances were found between the first and second molars, first and second premolars, and finally between the canines and first premolars. The most favorable maxillary interradicular spaces were found between the canines and first premolars, between premolars, and between the second premolar and first molar.

Conclusion: The safest interradicular site for miniscrew insertion in the mandible was found to be between the first and second molars, whereas in the maxilla, this site was between the canines and first premolars.

Key words: Tomography; miniscrews

Resumo

Objetivo: Miniimplantes apresentam vantagens sobre outros dispositivos utilizados como recurso de ancoragem, mas a determinação de áreas adequadas, por meio de tomografia computadorizada (TC) em todos os casos pode ser dispendiosa. Este estudo teve como objetivo avaliar o espaço interradicular adequadas para a inserção dos miniimplantes na maxila e mandíbula.

Metodologia: Usando TC de 12 pacientes adultos, foram obtidas média e desvio padrão para a distância interradicular nas alturas de 2, 5, 8 e 11 mm a partir da crista do osso alveolar. As médias foram comparadas com dados da literatura e médias foram novamente obtidas.

Resultados: Levando em conta a altura de 3 mm, a distância interradicular mais favorável na mandíbula foi encontrada entre os primeiros e segundos molares, entre primeiro e segundo pré-molares e, finalmente, entre caninos e primeiros pré-molares, respectivamente. Na maxila, os espaços interradiculares mais favoráveis foram encontrados entre caninos e primeiros pré-molares, entre pré-molares e entre segundos pré-molares e primeiro molar, respectivamente.

Conclusão: O local mais seguro para a inserção de miniimplantes interradiculares na mandíbula foi encontrada entre os primeiros e segundos molares, enquanto que na maxila, entre os caninos e primeiros pré-molares.

Palavras-chave: Tomografia; miniinplantes

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Introduction

The search for orthodontic treatment methods requiring minimal patient compliance while simultaneously providing maximal anchorage has led professionals to use a wide array of devices, such as mini-plates, dental implants and miniscrews (1). Miniscrews offer advantages such as their small size, low cost, streamlined insertion and removal surgical procedures and immediate load while (2-4) providing adequate anchorage to enable orthodontic movements (5).

Determining what type of orthodontic movement will be used prior to miniscrew placement is of paramount importance because insertion at an unsuitable site is likely to restrain the desired movement (6). Miniscrews can be inserted in a variety of maxillary and mandibular sites, notably in the interradicular spaces between adjacent teeth (7,8) as well as in the palate and retromolar area (9).

Screw length is not associated with stability for screws longer than 5 mm, whereas screw diameter has been significantly associated with stability (10). Unlike endosseous dental implants that osseointegrate, orthodontic miniscrews achieve stability primarily through mechanical retention and can be displaced within the bone (11). Failures have been noted with miniscrews inserted into gingival soft tissue areas, where there is a greater risk of tissue irritation and inflammation (12,13). There seems to be insufficient space for miniscrew placement and adequate bone and implant contact in areas of attached gingiva more than 6 mm above the alveolar bone crest (14).

Prior to implantation, both the site of placement and angulation of the miniscrew should be determined based on the patient's anatomical features (15). If the amount of interradicular bone, its inclination or its proximity to the roots are not properly assessed, the risk of root perforation increases.

Radiographic examinations should be conducted to determine whether there is adequate interradicular space for miniscrew insertion. Computed tomography (CT) enables very accurate assessments of interradicular spaces, but it is more expensive and involves greater radiation exposure. Periapical radiographic exams are simpler, are less expensive, require lower radiation exposure and can be used to evaluate the proximity of the miniscrew to the roots (13). Assessment using panoramic radiographs can reveal that certain areas do not comprise sufficient interradicular bone for miniscrew placement, which underscores the need for periapical radiographs to ensure a more accurate analysis (16). Each test has advantages and disadvantages, but they would all be unnecessary if professionals could have prior knowledge of the most favorable sites for miniscrew placement both in the maxilla and mandible.

Miniscrews are approximately 1.2 to 1.5 mm in diameter and are not completely stable. Rather, they tend to drift by an average of less than 0.5 mm. It is therefore advisable to allow a 2 mm space (1 mm on each side) between the miniscrews and adjacent anatomical structures. The adjacent tooth roots are also at risk (12) and can be damaged if interradicular distances are not properly assessed (17,18). Because the width of the periodontal ligament measures approximately 0.25 mm, a 1 mm slack space on the alveolar bone around the miniscrew should be sufficient to ensure periodontal health (4).

This study sought to assess mesiodistal interradicular distances at heights of 2, 5, 8 and 11 mm measured from the alveolar bone crest, using measurements obtained from CT images along with data from other studies to determine the most favorable sites for miniscrew placement.

Methods

To determine the interradicular spaces in the mandible and maxilla, linear CT image measurements were obtained using as subjects 12 patients referred for orthodontic treatment to the Orthodontic Clinic of the Fluminense Federal University, in Niteroi, RJ, Brazil. The patients were made aware of and voluntarily consented to all procedures performed in this study, and all applicable bioethical standards were observed.

The criteria for patient selection were as follows: Angle Class I malocclusion with bimaxillary protrusion; permanent dentition; all teeth present except the third molars; adults between 20 and 30 years of age; a treatment plan requiring the extraction of 4 bicuspids; no clinical or radiographic signs of periodontal disease or other pathologies associated with soft or hard tissues; and no gender or race distinctions.

CT scans of the subjects were obtained for the following planes: axial (longitudinal), panoramic and cross-sectional (Fig. 1 and 2). The CT slices were 1-mm thick section intervals measured with Dental Slice software, version 2.1 (Bio Parts - *www.bioparts.com.br*) supplied with a Newton 3G scanner (QR Verona, **Italy**). This software features a ruler with a centesimal scale in millimeters, which was used to obtain the measurements.

The central trend measurements (mean and standard deviation values) for the interradicular spaces were taken from the bone crest at heights of 2, 5, 8 and 11 mm.

Interradicular space mesio-distal (M-D) (Figure 1A, mandible and Figure 2A, maxilla) distances were measured based on a line drawn with the aid of the software across the dental crown centers and in the buccolingual orientation. Subsequently, the vertical heights of 2, 5, 8 and 11 mm were analyzed for the M-D measurements, which were made between the sites where the lines touched the tooth roots (Table 1)**.**

A PubMed (Medline) search query was performed, encompassing the period from January 1990 to June 2010 to identify the maximum number of studies in which miniscrews were inserted into safe interradicular zones. The information sources were periodicals in the following specialties (key words): mini-implants, microimplants, miniscrews, microscrews, safe zones, anchorage, interradicular space, interradicular sites, interradicular distance, root proximity, tomographic, three-dimension, cone beam. These data were combined with the data from this study to build a more reliable data set for determining the safest sites for miniscrew placement.

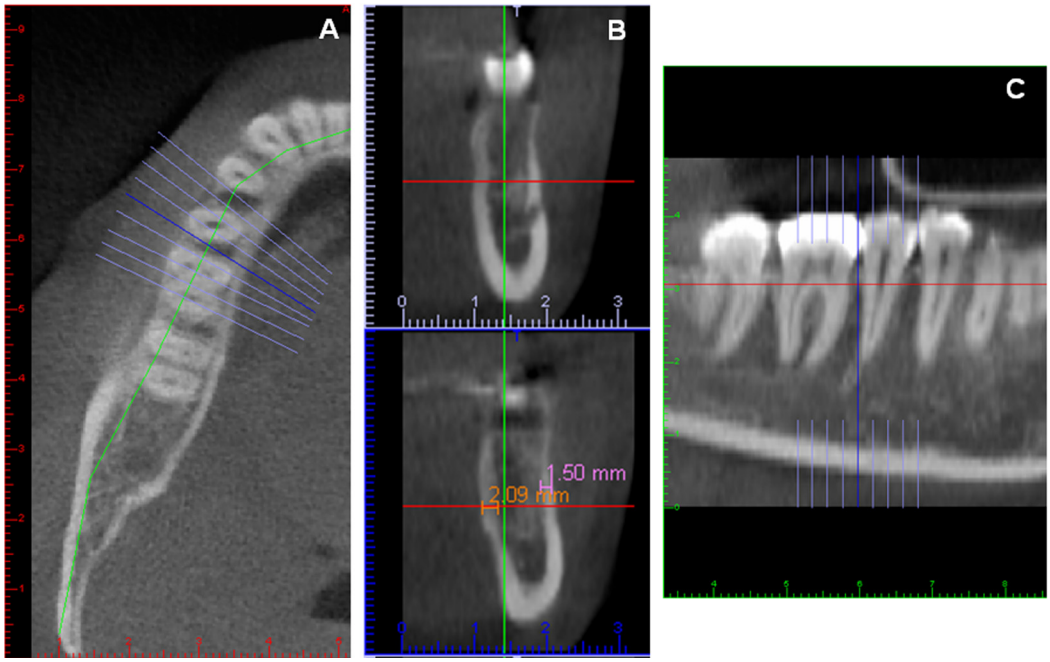

Fig. 1. **(A)** Axial image showing oblique sagittal slices in the **mandible**; **(B)** oblique sagittal slice, illustrating a cortical bone measurement in the buccolingual orientation between the left first molar and second premolar; **(C)** panoramic slice showing the distance between the left first molar and second premolar roots.

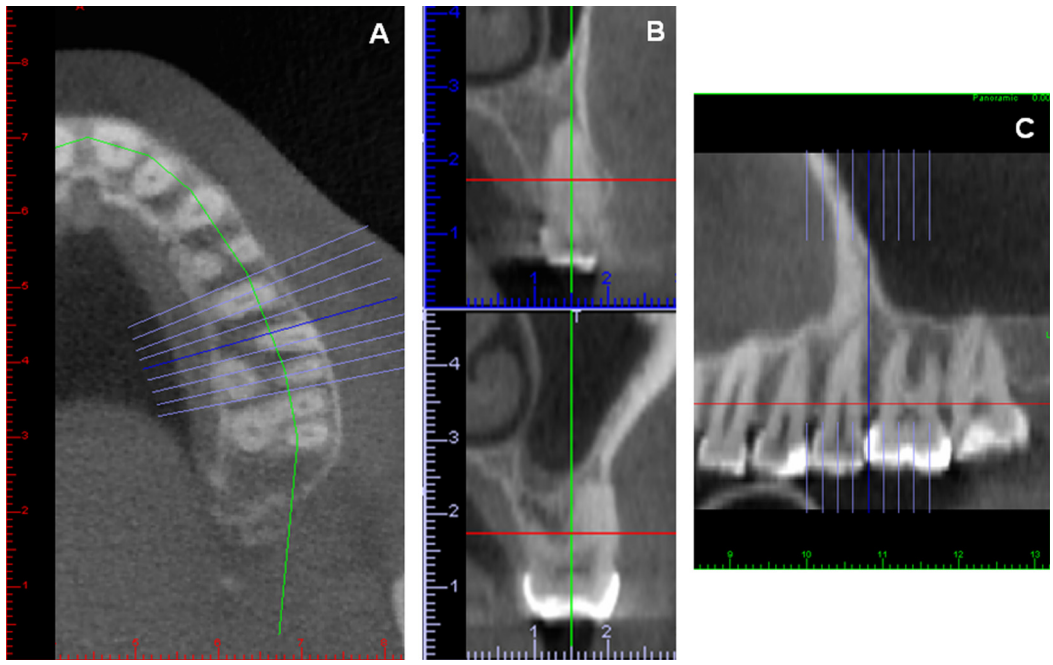

Fig. 2. **(A)** Axial image showing oblique sagittal slices in the **maxilla**; **(B)** oblique sagittal slice, illustrating a cortical bone measurement in the buccolingual orientation between the right first molar and second premolar; **(C)** panoramic slice showing the distance between the right first molar and second premolar roots.

Results

The data were collected and organized into tables, from which mean and standard deviation values were calculated. One asterisk represents sites that are favorable with caution for miniscrew insertion. Care should be taken to assess these areas when planning miniscrew insertions, considering individual variations and anatomical features. Two asterisks indicate sites that proved most favorable for miniscrew insertion.

Considering that the sample size was small (12 subjects) and after analyzing data obtained for the two sides of the arches (left and right), the data were found to be very similar for each region evaluated; we therefore summed the data from each region, which constitutes the total sample in this study.

This study did not assess the regions located between the lower incisors, as these were extremely narrow, thus rendering miniscrew insertion impracticable. Only the region below the incisor apexes proved suitable for implant placement, but this area was not investigated in the present study.

Table 1 shows the maxilla and mandible interradicular distances. In the maxilla, the greatest interradicular distance was found at the height of 11 mm (first molar and second premolar, first and second premolars, first premolar and canine) and 8 mm (first premolar and canine). In the mandible, the greatest interradicular distance was at the heights of 11 mm (first and second molars, first molar and second premolar), 8 mm (first and second molars, first molar and second premolar, first and second premolars, canine and lateral incisor), 5 mm (first and second molars, first molar and second premolar, first and second premolars, premolar, first and second premolars, first premolar and canine, canine and lateral incisor) and 2 mm (first and second molars and first and second premolars).

Table 2 shows data from other published studies in comparison with the data from this study regarding the safest insertion sites for miniscrews in the mandible and maxilla. It should be noted that most studies sought to determine suitable areas only in the mandible.

Table 1. Measurements (mean and standard deviation values) of interradicular distance (M-D) in the maxilla and mandible on the areas of teeth 2-3, 3-4, 4-5, 5-6 and 6-7 at heights of 2, 5, 8 and 11 mm.

Assessed sites	Heights	Distances between Maxilla and Mandible – teeth (mm)									
		2-3		3-4		4-5		5-6		6-7	
		Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Maxilla Interradicular Distance M-D	2 mm	1.35	0.41	1.60	0.53	1.45	0.40	1.75	0.61	1.29	0.39
	5 mm	1.64	0.51	1.70	0.58	1.41	0.47	1.77	0.70	1.03	0.39
	8 mm	1.66	0.54	2.16*	0.85	1.55	0.54	1.95	0.90	1.01	0.35
	11 mm			2.73*	0.96	2.07*	0.76	2.04*	1.09	1.59	0.88
Mandible Interradicular Distance M-D	2 mm	1.19	0.51	1.28	0.56	2.22*	0.65	1.89	0.68	2.53*	1.07
	5 mm	1.79	0.79	3.42**	0.97	2.53*	0.90	2.04*	0.84	2.76*	1.22
	8 mm	2.87*	1.42	1.73	0.83	2.90*	1.11	2.24*	0.85	3.32**	1.72
	11 mm	2.67*	2.17	1.78	0.78	3.58**	1.40	2.70*	0.87	4.48**	1.69

* = Caution; ** = Favorable.

Table 2. Data from other published studies in comparison with the data from this study regarding the safest insertion sites for insertion of miniscrews in the mandible and maxilla according to the different heights.

	Author/Year	N	Measures between teeth – Location from the bone crest																			
			7-6				6-5				5-4				4-3				3-2			
			0-3 mm	3-6 mm	6-9 mm	9-12 mm	0-3 mm	3-6 mm	6-9 mm	9-12 mm	0-3 mm	3-6 mm	6-9 mm	9-12 mm	0-3 mm	3-6 mm	6-9 mm	9-12 mm	0-3 mm	3-6 mm	6-9 mm	9-12 mm
MAXILLA	Pogio et al., 2006 (20)	25	2.5	2.3	2.5	0.8	2.7	2.9	3.0	1.6	2.9	3.2	3.5	3.3	3.0	3.4	3.9	4.3	----	----	----	----
	Degushi et al., 2006 (2)	10	----	1.5	3.8	----	----	2.1	6.1	----	----	----	----	----	----	----	----	----	----	----	----	----
	Bittencourt et al.*	12	1.2	1.0	1.0	1.5	1.7	1.7	1.9	2.0	1.4	1.4	1.5	2.0	1.6	1.7	2.1	2.7	1.3	1.6	1.6	----
	Mean		1.8	1.6	2.4	1.1	2.2	2.2	3.6	1.8	2.2	2.3	2.5	2.6	2.3	2.5	3.0	3.5	1.3	1.6	1.6	----
MANDIBLE	Pogio et al., 2006 (20)	25	3.2	3.0	3.5	4.7	3.0	2.9	3.1	3.9	3.2	3.7	4.3	4.9	2.7	2.8	3.0	3.5	----	----	----	----
	Degushi et al., 2006 (2)	10	----	1.5	5.4	----	----	1.7	4.6	----	----	----	----	----	----	----	----	----	----	----	----	----
	Monerat et al., 2009 (13)	15	3.7	4.1	4.9	6.2	3.0	3.2	3.9	4.5	2.6	3.0	3.7	3.9	1.9	2.1	2.4	2.8	1.8	2.1	2.6	3.0
	Park and Cho, 2009 (21)	60	----	1.6	1.6	2.0	----	2.4	2.7	3.3	----	2.0	2.2	2.4	----	2.2	2.4	2.6	----	----	----	----
	Bittencourt et al.*	12	2.5	2.7	3.3	4.4	1.8	2.0	2.2	2.7	2.2	2.5	2.9	3.5	1.2	3.4	1.7	1.7	1.1	1.7	2.8	2.6
	Mean		3.1	2.6	3.7	4.3	2.6	2.4	3.3	3.6	2.6	2.8	3.3	3.7	1.9	2.6	2.4	2.6	1.5	1.9	2.7	2.8

* = Present study.

Discussion

This study aimed to assess, using tomographic images and a literature review, which areas showed an adequate interradicular space for miniscrew insertion with the aim of simplifying the decision-making process with the use of diagnostic tools that are less cumbersome than CT for the examiner in charge of the procedure.

Miniscrew insertion into the interradicular space should avoid the space between roots (5). To accomplish this, one can displace the implant towards the apical region, for example. Miniscrew insertion into the alveolar bone between the roots and closer to the orthodontic archwires seems more favorable than in the basal bone because inserting the miniscrew in this area enhances the horizontal force component, thereby facilitating a wider variety of tooth movements (19).

Table 1 shows that the largest amount of interradicular bone in the mandible was found between the first and second molars (4.48 mm, ±1.69) at a height of 11 mm from the bone crest, and we therefore considered this the safest area for miniscrews of up to 1.5 mm in diameter.

No reliable space was found for miniscrew insertion between the laterals and canines in the mandible at heights of 2 mm (1.19 mm, ±0.51) or 5 mm (1.79 mm, ±0.79); between the canines and bicuspids at heights of 2 mm (1.28 mm, ±0.56), 8 mm (1.73 mm, ±0.83) or 11 mm (1.78 mm, ±0.78), or between the second bicuspids and first molars at a height of 2 mm (1.89 mm, ±0.68). Monnerat et al. (13) also found that the most reliable sites for miniscrew insertion in the mandible are the spaces between the firts and second molars at heights between 9 mm and 12 mm.

There is little interradicular space between the mandibular incisors, which renders the placement of miniscrews between their roots impracticable. The largest amount of interradicular bone found in the maxilla was located between the canines and first premolars (2.73 mm, ±0.96) at an 11 mm height from the bone crest, and we therefore considered this the safest area for miniscrews of up to 1.2 mm in diameter.

The second largest amount of interradicular bone found in the maxilla was located between the canines and first premolars (2.16 mm, ±0.85) at an 8 mm height from the bone crest, between the premolars (2.07 mm, ±0.76) at an 11 mm height, and between the second premolar and first molar (2.04 mm, ±1.09) at a height of 11 mm from the bone crest.

As in this study, most previous reports did not evaluate the interproximal spaces in the incisor region because of their insufficient size. The literature survey revealed that the results for the main regions assessed in the studies show a very close agreement, with only a few differences (13) found in the mandibular molar area, perhaps due to differences in sample characteristics or size. Table 2 shows that the largest amount of interradicular bone in the maxilla was found between the second bicuspid and first molar (3.6 mm) at a height of 6-9 mm from the bone crest.

The second largest amount of interradicular bone in the maxilla was found between the canines and first bicuspids at heights of 9-12 mm (3.5 mm) and 6-9 mm (3.0 mm). The largest amount of interradicular bone found in the mandible was located between the first and second molars (4.3 mm) at a height of 9-12 mm from the bone crest. The second largest amount of interradicular bone found in the mandible was located between the premolars (3.7 mm) at a height of 9-12 mm from the bone crest and between the molars (3.7 mm) at 6-9 mm from the bone crest. The third largest amount of interradicular bone in the mandible was located between the second premolar and first molar (3.6 mm) at 9-12 mm from the bone crest. The fourth largest amount of interradicular bone in the mandible was found between the premolars (3.3 mm) at a height of 6-9 mm from the bone crest and between the second premolar and first molar (3.3 mm) at a height of 6-9 mm from the bone crest. The fifth largest area in terms of the amount of interradicular bone in the mandible was located between the molars (3.1 mm) at a height of 0-3 mm from the bone crest.

Figure 3 presents schematic data illustrating the total results from Table 2 to provide a simple, summarized view of the results. Red areas constitute dangerous sites for miniscrew placement; yellow areas show average risk, and green areas are the most favorable.

In examining the quality and quantity of interradicular bone, further studies are required to assess the safest places for miniscrew insertion to promote maximum anchorage and stability without damaging the teeth or surrounding structures.

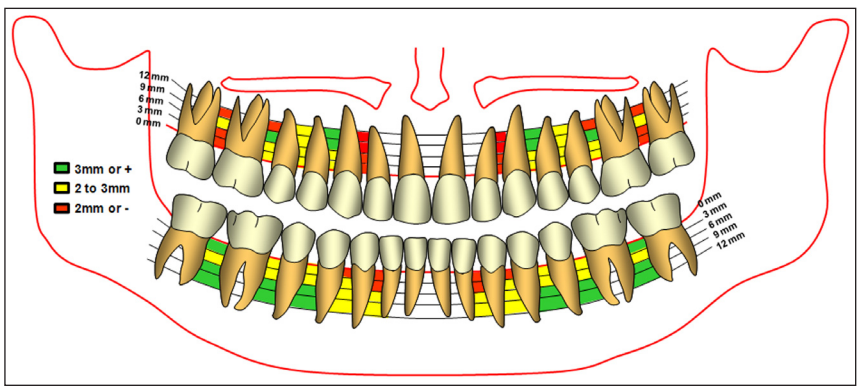

Fig. 3. Schematic data illustrating the compiled results from Table 2. Red areas indicate dangerous sites, yellow areas show sites of average risk and green areas are the most favorable.

Conclusions

The methodology used in this study and a review of the relevant literature have led us to conclude that the best sites for the placement of miniscrews are the following:

1. In the maxilla, at a height of 6-9 mm from the crest of the second premolar and first molar (3.6 mm).
2. In the mandible, at a height of 9-12 mm between the molars (4.3 mm).

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