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X-ray beam angulation can compromise 2-dimensional diagnosis of interradicular space for mini-implants

Sérgio Estelita Barros,[a] Matilde Abella,[a] Guilherme Janson,[b] and Kelly Chiqueto[a]
Rio Grande do Sul and São Paulo, Brazil

Introduction: The aim of this research was to evaluate the influence of x-ray projection geometry on interradicular space of the posterior maxillary arch. **Methods:** Cone-beam computed tomography (CBCT) scans of 32 patients (16.85 ± 4.93 years) who met the selection criteria were enrolled. One hundred ninety-two interradicular sites of the posterior maxillary arch were evaluated. Before measurements, each side of the maxillary arch was orientated in all 3 planes of space to obtain CBCT synthesized periapical radiographs with 0° projection geometry (orthogonal x-ray beam—orthogonal X-ray angulation [OX]). Standardized CBCT axial rotations (10°, 20°, –10°, and –20°) were used to simulate periapical radiographs taken with mesial and distal angulation of the x-ray beam (mesial x-ray angulation [MX] and distal x-ray angulation [DX]). Interradicular space widths were measured on OX, MX, and DX CBCT synthesized periapical radiographs. Measurements were performed parallel to the occlusal plane at 3 mm and 6 mm apical to the midpoint of the alveolar crest. Interradicular distances were statistically compared ($P < 0.05$). **Results:** Interradicular distances measured on MX and DX CBCT synthesized periapical radiographs were significantly smaller than those measured on OX. Interradicular distance was significantly correlated with the horizontal angulation of the x-ray beam. X-ray projection angle was the most influential variable on interradicular distance. About 30% reduction in interradicular space was observed for every 10° of deviation from orthogonal x-ray. **Conclusion:** Two-dimensional radiographs obtained away from the 0° projection geometry can reduce the actual interradicular space for mini-implants, inducing misdiagnosis. (Am J Orthod Dentofacial Orthop 2019;156:593-602)

Mini-implants have been an unmatched option to treat severe malocclusions requiring a high orthodontic anchorage level. The choice of mini-implant insertion site is mainly influenced by orthodontic mechanics and bone availability.[1] The interradicular septum is an insertion site widely used for mini-implant placement because of its high clinical applicability.[2] Several tomographic studies were already performed to determine the mean space between tooth roots.[2-4] Despite this, a presurgical radiograph is routinely indicated to evaluate the interradicular space because individual deviations from the population mean may put the integrity of adjacent roots and mini-implant stability at risk.[4-7]

A presurgical cone-beam computed tomography (CBCT) exam provides a 3-dimensional (3D) evaluation of the insertion site and allows building accurate surgical guides.[8,9] However, the guidelines for clinical use of CBCT has been considered controversial; its indication only to aid interradicular mini-implant insertion.[10-14] By contrast, pretreatment CBCT scans may not be useful to guide mini-implant placement after initial teeth alignment because of axial root changes and interradicular space redistribution. Considering that mini-implants are more frequently required after teeth alignment, 2-dimensional (2D) radiographs have been the most used presurgical exams for interrradicular mini-implant insertion.[10] Furthermore, 2D imaging is less expensive and less complex to be obtained in dental clinics.[10,15]

[a]Division of Orthodontics, Faculty of Dentistry, Federal University of Rio Grande do Sul, Porto Alegre, Rio Grande do Sul, Brazil.
[b]Department of Orthodontics, Bauru Dental School, University of São Paulo, Bauru, São Paulo, Brazil.

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Address correspondence to: Sérgio Estelita Barros, Division of Orthodontics, Faculty of Dentistry, Federal University of Rio Grande do Sul, Rua Ramiro Barcelos, 2492 Bairro Santana, Porto Alegre, Rio Grande do Sul 90035-003 Brazil; e-mail, sergioestelita@yahoo.com.br.

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In most cases, a periapical radiograph is enough to ensure accurate and safe mini-implant insertion between the tooth roots with a lower radiation dose.[10] However, periapical radiographs may underestimate the bone availability in the interradicular septum, since 2D images can only display the narrowest interradicular distance.[2] This fact seems to become even more critical if x-ray oblique projection is present and if it involves the maxillary arch, where interradicular bone availability is naturally smaller.[16-18] Periapical radiographs of the posterior maxillary arch are more frequently affected by improper x-ray projection angle.[19] It has been demonstrated that different horizontal angulations of the x-ray beam can influence the diagnosis of interproximal caries,[20,21] furcation defects,[22] proximal infrabony pocket,[23] and periodontal ligament width.[24]

It has been speculated that changes in the horizontal angulation of the x-ray beam could also produce misdiagnosis of interradicular space width and bone availability for mini-implant insertion.[16,17] However, no systematic study has been conducted to evaluate this assumption. Considering that an adequate interradicular space is an essential condition for mini-implant insertion, the aim of this study is to evaluate the influence of x-ray projection geometry on interradicular space of the posterior maxillary arch, using synthesized periapical radiographs from CBCT scans.

MATERIAL AND METHODS

This investigation was based on pretreatment CBCT scans retrospectively selected from a pool of 415 treated patients, from the files of the Department of Orthodontics, Faculty of Dentistry, University of Rio Grande do Sul. It was approved by the corresponding institutional review board, number 2.697.580. The diagnostic purposes of the CBCT images were in accordance with the SEDENTEXCT[14] and the American Academy of Oral and Maxillofacial Radiology guidelines.[25]

The sample size was calculated using values of α (type 1 error) and β (type II error) at 5% and 20%, respectively. The value of the variance of measurements σ^2 (standard deviation) was based on a previous study.[4] The minimum difference to be detected between interradicular spaces obtained from different horizontal x-ray beam angulations was 0.3 mm. Based on these parameters, a sample with 64 interradicular units for each interradicular site of the posterior maxillary arch was required.

Sample selection was based on the following criteria: (1) presence of all maxillary permanent teeth up to the second molar; (2) absence of posterior maxillary tooth size-arch length discrepancy, teeth rotation (teeth displacement <1 mm according to the American Board of Orthodontics grading system),[26] or ectopic eruption; (3) no radiographic evidence of periodontal disease; (4) absence of root shape anomalies.

According to the sample size calculation and selection criteria, CBCT scans of 32 patients (20 males and 12 females) with a mean age of 16.85 ± 4.93 years were enrolled in this study. Scans were performed with an i-CAT machine (Imaging Sciences International, Hatfield, Pa) at these settings: 36.9 mA, 120 kVp, exposure time of 40 seconds, an isotropic voxel size of 0.4 mm, and 16 × 22 cm field of view. Patients were scanned with their teeth together in centric occlusion and the Frankfort horizontal plane parallel to the floor. The CBCT scans were imported into Dolphin 3D software (version 11.5; Dolphin Imaging and Management Solutions, Chatsworth, Calif) for analysis as digital imaging and communications in medicine multifiles. Three different interradicular sites, located between maxillary premolars (4-5), premolar and molar (5-6), and molars (6-7) on each dental arch side of each patient were evaluated, totaling 192 interradicular units (64 units in each site).

Before measurement, each side of the posterior segment of the maxillary arch had interradicular spaces orientated in all 3 planes of space (Fig 1). Initially, the 3D maxillary orientation was adjusted to obtain CBCT synthesized periapical radiographs according to the paralleling technique principles (ie, 0° x-ray projection geometry; Fig 1).[27] The occlusal plane was positioned parallel to the horizontal reference line supplied by the software using the sagittal slice (Fig 1, *A*). The coronal slice was used to position the long axes of the posterior maxillary teeth parallel to the vertical reference line (Fig 1, *B*). The axial slice was used to vertically position a line passing through the contact points of the posterior maxillary teeth (Fig 1, *C*). These methodological procedures reorientated the 3D position of the posterior maxillary arch to obtain CBCT synthesized periapical radiographs using orthogonal x-ray beam (orthogonal X-ray angulation [OX]; Figures 1 and 3, *A*).[28]

From these settings (Fig 1, *A-D*), intentional axial rotations were performed in the head position to simulate deviations of horizontal angulation of the x-ray beam from 0° projection geometry (Fig 2).[20,24] The axial slice was then handled to produce standardized clockwise and counterclockwise rotations of the posterior maxillary arch (Fig 2, *A-D*), to obtain CBCT synthesized

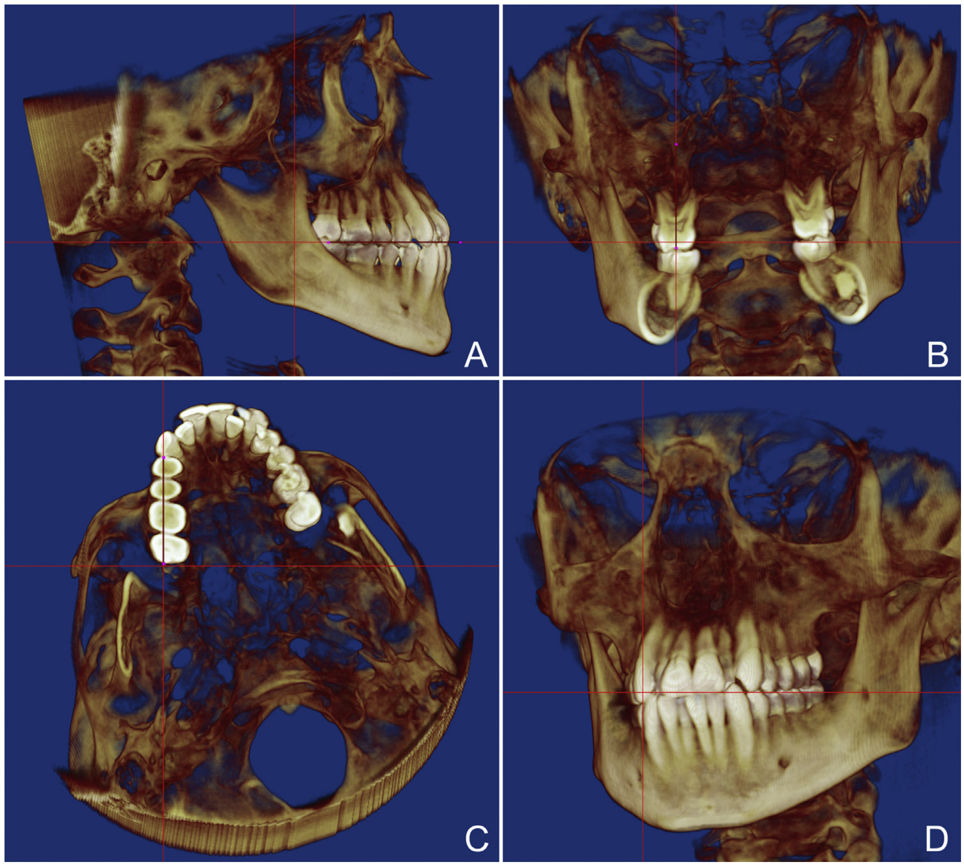

Fig 1. 3D orientation of the posterior maxillary arch. **A,** Occlusal plane parallel to the horizontal reference line. **B,** Long axes of the posterior maxillary teeth parallel to the vertical reference line. **C,** Line of the contact points of the posterior teeth parallel to the vertical reference line. **D,** Final 3D positioning of the posterior maxillary arch used to obtain CBCT synthesized periapical radiographs with 0° projection geometry.

periapical radiographs taken with mesial and distal angulations of the x-ray beam (mesial x-ray angulation [MX] and distal x-ray angulation [DX]; Fig 3, *B*).[28] Thus, the CBCT synthesized periapical radiographs taken with orthogonal, mesial, and distal angulations of the x-ray beam (OX 0°, MX 10° and 20°, and DX −10° and −20°) were obtained from each side of the posterior maxillary arch (Fig 3, *A* and *B*). The MX angulations were standardized as positive, whereas the DX angulations were identified as negative. (MX 10° and 20°; DX −10° and −20°).[22,24]

All CBCT synthesized periapical radiographs were built using a 2D lateral cephalometric view adjusted to generate a perspective projection with 5% magnification (Fig 3), which is consistent with the magnification factor associated with periapical radiographs taken from the posterior maxillary arch using paralleling technique (5%-6%).[29,30] Although CBCT synthesized periapical radiographs required a thicker CBCT slice, it has been demonstrated that its influence on measurement accuracy is known and clinically acceptable.[31-33]

Afterward, the synthesized periapical radiographs were used to measure the interradicular distance width at 3 mm and 6 mm apical to the alveolar crest. The vertical heights were defined on a vertical line perpendicular to the occlusal plane, passing through the midpoint of the alveolar crest (Fig 4). The distances between the adjacent roots were measured on a horizontal line parallel to the occlusal plane, passing 3 mm and 6 mm apical to the bone crest (Fig 4). When the mesial or distal angulations of the x-ray beam produced root overlapping of the adjacent teeth, showing no available interradicular space, 0 mm was recorded.

An experienced and trained orthodontist (S.E.B.) made all measurements. Intraclass correlation

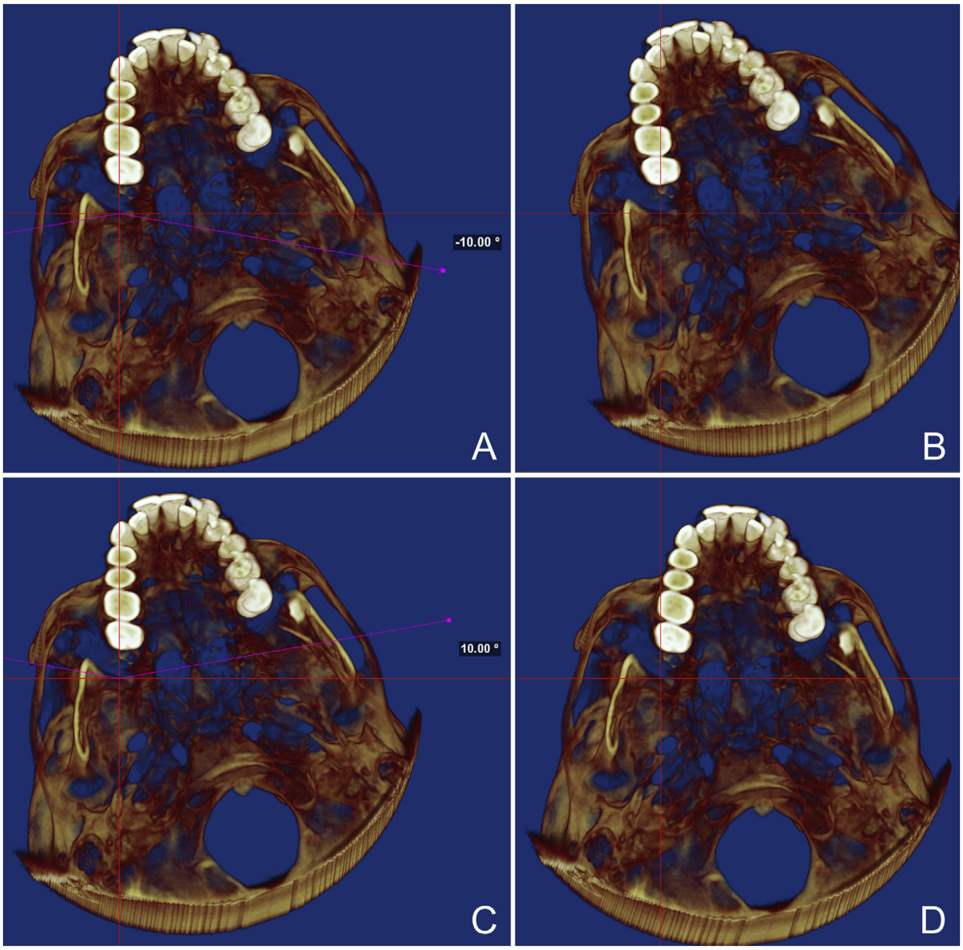

Fig 2. Axial rotations performed to simulate mesial and distal angulation of the x-ray beam. **A,** Software setting to produce axial counterclockwise rotation of 10°. **B,** Axial rotation to simulate mesial angulation of the x-ray beam. **C,** Software setting to produce axial clockwise rotation of 10°. **D**, Positioning to simulate distal angulation of the x-ray beam.

coefficient (ICC) was used to check the intraexaminer reliability. Three-dimensional orientation of the maxillary arch and interradicular space measurements were repeated by the same examiner with an interval of 3 weeks, on 25% of the CBCT scans randomly selected.

Statistical analysis

Descriptive statistics for interradicular space measurements were calculated for each set of vertical height and x-ray angulation. The Shapiro-Wilk test did not show normal distribution of the data, and statistical evaluation was performed using nonparametric tests.

Interradicular distances measured on CBCT synthesized periapical radiographs obtained with OX, MX (10° and 20°), and DX (−10° and −20°) angulations were compared using Kruskal-Wallis test by rank, followed by a Dunn multiple comparison test. The correlation between the interradicular distance and x-ray angulation was evaluated with a Spearman rho (*r*) correlation test.

To evaluate the influence of the studied variables on interradicular space width, a multiple regression analysis was performed. Interradicular space was taken as a dependent variable, whereas the x-ray angulation, interradicular site (interradicular distance between maxillary premolars (PMs); interradicular distance between maxillary second premolar and first molar (PM-M) and interradicular distance between first and second molars [Ms]), and measurement height (3 mm and 6 mm) were independent variables.

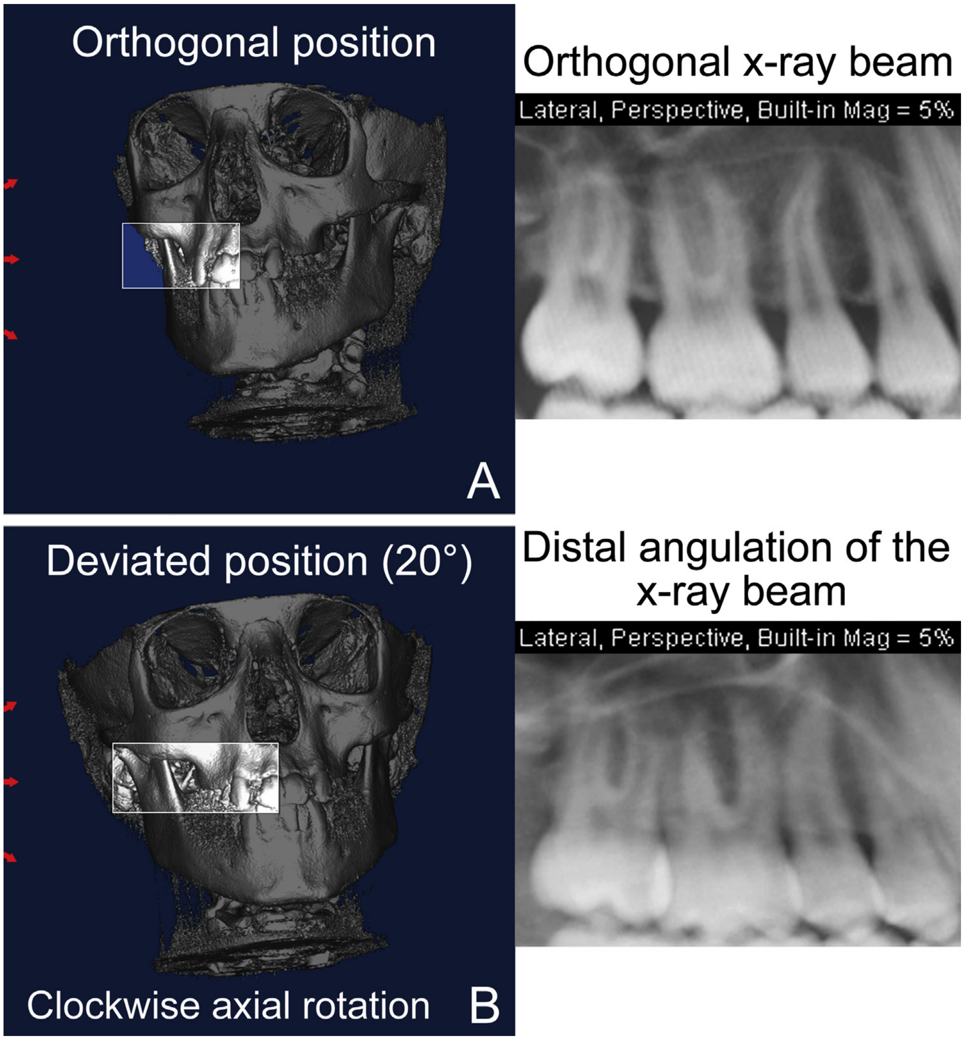

Fig 3. Obtainment of CBCT synthesized periapical radiographs. **A,** Synthesized periapical radiograph taken with orthogonal x-ray. **B,** Synthesized periapical radiograph taken with distal angulation of the x-ray beam (20°).

The mean reduction of the interradicular space width produced by changes of the x-ray angulation from 0° projection geometry was calculated for each interradicular site and measurement height.

Statistical analyses were performed with Statistica for Windows software (version 7.0; StatSoft, Tulsa, Okla). The results were considered statistically significant at $P < 0.05$.

RESULTS

The ICC indicated excellent 3D orientation consistency and measurement reliability. Interradicular sites between PMs, PM-M, and Ms had an ICC of 0.969 (95% confidence interval [CI], 0.956-0.978), 0.973 (95% CI, 0.962-0.98), and 0.935 (95% CI, 0.907-0.954), respectively.

Changes in horizontal angulation of the x-ray beam from its orthogonal position produced synthesized periapical radiographs with significant reduction of the interradicular space width for all measurement heights. This fact was true for both mesial and distal angulation of the x-ray beam (Tables I and II). In general, the mean reduction of interradicular space ranged from 0.5-1 mm for every 10° change in x-ray angulation, to mesial or distal, accumulating a mean reduction that ranged from 1-2 mm for 20° angulation (Fig 5).

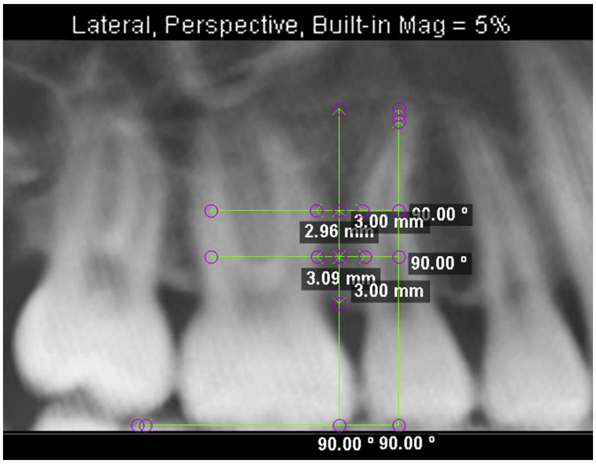

Fig 4. Interradicular distance measurement performed parallel to the occlusal plane at 3 mm and 6 mm apical to the midpoint of the alveolar crest.

Table I. Interradicular distances obtained from orthogonal and mesial angulation of the x-ray beam

Variables (mm)		OX (n = 64) Mean	OX SD	MX 10° (n = 64) Mean	MX 10° SD	MX 20° (n = 64) Mean	MX 20° SD	P*
PMs	3	2.61[a]	0.60	1.87[b]	0.56	0.98[c]	0.55	<0.001
PM-M	3	2.58[a]	0.58	2.01[b]	0.61	1.03[c]	0.62	<0.001
Ms	3	1.54[a]	0.57	0.74[b]	0.58	0.16[c]	0.29	<0.001
PMs	6	2.83[a]	0.73	2.14[b]	0.71	1.30[c]	0.67	<0.001
PM-M	6	2.81[a]	0.80	2.30[b]	0.79	1.38[c]	0.85	<0.001
Ms	6	1.11[a]	0.74	0.41[b]	0.53	0.07[c]	0.21	<0.001

Note: Comparison by Kruskal-Wallis followed by Dunn tests.
SD, standard deviation.
[a,b,c]Different letters represent statistically significant differences.
*Statistically significant at $P < 0.05$.

Table II. Interradicular distances obtained from orthogonal and distal angulation of the x-ray beam

Variables (mm)		OX (n = 64) Mean	OX SD	DX −10° (n = 64) Mean	DX −10° SD	DX −20° (n = 64) Mean	DX −20° SD	P*
PMs	3	2.61[a]	0.60	1.85[b]	0.64	1.01[c]	0.61	<0.001
PM-M	3	2.58[a]	0.58	1.71[b]	0.61	0.75[c]	0.57	<0.001
Ms	3	1.54[a]	0.57	0.90[b]	0.56	0.29[c]	0.43	<0.001
PMs	6	2.83[a]	0.73	2.09[b]	0.81	1.20[c]	0.75	<0.001
PM-M	6	2.81[a]	0.80	1.75[b]	0.76	0.84[c]	0.72	<0.001
Ms	6	1.11[a]	0.74	0.77[b]	0.67	0.31[c]	0.54	<0.001

Note: Comparison by Kruskal-Wallis followed by Dunn tests.
SD, standard deviation.
[a,b,c]Different letters represent statistically significant differences.
*Statistically significant at $P < 0.05$.

The interradicular distance showed a significant correlation with the x-ray angulations used to obtain the synthesized periapical radiographs (Table III). Thus, the more the clockwise or counterclockwise axial rotation deviated the posterior maxillary arch away from the orthogonal position (Fig 1, *D* and 3, *A*), the more the imaging of the interradicular space was reduced by x-ray projection geometry (Fig 3, *B*).

Regression analysis showed that all studied variables presented significant influence on the reduction of the interradicular space width (Table IV). This multivariate model explained about 50% of the interradicular distance variability (R^2). The change in x-ray angulation was the most influential variable (−0.544), whereas the measurement height of the interradicular space was the least influential variable (0.041). Considering the interradicular distance measured from the orthogonal x-ray projection, the total mean reduction in the posterior maxillary arch was about 30% for each 10° of deviation in both mesial and distal directions (Table V).

DISCUSSION

Two-dimensional radiographic imaging is frequently used to insert mini-implants.[10] Although CBCT scanning has been used to aid mini-implant interradicular insertion,[8,9] 2D radiographs involve lower radiation dose, lower cost, more affordable technology, besides providing the required information.[10] It has been speculated that the 2D diagnosis accuracy of the insertion site may be affected by the x-ray projection geometry.[16,17] But to our knowledge, this is the first study that quantified the influence of x-ray projection geometry on the interradicular space width for mini-implants.

Theoretically, periapical radiographs should be the most suitable 2D imaging to evaluate interradicular space, because panoramic machines frequently produce x-ray oblique projections owing to the discrepancy between the projection angle of the x-ray beam and the dental arch form.[34] However, it has been demonstrated that incorrect x-ray beam angulation and patient positioning summed more than 50% of all errors for intraoral radiographs.[35] In addition, errors in horizontal angulation of the x-ray beam seem to be more frequent than vertical errors.[36] Finally, periapical radiographs of the posterior maxillary arch are more frequently affected by oblique projection angle of the x-ray beam.[19] The results of this study showed that the influence of the horizontal angulation of the x-ray beam on the interradicular space width was statistically and clinically significant (Tables I and II). The association of this study with previous findings shows that an accurate 2D

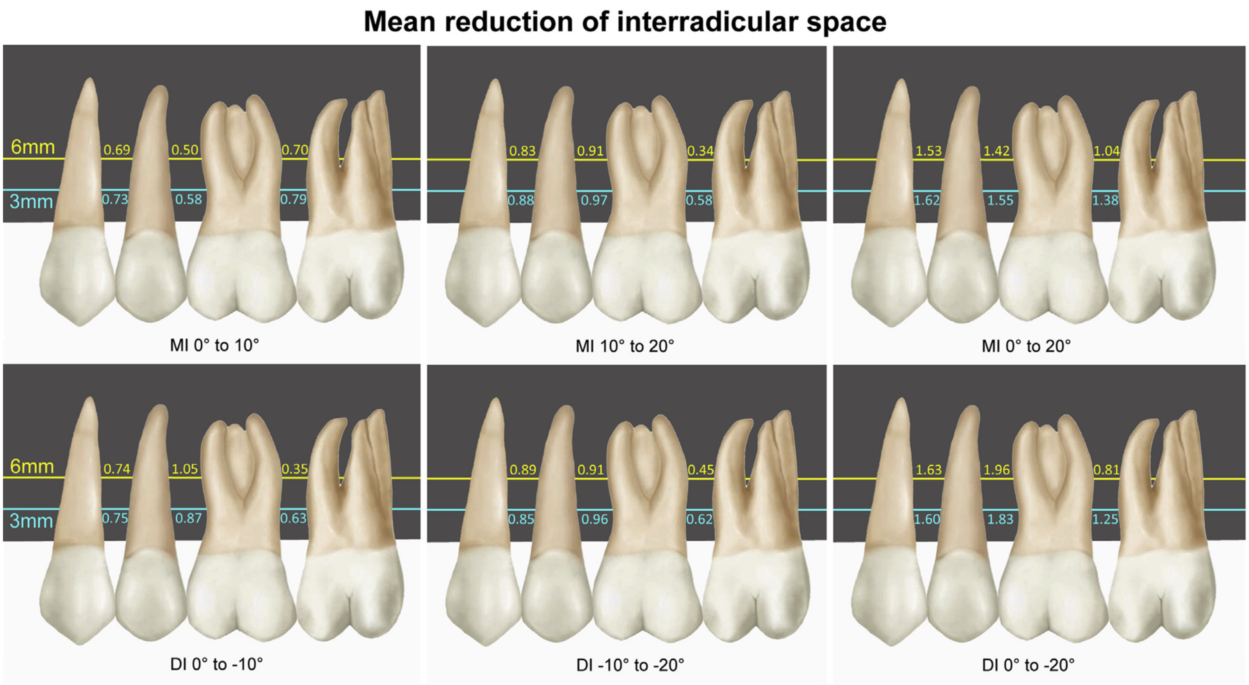

Fig 5. Mean reduction of interradicular spaces produced by mesial and distal angulation of the x-ray beam.

Table III. Correlation between the interradicular distance and horizontal angulation of the x-ray beam

Variables		*r*	P*
PMs	3 mm × MX	−0.770	<0.001
PM-M	3 mm × MX	−0.730	<0.001
Ms	3 mm × MX	−0.779	<0.001
PMs	6 mm × MX	−0.667	<0.001
PM-M	6 mm × MX	−0.576	<0.001
Ms	6 mm × MX	−0.680	<0.001
PMs	3 mm × DX	0.743	<0.001
PM-M	3 mm × DX	0.807	<0.001
Ms	3 mm × DX	0.736	<0.001
PMs	6 mm × DX	0.664	<0.001
PM-M	6 mm × DX	0.739	<0.001
Ms	6 mm × DX	0.515	<0.001

Note: Evaluation by Spearman rho (r) correlation test.
*Statistically significant at $P < 0.05$.

Table IV. Multiple regression analysis taking interradicular space as the dependent variable

Variables	R^2	*β coefficients*	*SE*	*F to remove*	P*
X-ray angulation (OX, MX, and DX)	0.296	−0.544	0.002	1172.74	<0.001
Interradicular sites (PMs, PM-M, and Ms)	0.216	−0.464	0.019	853.78	<0.001
Measurement heights (3 mm and 6 mm)	0.001	0.041	0.010	6.86	0.008

SE, standard error of the mean.
*Statistically significant at $P < 0.05$.

evaluation of the interradicular space width may be a critical procedure, especially in the posterior maxillary arch.

It has been suggested that interradicular spaces should have at least 2.5 mm to receive a 1.5-mm diameter mini-implant, remaining 0.5 mm between mini-implant and the adjacent tooth roots.[3,37,38] According to the results, deviations in horizontal angulation of the x-ray beam equal to 10° or more may induce the misclassification of an acceptable interradicular space (2.5 mm) as unacceptable to receive a 1.5-mm diameter, because the deceitful reduction of the interradicular space owing to x-ray oblique projection was >0.5 mm (Tables I and II; Fig 5). In addition, the results showed that this misclassification could occur regardless of the x-ray deviation direction (mesial or distal) and insertion height (3 mm or 6 mm; Tables I and II; Fig 5). Although horizontal angulation errors of about 20° can be easily identified, deviations around 10° may not be so evident, leading to a misinterpretation.

Table V. Mean reduction rate of interradicular space

Variables		0° to 10°	10° to 20°	0° to −10°	−10° to −20°
PMs	3 mm	27.96	33.71	28.73	32.56
PM-M	3 mm	22.48	37.59	33.72	37.21
Ms	3 mm	51.29	37.66	40.90	40.25
PMs	6 mm	24.38	29.32	26.14	31.44
PM-M	6 mm	17.79	32.38	37.36	32.37
Ms	6 mm	63.06	30.63	31.53	40.54
Total		34.49	33.54	33.06	35.72

Note: All degree data represented as %.

Considering that the mean interradicular distance ranged from 1.11-2.83 mm (Tables I and II), 10° of horizontal deviation of the x-ray beam to mesial or distal might be sufficient to misclassify adequate interradicular spaces between premolars and between second premolar and first molar (2.58-2.83 mm) as dangerous or inappropriate insertion sites (1.71-2.3 mm; Tables I and II).[3,4] These results emphasize the relevance of a well-controlled intraoral radiographic technique for presurgical diagnosis of available interradicular space for mini-implants. If conventional intraoral radiograph is not accurately obtained, 2D diagnosis may erroneously contraindicate the use of the skeletal anchorage or induce the practitioner to perform unnecessary mechanical procedures, such as opening spaces or changing teeth angulation to increase a suitable interradicular space, which appears to be smaller than it actually is, because of the overlapping images of the adjacent teeth.[16,17]

In this study, the smallest mean interradicular distance was between the maxillary molars (Table I). Only 8 coronal and 8 apical interradicular sites between the maxillary molars had available space >2 mm, making this area even more sensitive to the effects of improper x-ray beam horizontal angulation. In addition, unlike other insertion sites, the interradicular distance between maxillary molars decreased toward the apical area (1.54-1.11 mm). Although mini-implant placement with oblique insertion angle has been frequently indicated to minimize the risk of mini-implant contact with adjacent teeth roots at narrow insertion sites,[39] this procedure may not be advantageous to insert mini-implants between the maxillary molars. This inverse interradicular width behavior was also supported by a previous CBCT study.[1] CBCT may be advisable to allow accurate 3D diagnosis and mini-implant planning in cases of complex anatomy of interradicular sites.[10] In these cases, mini-implant freehand insertion should be avoided.[40] Surgical guides manufactured from CBCT seem to be a bit more successful to achieve mini-implant ideal positioning than metallic surgical guides visualized on periapical radiographs.[10,41] Although this refined mini-implant positioning in the interradicular septum is always desired, it has been demonstrated that the rate of poorly positioned mini-implants contacting dental roots was about 15% for both insertion techniques.[10,41]

Because a significant correlation was observed between the interradicular distance and horizontal angulation of the x-ray beam, progressive reductions of the interradicular spaces can be expected, proportional to the amount of x-ray angulation away from the orthogonal direction (Table III; Fig 5). The total reduction rate of the posterior maxillary interradicular space in each deviation interval of the x-ray angle was about 30% (Table V). These results were considered clinically significant because more than one third of the interradicular space width was reduced when the horizontal angulation of the x-ray beam was deviated 10° to the mesial or distal, whereas more than two thirds (0° to 20°, 68.03% and 0° to −20°, 68.78%) of the space was reduced with 20° of mesial or distal deviation (Fig 3, *B*; Table V).

Although the influence of x-ray projection geometry on the interradicular space width for mini-implants has not been previously evaluated, a previous study evaluating the impact of horizontal angulation of the x-ray beam on the width of the periodontal space demonstrated that 12° of variation in x-ray beam angulation produces periodontal space enlargement, which may exceed 1 mm.[24] In addition, it has been demonstrated that there is a linear correlation between the horizontal angulation of the x-ray beam and the interproximal overlapping width, and that a deviation of 12° would produce an interproximal overlapping width of about 0.75 mm.[20] These findings are similar and related to the results obtained from this study (Tables I and II, and III; Fig 5). However, owing to ethical reasons, these were dry skull studies using conventional intraoral radiographs. Presently, synthesized radiographs obtained from pre-existing CBCT files of living individuals could overcome this ethical limitation. It has been demonstrated that measurements obtained from CBCT synthesized cephalograms are realistic and similar to those of conventional cephalograms.[42,43]

It is well known that interradicular space width can be influenced by factors other than x-ray projection geometry, such as the location of the interradicular space in the dental arch, the evaluation height of the interradicular space, besides the influence of the tooth crown shape and tooth angulation that were not considered in this study.[3,37,38,44-46] The multiple regression analysis showed that among the studied variables, the x-ray projection geometry was the main factor contributing to explain the variation of the interradicular space width (Table IV). This evidence reinforces that x-ray projection geometry may play an important role in the availability of the interradicular space, requiring special professional attention when the radiographic diagnosis of the insertion site is based on conventional 2D imaging. Height of the interradicular space was the least relevant factor to explain its width variation, because both selected cutting heights (3 mm and 6 mm) were not located in the apical third of the dental root, where the greatest changes in tapering and distance between adjacent roots occur.[2]

Because the anterior segment of the dental arch has a greater curvature degree and smaller buccolingual thickness than the posterior segment, further studies should be conducted to investigate the impact of the changes in the horizontal angulation of the x-ray beam on the anterior interradicular space.

Clinical implications

Although periapical radiographs have been considered able to ensure a safe mini-implant insertion,[10] a small x-ray deviation from 0° projection geometry during 2D image obtainment may have a clinically relevant influence on the diagnosis of the interradicular space, compromising the reliability and accuracy of the conventional surgical guides, because of buccal object rule.[16,17,47] Thus, if a periapical radiograph shows that the interradicular space width in the interest area presents a threshold value of 1.5-2 mm, the professional could resort to a small-volume CBCT (SV-CBCT),[48] because an unnoticed variation in horizontal angulation of the x-ray beam may reduce the actual interradicular distance in about 0.5-1 mm, making it deceptively improper (Fig 5). In addition, periapical radiographs are prone to underestimate bone availability in the interradicular septum,[2] and this diagnostic limitation may become critical for narrower interradicular spaces. Since SV-CBCT can drastically reduce the radiation dose delivered to the patient,[48,49] the professional could use this 3D evaluation before deciding to open space between adjacent teeth, change teeth angulation, use indirect skeletal anchorage, or even discard mini-implant use. However, SV-CBCT should be indicated for threshold widths of the interradicular space and not as a routine presurgical exam to insert mini-implants, because it has a higher cost and complexity, besides a higher radiation dose (20-40 μSv) than a periapical radiograph (0.6-0.7 μSv).[10,49,50] According to the results, mini-implant insertion between the maxillary molars may more frequently require SV-CBCT for accurate evaluation of this narrow interradicular site, contributing to a reduction in accidents and complications.[10,48]

CONCLUSIONS

1. The width of the posterior maxillary interradicular space was sensitive to horizontal angulation changes of the x-ray beam.
2. Significant interradicular space reduction was associated with mesial and distal angulation of the x-ray beam for all evaluated insertion sites.
3. 2D radiographs obtained away from the 0° projection geometry can mask the actual width of the septum, inducing misdiagnosis.

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