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Original Article

Tomographic prevalence of juxta-apical radiolucency and adjacent structures: a cross-sectional study

Prevalência tomográfica da radiolucência justapical e estruturas adjacentes: um estudo transversal

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Resumo

Objetivo: O objetivo deste estudo foi avaliar a prevalência da radiolucência justa-apical (RJA) e sua relação com estruturas adjacentes por meio da tomografia computadorizada de feixe cônico (TCFC). **Material e método:** Exames de TCFC foram analisados a partir de um banco de dados de 2017 a 2021 de pacientes adultos com terceiros molares inferiores para avaliação da presença de RJA. Os terceiros molares associados a RJA foram classificados de acordo com a profundidade de impactação, angulação e desenvolvimento radicular. A RJA também foi classificada de acordo com sua relação com o canal mandibular e sua área cortical, tamanho e localização. **Resultado:** 1.097 exames de TCFC foram coletados do banco de dados durante o período de avaliação e, após a aplicação dos critérios de elegibilidade, 155 exames foram incluídos na análise. Trinta e um terceiros molares apresentaram presença de RJA com prevalência de 20%. Observou-se que a maioria dos casos eram unilaterais (84%), localizados mesialmente (53%), e de tamanho médio (53%), em contato com o canal mandibular com presença cortical (50%), visualizados em terceiros molares principalmente mesioangulares (36%), parcialmente intraósseo (86%) e com desenvolvimento radicular completo (92%). Não foram detectadas diferenças entre sexo e idade quanto à presença de RJA. **Conclusão:** Os dados obtidos revelaram alta prevalência de RJA, frequentemente em contato com o canal mandibular, sendo considerado um risco potencial para lesão do nervo alveolar inferior.

Descritores: Tomografia computadorizada de feixe cônico; terceiro molar; nervo mandibular; tecido periapical; lesões do nervo mandibular; extração dentária.

Abstract

Objective: The aim of this study was to evaluate juxta-apical radiolucency (JAR) prevalence and its relationship with adjacent structures using cone-beam computed tomography (CBCT). **Material and method**: CBCT scans were analyzed from a database from 2017 to 2021 of adult patients with mandibular third molars to visualize the presence of JAR. Third molars associated with JAR were classified according to impaction depth, angulation, and root development. JAR was also classified according to its relationship with the mandibular canal and its cortical area, size, and location. The chi-square test and the Mann-Whitney Test were performed to compare the age of patients and gender regarding the presence or absence of JAR. **Result:** 1097 CBCT scans were collected from the database during the evaluation period, and after the application of the eligibility criteria, 155 scans were included in the analysis. Thirty-one third molars showed the presence of JAR with a 20% prevalence. Most cases were observed to be unilateral (84%), located mesially (53%), and medium-sized (53%), in contact with the mandibular canal with cortical presence (50%), visualized in third molars mostly mesioangular (36%), partially intraosseous (86%), and with complete root development (92%). No significant differences were detected between gender and age concerning the presence of JAR. **Conclusion:** High JAR prevalence was observed, which was frequently in contact with the mandibular canal, being considered a potential risk for nerve damage.

Descriptors: Cone-beam computed tomography; third molar; mandibular nerve; periapical tissue; mandibular nerve injuries; tooth extraction.

INTRODUCTION

Nerve injuries to the inferior alveolar nerve (IAN) post-third molars extraction have a high incidence, which is estimated at 20% for transient sensory lesions and up to 3.6% for permanent paresthesias[1,2]. These injuries are related to several factors during the surgical process, such as surgeon's experience, patient's age, tissue manipulation intensity, post-surgical edema, and anatomical proximity to the IAN[3]. To minimize the risk of sensory injuries, a detailed preoperative evaluation is required including imaging examinations. Imaging findings associated with the risk of IAN injury may be illustrated as root darkening, canal deviation, root deviations, narrowing of the mandibular canal, disruption of the cortical, and juxta-apical canal radiolucency[1,4].

Juxta-apical radiolucency (JAR) was indicated as a risk factor for IAN injury by Renton in 2005, due to the possibility of bone fragility resulting from the contact between the tooth and the mandibular canal[1]. JAR is an anatomical variation of the cancellous bone space, characterized by a well-defined hypodense area located apical or lateral to the roots of mandibular third molars[2,5]. Previous studies reported a JAR prevalence ranging from 11% to 45%[4,6-10], and the wide variation of prevalence is due to different assessment methods and diagnostic criteria, even if most studies reported the evaluation of JAR in panoramic radiographs (PR).

Although third molars can be evaluated in two-dimensional radiographic exams (2D), this exam does not allow an adequate assessment of the relationship between third molars with adjacent structures such as IAN[5,11,12]. A detailed evaluation of the third molar anatomy, its relationship with adjacent structures, and anatomical variations is crucial for a successful surgical procedure with reduced risk of nerve injury. In cases of the proximity of third molars with IAN, cone beam computed tomography (CBCT) should be indicated, to allow a three-dimensional evaluation[11,12]. CBCT exams can provide more information on the spatial relations of third molars with the IAN during diagnostic and treatment processes for tooth extraction due to its higher image resolution when compared to PR[6,7,13]. To date, JAR evaluation results have been limited showing the majority of studies assessed with PR, and the results of these studies could be misinterpreted due to the technical limitation of an imaging exam[1,2,6-8]. Therefore, the aim of this study was to assess the prevalence of JAR using CBCT and to describe the relationship between JAR and adjacent structures.

METHOD

This observational study (cross-sectional) was approved by the Research Ethics Committee of the State University of Ponta Grossa (CAAE: #31765020.60000.0105).

Sample Selection

A total of 1097 CBCT scans were collected from 2017 to 2021 in a dental radiology clinic located in southern Brazil. The eligibility criteria included individuals over 18 years old who presented the two mandibular third molars, in which the CBCT was requested for any dental evaluation. Exclusion criteria were third molars with caries lesions, extensive restorations, endodontic treatment, traumatic lesions, examinations with artifact formation that underlay the area of interest, examinations of the same patient in other periods, and volumes that did not cover the area of interest.

Sample Acquisition

CBCT scans were acquired using the i-CAT equipment model Gendex GX- CB-500 (KaVo Kerr, Detroit, USA). The acquisition process was performed by a qualified professional with kilovoltage (kV) values of 120 kV, an image size matrix of 432 x 432 pixels, a milliamperage (mA) of 5 mA, an exposure time of 6 seconds, an acquisition time of 23 seconds, and a 0.2 mm resolution. The scans evaluated had different fields of view (FOV), as well as different acquisition areas, which could be in FOV 8 x 8 or 14 x 8.

Image Analysis

The images were analyzed by a single examiner dental surgeon radiologist (G.C.N.F.). The examiner first evaluated all the images and then examined 20% of the total sample again, which obtained a calibration with a calculation of intraexaminer Kappa coefficient value of 0.8. The DICOM (Digital Imaging and Communications in Medicine) files analysis was performed with the software RadiAnt DICOM Viewer (Medixant, Poznan, Poland) in a low light environment using an LG Ultrawide 25UM58G-25''ips Full HD monitor (1920 x 1080 resolution).

All mandibular third molars were evaluated for the presence of JAR, in which the diagnosis was based on a hypodense and well-defined area located apical or lateral to the roots of mandibular third molars. The teeth that presented JAR were classified as follows: 1) distribution: unilateral or bilateral; 2) location: vestibular (Figure 1A), lingual (Figure 1B), distal (Figure 1C), mesial (Figure 1D), apical (Figure 1E); 3) depth of impaction: intraosseous (Figure 1F) or partially intraosseous (Figure 1G) (Figure 2); 4) angulation of the third molar: vertical (Figure 2A), horizontal (Figure 2B), mesioangular (Figure 2C), distoangular (Figure 2D), inverted (Figure 2E), and transverse (Figure 2F)[14] (Figure 3); 5) Root development: Pre-eruptive stage (Nolla; 1-6) (Figure 2G), eruptive stage (Nolla; 7-8) (Figure 2H), and post-eruptive stage (Nolla; 9-10) (Figure 2I); 6) Relationship between JAR and the mandibular canal: distant (Figure 2J), in contact with the presence of cortical in the canal (Figure 2K), or contact with the absence of cortical in canal (Figure 2L)[15]; and 7) JAR size: Small (<4mm), medium (≥ 4 and ≤6mm) or large (>6mm) using measurement in the three different dimensions (vestibulo-lingual, super-inferior and mesio-distal) through the software measurement tool, using the largest measurement for classification (Figure 3)[7].

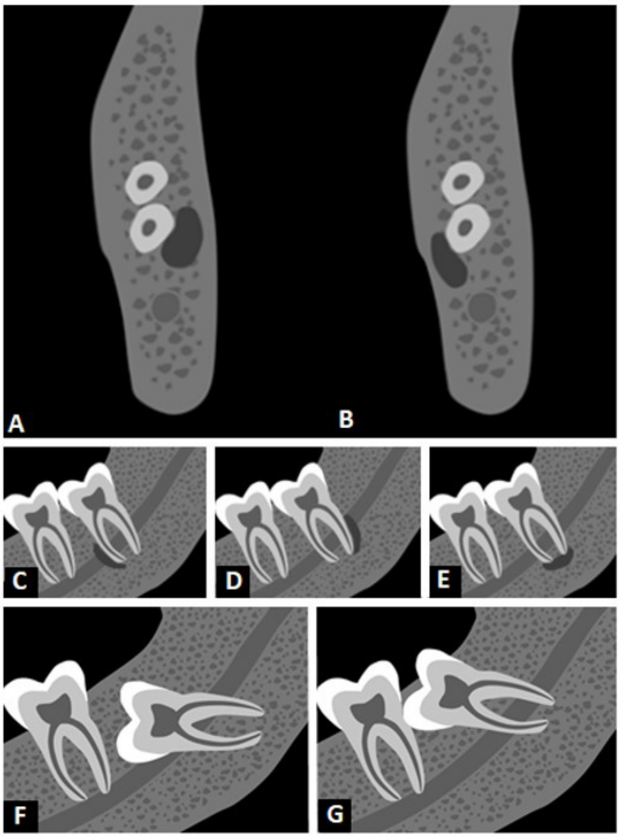

Figure 1. Coronal cone-beam computed tomography illustrating the vestibular (A) and lingual (B) and in the sagittal illustrating the mesial (C), distal (D), and apical (E) positions of JAR. Sagittal cone-beam computed tomography illustrating intraosseous (F) and partially intraosseous (G) third molar impaction.

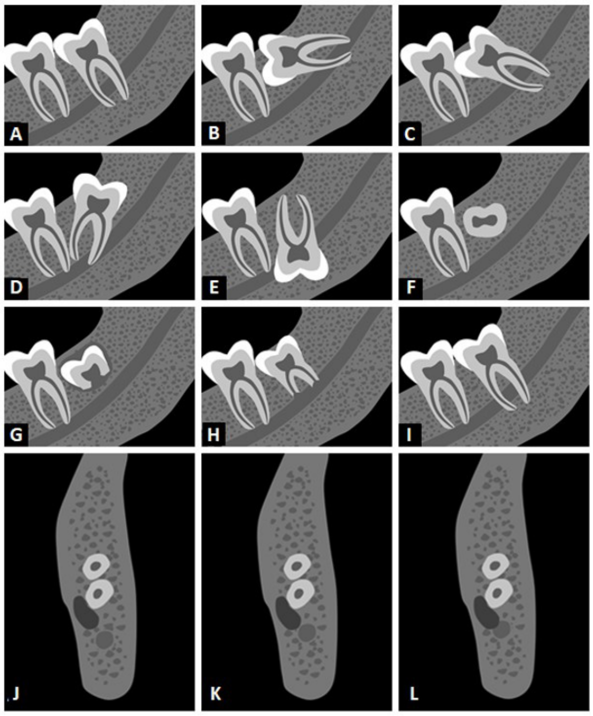

Figure 2. Sagittal cone-beam computed tomography illustrating the position of the third molar according to its angulation, which can be vertical (A), horizontal (B), mesioangular (C), distoangular (D), inverted (E) and transverse (F). Sagittal cone-beam computed tomography illustrating the third molar root development in the pre-eruptive stage (G), eruptive stage (H), and post-eruptive stage (I). Coronal cone-beam computed tomography illustrating the relationship of juxta-apical radiolucency distant from the mandibular canal (J), in contact with the presence of cortical from the mandibular canal (K), and in contact with the absence of cortical from the mandibular canal (L).

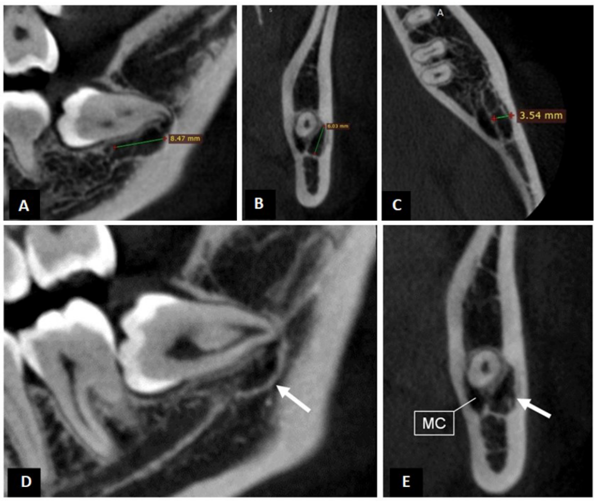

Figure 3. Cone-beam computed tomography in the sagittal (A), coronal (B), and axial (C) juxta-apical radiolucency view showing juxta-apical radiolucency size measurements. Cone-beam computed tomography in the sagittal (D) and coronal (E) view of juxta-apical radiolucency (arrow) located adjacent to tooth 38, which is in the mesioangular position, partially intraosseous, and with complete root development. Juxta-apical radiolucency is located mesial to the tooth, presents medium size and in contact with the mandibular canal (MC).

Statistical Analysis

The categorical data were arranged in a spreadsheet and evaluated using descriptive statistics and analytical methods. Descriptive statistics were used to report the overall JAR prevalence according to distribution, location, impaction depth, angulation, root development, the association between JAR and mandibular canal, and JAR size. Data was reported with absolute and relative frequencies. Analyses using the Chi-square test and the Mann-Whitney Test employing the JAMOVI software (San Francisco, California, USA) were also used to compare the patients'age and gender regarding the presence or absence of JAR.

RESULT

A total of 1097 CBCT scans were screened and evaluated, of which 942 were excluded through eligibility criteria totaling 155 scans included in our analysis. Out of the remaining 155 exams, the overall JAR prevalence was 20%, with a total of 31 mandibular third molars evaluated. Individuals' ages ranged from 18 to 77 years with a mean age of 29.28 (±2.05). Thirty-one participants presented JAR, out of which 10.48% were males (Table 1) affecting commonly individuals between 18 and 25 years old (14.9%).

Table 1. Profile of the JAR sample in lower third molars regarding gender

		Presence	Absence	Total	%	p-value
Gender	Female	17	68	85	10.97%	1.000
	Male	14	56	70	9.03%	
Total		31	124	155	20%	

Absolute %: referring to the sample total.

No significant differences were detected regarding gender and the presence of JAR (Chi-Square Test p=1.000). No differences regarding age and presence of JAR were observed (Mann-Whitney Test p=0.066). Regarding those 31 individuals, five had bilateral locations corresponding to an overall 36 teeth with JAR.

According to the variables analyzed, JAR was frequently unilateral (84%), located in the mesial region (53%), medium-sized (53%), in contact with the mandibular canal with the presence of cortical bone (50%), visualized in the mandibular third molars mostly mesioangular (36%), partially intraosseous (86%), and with complete root development (92%) (Figure 3) (Table 2).

Table 2. Prevalence of JAR according to the parameters evaluated

		n	%
JAR distribution	Unilateral	26	83.87%
	Bilateral	5	16.13%
Location	Vestibular	3	8.33%
	Lingual	4	11.11%
	Mesial	19	52.77%
	Distal	6	16.66%
	Apical	4	11.11%
Relationship between JAR and mandibular canal	Distant	9	25%
	Contact with presence of cortical in canal	18	50%
	Contact with absence of cortical in canal	9	25%
Deep of impaction	Intraosseous	5	13.88%
	Partially intraosseous	31	86.12%
Angulation of the third molar	Vertical	12	33.33%
	Horizontal	9	25%
	Mesioangular	13	36.11%
	Distoangular	2	5.55%
	Inverted	0	0%
	Transverse	0	0%
Root development	Pre-eruptive stage	0	0%
	Eruptive stage	3	8.33%
	Post-eruptive stage	33	91.66%
JAR size	Small (<4mm)	13	36%
	Medium (≥4mm and ≤6mm)	19	53%
	Large (>6mm)	4	11%
Total		36	100%

Relative %: referring to the "n" of JAR.

DISCUSSION

Our results revealed a high prevalence of JAR and agreed with previous studies that reported rates between 11 and 45%[4,6-10]. The large variation in the prevalence of JAR may be related to the different populations and imaging methods used in those studies. The use of CBCT images allows greater detection of JAR when compared to panoramic radiography[7]. In fact, authors who evaluated the presence of JAR in panoramic radiographs reported a prevalence of 24% while evaluations performed on CBCT scans revealed a prevalence of 32.6%[7]. In this context, it is evident that three-dimensional images are more suitable to assess the presence of JAR, as well as to describe its relationship with adjacent anatomical structures.

A hypothesis has been raised that JAR should be considered an extension of the mandibular canal cortical being a single topography[11]. However, this hypothesis was not confirmed in studies that used CBCT[6,10]. According to these studies, CBCT was able to distinguish the presence of JAR and mandibular canal contradicting the previously cited association[16]. In our study, the JAR was mostly found in contact with the mandibular canal (50%) with the preservation of the cortical bone as reported by Hasani et al.[17] To date, JAR has been considered an anatomical variation of the trabecular bone that has large spongy spaces[5]. Findings in the literature revealed that 32% of the JAR that was in contact with the mandibular canal was predisposed to IAN injury[17]. Therefore, it is crucial to perform a correct diagnosis with a three-dimensional exam before surgical treatment whenever possible to decrease further injuries to IAN.

Some authors have reported the association between JAR and injury to IAN due to mandibular bone fragility[8]. The IAN injury is caused by cortical thinning of the mandibular canal that enhances this bone susceptibility to be exposed to unfavorable forces during tooth extraction[6,7,16]. Gilvetti et al.[4] reported that JAR is not an independent risk factor for permanent IAN injury. Alternatively, other authors have observed a significant association between JAR and the lingual position of the mandibular canal, which might be considered a position that is more favorable to IAN injury[16]. Furthermore, JAR was associated with unerupted third molars that indirectly influence it, once the shorter distance between the third molar and the mandibular canal could predict IAN injury[7,16]. Thus, there is no agreement in the literature that JAR is a risk factor during mandibular third molar extraction, despite being mentioned in previous studies[1,18,19]. Future studies are necessary to clarify JAR and its relationship with adjacent structures, especially concerning the mandibular canal as was highlighted. In addition, the classification of mandibular third molars, which correspond to their position and angulation, serves as a guide in the evaluation of possible oral surgical-related risks and should be performed by dental clinicians to prevent IAN injury.

According to the relationship between JAR and third molar angulation, in this study, we could demonstrate more JAR prevalence with mesioangular tooth angulation. Likewise, Kapila et al. [6] found a significant association between JAR and mesioangular mandibular third molars. In contrast, Yalcin, Artas[10] and Nascimento et al. [7] both reported that JAR is mainly related to vertical mandibular third molars. Concerning position, Yalcin, Artas[10] found JAR most in the mesial position of the third molar, which agrees with our study. Regarding size, the prevalence identified was medium size, as pointed out by Nascimento et al. [7,16] However, Yalcin, Artas[10] reported that JAR was mostly present in small sizes. To date, few studies have evaluated JAR size, and therefore, more studies are needed to determine this association.

Due to the increasing demand for third molar removal, knowing its anatomy, as well as anatomical variations, is paramount for treatment success. Since JAR has a significant prevalence and may even be associated with an increased risk of nerve injuries, new studies should address anatomical variations to report evidence more concisely. A preoperative imaging examination is important before third molar extraction[19]. This preoperative investigation leads to greater safety, to avoid complications arising from dental surgery[9]. The standard imaging analysis for preoperative evaluation is the panoramic radiograph, enabling an assessment of the degree of surgical difficulty, morphology, position, and proximity to adjacent structures[20]. When imaging signs indicate the need for proximity, CBCT may be useful, as it can change the level of confidence of the dental surgeon in the diagnosis and surgical planning[21].

Based on our results, it is possible to conclude that JAR is not a rare entity, a 20% prevalence has been reported, and it is frequently found in unilaterally, mesial position, mesioangular teeth, partially intraosseous, with complete root development, and in contact with the mandibular canal with cortical presence. The CBCT is helpful to detect JAR, and when available, this imaging exam should be performed prior to the extraction of mandibular third molars.

AUTHOR CONTRIBUTION

Natália Mariane Rigo: investigation, methodology, writing original draft.
Gilson Cesar Nobre Franco: conceptualization, writing review and edition.
Caique Mariano Pedroso: formal analysis, writing review and edition.
Thais Albach: investigation, methodology, writing review and edition.
Adrielli Guimarães Ferreira: investigation, methodology, writing review and edition.
Marcela Claudino: conceptualization, supervision, writing review and edition.
Marcelo Carlos Bortoluzzi: formal analysis, supervision, writing review and edition.
Amanda Regina Fischborn: conceptualization, project administration, writing review and edition.

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CONFLICTS OF INTERESTS

The authors declare that there is no conflict of interest related to this study.

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