Concordance and consistency in the evaluation of diagnostic images of periapical tissue in endodontics

Concordancia y consistencia en la evaluación de imágenes diagnósticas del tejido periapical en endodoncia

Claudia García-Guerrero [ID][1], Ángela V. Caicedo-Rosero [ID][2], Cindy E. Delgado-Rodríguez [ID][3], Sara Quijano-Guauque [ID][4], Mauricio Rodriguez-Godoy [ID][5], Hannia Camargo-Huertas [ID][6]

1. Universidad Nacional de Colombia. Bogotá, Colombia. Correo: ccgarciag@unal.edu.co - https://orcid.org/0000-0002-3547-6338
2. Universidad Nacional de Colombia. Bogotá, Colombia. Correo: avcaicedor@unal.edu.co - https://orcid.org/0000-0001-5220-8688
3. Universidad Nacional de Colombia. Bogotá, Colombia. Correo: ciedelgadoro@unal.edu.co - https://orcid.org/0000-0002-4622-0151
4. Universidad Nacional de Colombia. Bogotá, Colombia. Correo: sbquijanog@unal.edu.co - https://orcid.org/0000-0001-8249-6617
5. Universidad Nacional de Colombia. Bogotá, Colombia. Correo: mrodriguezgo@unal.edu.co - https://orcid.org/0000-0002-5409-8264
6. Universidad Nacional de Colombia. Bogotá, Colombia. Correo: hgcamargoh@unal.edu.co - https://orcid.org/0000-0002-2507-815X

ABSTRACT

To estimate the degree of concordance and consistency in the radiographic and tomographic evaluation of the periapical area. A study of diagnostic tests was designed. Three blind evaluators analyzed radiographic images, which were selected at two different points in time. An oral radiologist and an endodontist determined the second observation moment. The degree of similarity and variability, concordance and consistency for each radiograph was set at 95% confidence. A Kappa coefficient (κ), for radiographic findings and a correlation coefficient of Lin (CCC) for tomographic measurements was established. 12 radiographies and 19 tomographs were evaluated. The intraobserver consistency determined a k= 1 (Almost Perfect) and a CCC from 0.42 to 0.95 (Poor to Substantial) for both observation times. For radiographies, the interobserver concordance did not show changes between the first and second observation. Values include a k= 0.56-0.80 (Moderate to Good) and a CCC with greater degree of agreement, after training, as follows: axial view: CCC 0.86, 95% of Confidence Interval (CI) 0.69-0.94, coronal view: CCC 0.90 95%CI 0.75-0.96, and sagittal view: CCC 0.96, 95%CI 0.90-0.98. The statistical tests estimated the consistency and concordance to observe radiographically and tomographically the periapical tissue in endodontics.

RESUMEN

Se diseñó un estudio de pruebas diagnósticas para estimar el grado de concordancia y consistencia en la evaluación radiográfica y tomográfica del área periapical. Tres evaluadores ciegos analizaron imágenes radiográficas, que fueron seleccionadas en dos momentos diferentes. El grado de similitud y variabilidad, concordancia y consistencia para cada radiografía se estableció en un 95% de confianza. Se estableció un coeficiente Kappa (κ), para los hallazgos radiográficos y un coeficiente de correlación de Lin (CCC) para las mediciones tomográficas. Se evaluaron 12 radiografías y 19 tomografías. La consistencia intraobservador determinó un k = 1 (casi perfecto) y un CCC de 0,42 a 0,95 (deficiente a sustancial) para ambos tiempos de observación. Para las radiografías, la concordancia entre observadores no mostró cambios entre la primera y la segunda observación. Los valores incluyen un k = 0.56-0.80 (moderado a

bueno) y un CCC con mayor grado de acuerdo, después del entrenamiento, de la siguiente manera: vista axial: CCC 0.86, 95% del intervalo de confianza (IC) 0.69-0.94, vista coronal: CCC 0.90 IC del 95% 0,75-0,96 y sagital view: CCC 0,96, IC del 95% 0,90-0,98. Las pruebas estadísticas estimaron la consistencia y concordancia para observar radiográfica y tomográficamente.

INTRODUCTION

The success of a root canal treatment (RCT) is established both clinically and radiographically. Therefore, while clinical evaluation involves a comprehensive analysis of the patient´s response to the procedure, radiography allows the clinician to assess the status of the RCT, the surrounding tissues, and the tooth itself[1]. When bacteria persist at the periapical tissues, the local inflammatory process triggers the onset of disease, i.e., apical periodontitis, which ultimately causes notorious changes in the structure of bone[2].

As the infection progresses, it becomes visible on radiographic or tomographic images as a radiolucent or hypodense lesion around the compromised area[3,4]. Under such circumstances, the reestablishment of a healthy periapical tissue becomes a priority. When the etiologic factors have been eradicated, healing of the periapical tissue includes the typical regenerative processes of bone that are readily identifiable in images, which provide an indirect measure of the cellular and molecular changes occurring inside the bone[5].

Radiographic and tomographic images, however, are directly influenced by the technique, the conditions under which the image is obtained, the anatomy of the tooth, and the observer's interpretation[4,5]. Those differences, well recognized in prognostic studies, may challenge evaluation of the periapical tissue, i.e., an evaluation method that is 100% reproducible and that can be verified. Therefore, each of the abovementioned factors play a role in the ability to read and interpret diagnostic images accurately[6-8].

To compensate for the differences between observation and interpretation, statistical tests that estimate the agreement between observers and the observed object have been designed[9,10]. Thus, the word concordance, derived from the Latin "*concordare*", refers to the correspondence or conformity of one thing with another[11].

A concordance-conformity analysis provides information about the reliability of diagnostic images, while agreement among observers can be used to verify the consistency of a method. The clinical implications of this are of paramount importance, especially if they can be used to better understand and eliminate any pathosis[4]. Additionally, the agreement between observers can provide a general estimate of the value of an imaging technique. However, concordance-consistency analysis establishes from the statistical point of view not only the degree of agreement between observers but also the intra-observer's reliability to analyze images in similar conditions in order to obtain accurate observations[12].

Therefore the present investigation aims to estimate the degree of concordance and consistency between observers when evaluating radiographic/tomographic images of the periapical area of root-treated teeth (RTT).

MATERIALS AND METHODS

Type of study

A diagnostic test, the concordance-consistency study was designed and implemented. Radiographic and tomographic images of the periapical area of RTT were included. Images were obtained from the patients' database available at the University Program in Endodontics. Images whose quality or condition did not allow the proper observation of the tooth were excluded.

Sample size, Variables, and Hypothesis

The calculation of the sample was estimated with a 95% confidence interval (CI), an alpha value of 0.05 and a statistical power of 80% for multiple observations with repeated measures of the same

DUAZARY

object. This algorithm led to 35 radiographic and 100 tomographic images, sufficient to establish significant differences. Each image was analyzed by 3 independent researchers at 2 different moments. While evaluation of radiographic images was deemed a categorical variable, evaluation of tomographic images was considered continuous. The posed hypothesis determined the expected values for agreement and consistency, a Cohen's kappa statistic (Kw); Ho: ƙ<0.40 and Ha: ƙ> 0.41 and a Correlation Coefficient of Lin (CCC) (rc); Ho: rc <0.95 and Ha: rc> 0.95, respectively.

Sampling

A convenience sampling was performed to select the images. This sampling method ensured the identification of different conditions that might arise around the apical area of RTT. For radiographic and tomographic visualization, we used Carestream RVG Digital Imaging System (Radio Visio Graphy® 5100®, Dental Imaging Carestream® software) and CS 3D Imaging Tomography Software, version 3.5.15 (Carestream Health®, Rochester, NY), respectively. Selected images were anonymized using codes to guarantee patient's confidentiality throughout the study.

Observers

An oral radiologist (HC), an endodontist (CG), and three blinded researchers with training in endodontics (Obs1, Obs2, and Obs3) performed the observations. The role of the experts (oral radiologist; endodontist) was to establish training aimed at blinded researchers after the first observation (First moment).

Observational Methods

Images were selected randomly, not consecutively. As a categorical variable, apical periodontitis (AP) in radiographies was defined as "presence or absence of periapical radiolucency" [7] (Figure 1). As a continuous variable, AP in tomographies was determined by observing a periapical hypodense area (Figure 2). Each radiographic/tomographic observation was performed at two different moments. A first moment

The three blind researchers reviewed the images at two different times as follows: **first moment** without training or calibration, the three blind observers carry out the radiographic or tomographic identification of the periapical tissue, according to their experience in the area of Endodontics. **Second moment**: the three blind observers perform the radiographic or tomographic identification of the periapical tissue; after being trained by two imaging experts, (1 radiologist; 1 endodontist). Data was recorded and stored in digital files (Microsoft Excel 2007 / 12.0).
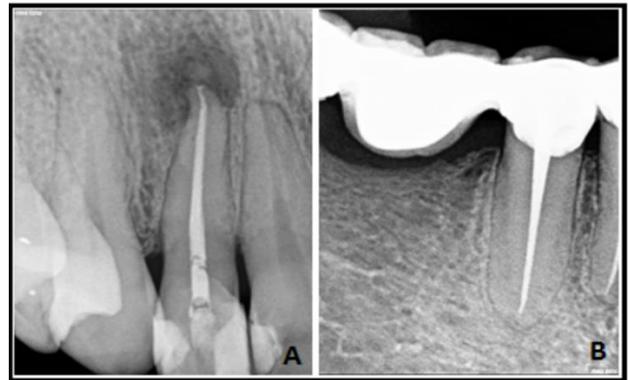
Figure 1. Radiographic images. A. Presence of periapical radiolucency. B. Absence, normal apical tissue.

All tomographic films were viewed and evaluated at the oblique axis of the integration panel using the highest resolution (76, 90 and up to 200 microns) with the greatest possible zoom. Once the plane was located, the longitudinal axis of the root or tooth was adjusted according to the extension of the apical lesion and to its relationship with the roots of the compromised tooth. On the axial plane, the mesiodistal and buccolingual positions were established to standardize the position of the axes: coronal, sagittal, and axial, where the hypodense zone was measured (Figure 2). For tomographies, this study estimated the degree of similarity and variability.
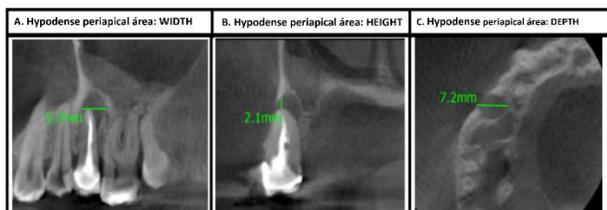
Figure 2. Tomographic appearance of a periapical pathology. A. Coronal view. B. Sagittal view. C. Axial view

Statistical Analysis

Consistency (intraobserver) and concordance (interobserver) analysis were done for every image during each measurement, before and after training. Calculation of Cohen's kappa statistic (Kw) test for radiographic measurements and CCC for tomographic measurements were carried out. The strength of the agreement was determined by the Landis and Koch scale (Kw), using the following definitions: 0.01: poor; 0.01-0.20: slight; 0.21-0.40: fair; 0.41-0.60: moderate; 0.61-0.80: substantial; and 0.81-1.00: almost perfect[9]. CCC was determined according to the scale recommended by Lin[11]. An IC of 95% was set. All statistical analyzes were performed using the psych package and the Cohen function kappa (statistical software R version 3.2.2).

Ethics

The protocol was approved by our Institutional Review Board/Ethics Committee (Code # CIE-20-15) according to the Declaration of Helsinki on medical protocol and ethics and the Regulation 8430 in 1993 Colombia, Ministerio de Salud.

RESULTS

Due to the limited size of the initial sample, more radiographs and tomographies were included in order to augment the statistical power and precision of the study. Thus, 48 radiographies and 114 tomographies were evaluated by the three blinded observers. In tomographic images, the average size of the periapical lesion was 5.24mm (ranging from 0.8mm to 13.3mm).

When analyzing measurement variability (intra and inter-observer), all three observers recorded similar values. This similarity does not imply, however, the existence of agreement. It must be noted, nevertheless, that a greater degree of inter observer agreement was reached after training (Table 1). For radiographic images, the intra observer consistency analysis identified a ƙ: 1 at both observation moments, i.e., an "almost perfect" consistency for each of the three observers[13].

For tomographic measurements, on the other hand, the CCC determined a degree of consistency ranging from 0.42 to 0.95 at both observation moments. This means a consistency of "poor to substantial" for each of the three observers. Table 2 describes the intra observer consistency at both moments (CI 95% between 0.074 - 0.980). "Substantial" consistency was achieved by observer #2 at the sagittal view (Figure 3). For radiographs the establishment of inter observer agreement did not show changes between the first and second observation moments. Agreement values ranged from 0.56 (Observer #1 and #2) to 0.80 (Observer #1 and #3 and Observer #2 and #3). The strength of the agreement was identified as "moderate to substantial",[13] which is detailed in Table 2. Ultimately, H0 was rejected.

For tomographic images, the degree of interobserver agreement was established with a CI 95%. Correlation categories, which were expressed graphically, recognized a greater degree of agreement or concordance among the three observers after training. The highest degree of agreement was observed between observers 1 and 3 in the sagittal view (Figure 4A, 4B). Moreover, a smaller dispersion of the observations was noted, in addition to the decrease of the range that established the limits of the inter agreement precision (Figure 4B). Table 3 provides detailed information regarding the observation of the height of the lesion.

Claudia García-Guerrero, Ángela V. Caicedo-Rosero, Cindy E. Delgado-Rodríguez, Sara Quijano-Guauque, Mauricio Rodriguez-Godoy, Hannia Camargo-Huertas

Table 1. Consistency. Variability analysis for continuous measurements.

	Obs1		Obs3		Obs2	
AXES	**First moment**	**Second moment**	**First moment**	**Second moment**	**First moment**	**Second moment**
Oblique Coronal	2.87	3.75	3.36	3.81	3.2	3.25
Oblique Sagittal	5.76	5.89	6.37	5.66	5.95	5.77
Oblique Axial	6.27	6.24	6.81	6.57	6.54	6.25

Table 2. Intra-observer consistency. First and second moments.

Observer	View	Lower Limit	CCC Lin	Upper Limit
Ob1	Axial	0.3219	0.67	0.8574
Ob1	Coronal	0.0745	0.42	0.6741
Ob1	Sagittal	0.7633	0.90	0.9577
Ob2	Axial	0.6207	0.83	0.9316
Ob2	Coronal	0.6814	0.86	0.9431
Ob2	Sagittal	0.8920	0.95	0.9809
Ob3	Axial	0.4070	0.72	0.8806
Ob3	Coronal	0.1079	0.51	0.7721
Ob3	Sagittal	0.6212	0.82	0.9209
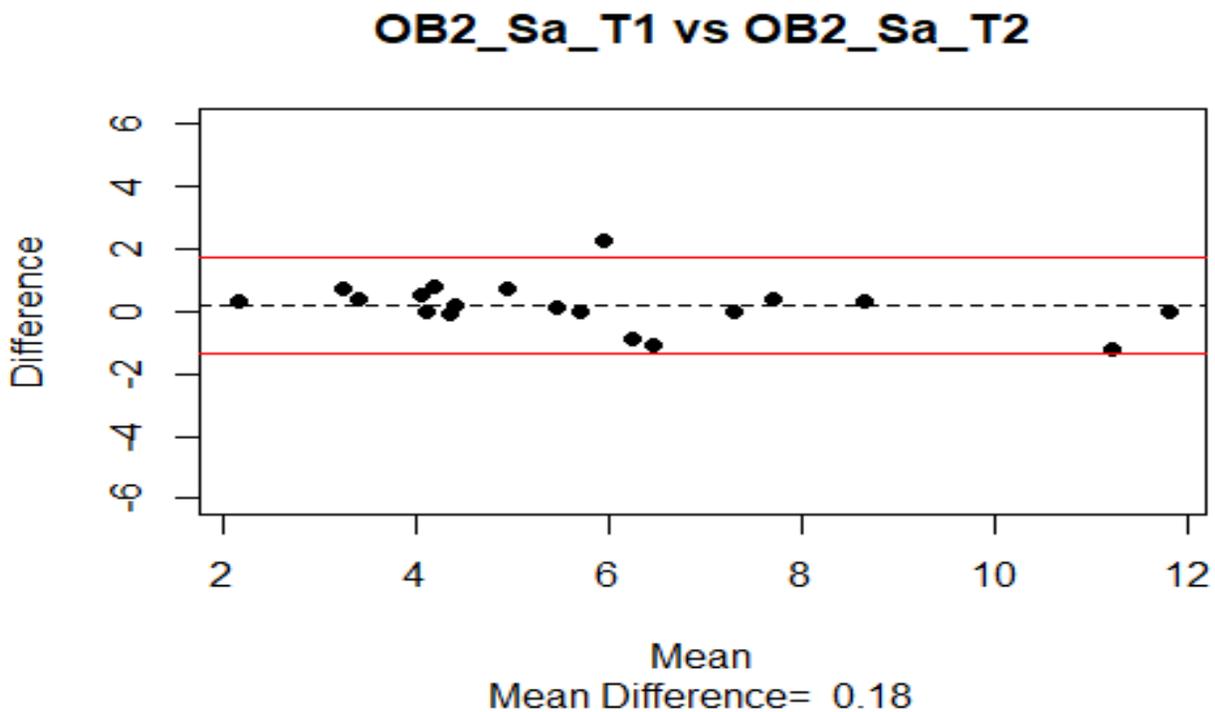
Figure 3. Bland and Altman graph. Intra examiner consistency achieved "Substantial" in the sagittal view.
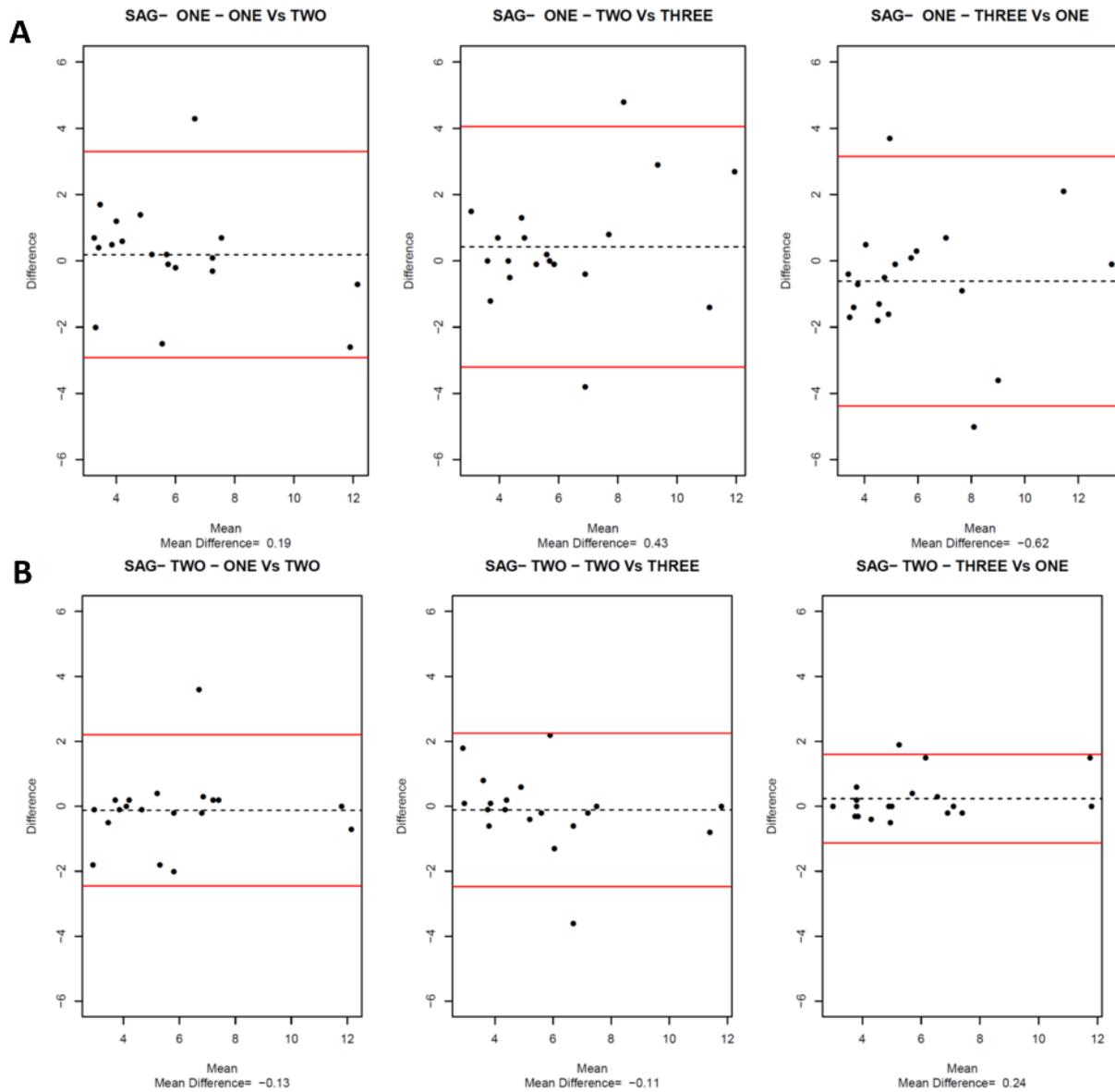
Figure 4. Graphic representation of the inter-examiner concordance according to the moment of observation. A. First observation moment. B. Second observation moment. Bland and Altman graphs.

Claudia García-Guerrero, Ángela V. Caicedo-Rosero, Cindy E. Delgado-Rodríguez, Sara Quijano-Guauque, Mauricio Rodriguez-Godoy, Hannia Camargo-Huertas

Table 3. Concordance.

Radiographic Observer	First Observation Moment				Second Observation Moment			
	Lower limit	*Kappa*	Upper limit	Concordance*	Lower limit	*Kappa*	Upper limit	Concordance*
1 Vs 2	0.01	0.56	1.1	Moderate	0.01	0.56	1.1	Moderate
1 VS 3	0.43	0.8	1.2	Good	0.43	0.8	1.2	Good
2 Vs 3	0.43	0.8	1.2	Good	0.43	0.8	1.2	Good
Tomographic Observer	Lower limit	CCC	Upper limit	Concordance†	Lower limit	CCC	Upper limit	Concordance†
CORONAL								
1 Vs 2	0.75	0.89	0.95	Poor agreement†	0.19	0.55	0.78	Poor agreement
2 Vs 3	-0.7	0.37	0.70	Poor agreement†	0.42	0.70	0.86	Poor agreement
1 Vs 3	0.00	0.41	0.70	Poor agreement†	0.75	0.90	0.96	Moderate
SAGITTAL								
1 Vs 2	0.63	0.83	0.93	Poor agreement	0.77	0.90	0.96	Moderate
2 Vs 3	0.50	0.76	0.90	Poor agreement	0.75	0.89	0.96	Poor agreement
1 Vs 3	0.52	0.77	0.90	Poor agreement	0.90	0.96	0.98	Substantial
AXIAL								
1 Vs 2	0.62	0.82	0.92	Poor agreement	0.79	0.90	0.95	Moderate
2 Vs 3	0.29	0.65	0.85	Poor agreement	0.56	0.80	0.92	Poor agreement
1 Vs 3	-0.5	0.38	0.69	Poor agreement	0.69	0.86	0.94	Poor agreement

The highest degree of agreement was achieved by Observers #1 and #3 at the axial view (CCC 0.86, CI 95% 0.69-0.94). Data obtained at the coronal view (CCC 0.90 CI 95% 0.75-0.96) allowed the classification of the agreement as "moderate". Finally, data obtained at the sagittal view determined a "substantial" agreement (CCC 0.96, CI 95% 0.90-0.98), as shown in Table 3 and Figure 4B. According to the tables, a better degree of agreement was obtained at the sagittal view. With such findings, rejection of the H0 was possible once again.

Agreement data for categorical variables (radiographic images) and agreement data for continuous variables (tomographic images). Agreement data for the three blind evaluators are represented for each observation moment. Evaluation scales are included for each statistical test. Landis y Kosch*[9], CCC†[11].

DISCUSSION

Within the scope of endodontics[14], an adequate reading of images is a fundamental tool for establishing the diagnosis, treatment planning, and prognosis. Since digital radiographies and cone-beam tomography are reliable diagnostic tools[15,16], it is important to standardize not only the technique but also observation and analysis methods. The

DUAZARY

present investigation described the methodology to define training, standardization, and degree of agreement between blinded observers in order to control the internal validity of prognostic clinical studies in endodontics.

With k = 1, the results of the present study reached the highest consistency (almost perfect) and CCC = 0.954 (substantial), which represent the intra observer data for each diagnostic image (Figure 3). On the other hand, concordance reached the greatest agreement in the following categories: GOOD, k = 0.80 and SUBSTANTIAL, CCC = 0.96 for radiographic and tomographic observations, respectively. Both training and image standardization had positive effects on the degree of concordance in tomographies. Of note, standardization of the observation and previous training did not have the expected effect.

In 1987 Molven et al[7], published a classic paper which is commonly used in endodontics to determine the results of root canal treatment. In this article, radiographic observation of the periapical tissue is a key factor. The authors made independent evaluations, which were performed by a surgeon, an endodontist, and a radiologist. They identified several problems when classifying images, which made them consider "chance and azar" as part of the differences. To solve the inconvenience, the investigators employed the "Cohen's Kappa" statistical test to mathematically express the agreement between observers, including azar as an influencing factor when reading a categorical variable representing the periapical area of RTT.

Thirty years later, the concept of methodological refinement for clinical studies is maintained. In this sense, training, standardization, and blinding the evaluators have led to more accurate results and without bias. The introduction of 2-3 experienced evaluators was suggested in 1975 as a methodological strategy to achieve observation agreement[17]. Taking into account the progress in observation methods and the implementation of diagnostic aids, reading the periapical tissue has led to the construction of radiographic[16], tomographic[6,18], healing algorithms[19], and scales[7,20,21] whose accuracy depend on the

observer's interpretation, the nature of the image, and the condition of the observed object. Therefore, the implementation of concordance-consistency studies diminishes the bias when observing periapical images. It is clear that a reading error will increase the tendency to either under or overestimate the outcome of the root canal treatment when evaluated through apical healing[22]. The statistical test that identifies consistency is determined according to the nature of the observed variable. Thus, the kappa index for categorical variables is limited to establishing only the magnitude of the agreement between observers (either 2 different or oneself) without estimating the accuracy and quality of the observation[9,10]. A concordance value of 0.80 obtained in the present study would be considered "excellent", according to Molven et al[7]. The authors suggest previous calibration to increase the degree of agreement. In the present study, radiographic image calibration did not influence positively the observation.

In 2014 Verkutonis et al[16], noted an unavoidable variability among observers when analyzing two-dimensional radiographic images, independently of the calibration process. This might explain why, despite the experience of the endodontist and even after training, the agreement for radiographic observations did not increase (k = 0.80), thus highlighting the subjectivity of the reading process and the difficulties encountered when visualizing three-dimensional objects in bidimensional images[6]. Although classification systems permit categorizing the observations[13], it is important to note that such ranges are broad and usually arbitrary, which implies around 1% of changes from one category to another[1]. With the advent of tomographic equipment capable of evaluating qualitatively dental structures and their supporting tissues, other statistical tests must be considered.

In 2008 Estrela et al[6], evaluated the inter examiner agreement using the kappa statistical test. The implementation of statistical tests such as CCC favors the quantitative analysis of all tomographic measurements, allowing the reading of continuous variables without losing the mathematical value of each data and its individual contribution to the equation. The correlation-agreement coefficient of

Lin rates the agreement in a demanding manner, combining a measure of precision with a measure of accuracy, thus diminishing the risk of bias. This gives reproducibility to the observations[10], a fundamental principle for reading periapical tissues.

The abovementioned statement implies a degree of reproducibility of the observations[10]. With the accuracy of tomographic images to determine the size of periapical lesions by means of continuous measurements, an increase in the degree of agreement after the standardization and training of the evaluators becomes evident[23] (Table 3 and Figure 4B). This complements the results of Kruse et al in 2015[24], who attributed the increase of the inter observer agreement to the calibration process. This is, without question, a starting point for researchers and academicians to strengthen a mandatory method for the design and evaluation of clinical studies in endodontics.

CONCLUSION

With the application of statistical tests, it is possible to estimate the degree of agreement and intra/inter observer variability when evaluating radiographic and tomographic images of the periapical tissue in RTT.
Standardization of the tomographic observation and proper training allowed to increase the inter observer agreement when the periapical tissue was observed. No significant impact or variability is observed in reading two-dimensional digital images.

CONFLICT OF INTEREST

None declared

ACKNOWLEDGMENTS

AUTHORS' CONTRIBUTION

Claudia García-Guerrero: Conception, design, analysis, critical revision of intellectual content and interpretation of the data, and drafting and review of the manuscript.

Ángela V Caicedo-Rosero: Student leader, collection of images, training in reading and interpretation of radiographic and tomographic images. Analysis of results.
Cindy E Delgado-Rodríguez: Training in reading and interpretation of radiographic and tomographic images.
Sara Quijano-Guauque: Training in reading and interpretation of radiographic and tomographic images.
Mauricio Rodriguez-Godoy: Study design, results analysis.
Hannia Camargo-Huertas: Project management, expert radiologist, standardization of images, training for blind observers, document writing.

BIBLIOGRAPHICAL REFERENCE

1. Fernández R, Cadavid D, Zapata SM, Alvarez LG, Restrepo FA. Impact of three radiographic methods in the outcome of nonsurgical endodontic treatment: a five-year follow-up. J Endod 2013; 39:1097-103. Doi: http://dx.doi.org/10.1016/j.joen.2013.04.002. Epub 2013 May 21.

2. Braz-Silva PH, Bergamini ML, Mardegan AP, De Rosa CS, Hasseus B, Jonasson P. Inflammatory profile of chronic apical periodontitis: a literature review. Acta Odontol Scand 2019;77(3):173-180. Doi: http://dx.doi.org/10.1080/00016357.2018.1521005. Epub 2018 Dec 26. PMID: 30585523.

3. Bornstein MM, Bingisser AC, Reichart PA, Sendi P, Bosshardt DD, von Arx T. Comparison between Radiographic (2-dimensional and 3-dimensional) and Histologic Findings of Periapical Lesions Treated with Apical Surgery. J Endod 2015; 41(6):804–11. Doi: http://dx.doi.org/10.1016/j.joen.2015.01.015. Epub 2015 Apr 8. PMID: 25863407.

4. Tsesis I, Rosen E, Taschieri S, Telishevsky Strauss Y, Ceresoli V, Del Fabbro M. Outcomes of surgical

DUAZARY

endodontic treatment performed by a modern technique: an updated meta-analysis of the literature. J Endod 2013; 39(3): 332–9. Doi: http://dx.doi.org/10.1016/j.joen.2012.11.044.

5. Serrano-Giménez M, Sánchez-Torres A, Gay-Escoda C. Prognostic factors on periapical surgery: A systematic review. Med Oral Patol Oral Cir Bucal 2015; 20(6): e715-22. Doi: http://dx.doi.org/10.4317/medoral.20613.

6. Estrela C, Bueno MR, Azevedo BC, Azevedo JR, Pécora JD. A new periapical index based on cone beam computed tomography. J Endod 2008; 34(11):1325–31. Doi: http://dx.doi.org/10.1016/j.joen.2008.08.013.

7. Molven O, Halse A, Grung B. Observer strategy and the radiographic classification of healing after endodontic surgery. Int J Oral Maxillofac Surg 1987; 16(4): 432–9. Doi: http://dx.doi.org/10.1016/s0901-5027(87)80080-2.

8. Rud J, Andreasen JO, Jensen JE. Radiographic criteria for the assessment of healing after endodontic surgery. Int J Oral Surg 1972; 1(4):195–214. Doi: http://dx.doi.org/10.1016/s0300-9785(72)80013-9.

9. Kundel HL, Polansky M. Measurement of observer agreement. Radiology 2003; 228(2): 303-8. Doi: http://dx.doi.org/10.1148/radiol.2282011860.
10. Cortés-Reyes É, Rubio-Romero JA, Gaitán-Duarte H. Métodos estadísticos de evaluación de la concordancia y la reproducibilidad de pruebas diagnósticas. Rev Colomb Obstet Ginecol 2010; 61(3):247–55. Doi: http://dx.doi.org/10.18597/rcog.271

11. Lin LI-K. A Concordance Correlation Coefficient to Evaluate Reproducibility. Biometrics 1989; 45: 255–68. Doi: http://dx.doi.org/10.2307/2532051

12. Elzinga M, Segers M, Siebenga J, Heilbron E, de Lange-de Klerk ES, Bakker F. Inter- and intraobserver agreement on the Load Sharing Classification of

thoracolumbar spine fractures. Injury 2012; 43(4): 416-22. Doi: http://dx.doi.org/10.1016/j.injury.2011.05.013.

13. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977; 33(1): 159-74. Doi: http://dx.doi.org/10.2307/2529310

14. The Scope of Endodontics [Internet]. Dentistry Today. 2015. Available at: https://www.dentistrytoday.com/viewpoint/10061-revisiting-the-scope-of-contemporary-endodontics

15.Huumonen S, Ørstavik D. Radiological aspects of apical periodontitis. Endod Top 2002; (1):3–25. Doi: http://dx.doi.org/10.1034/j.1601-1546.2002.10102.x

16. Venskutonis T, Daugela P, Strazdas M, Juodzbalys G. Accuracy of digital radiography and cone beam computed tomography on periapical radiolucency detection in endodontically treated teeth. J Oral Maxillofac Res 2014;5(2):e1. Doi: http://dx.doi.org/10.5037/jomr.2014.5201.

17. Koran LM. The reliability of clinical methods, data and judgments (first of two parts). N Engl J Med 1975;293 (13):642–6. Doi: http://dx.doi.org/10.1056/NEJM197509252931307

18. Pope O, Sathorn C, Parashos P. A comparative investigation of cone-beam computed tomography and periapical radiography in the diagnosis of a healthy periapex. J Endod 2014; 40(3):360-5. Doi: http://dx.doi.org/10.1016/j.joen.2013.10.003.

19. Yu VS, Khin LW, Hsu CS, Yee R, Messer HH. Risk score algorithm for treatment of persistent apical periodontitis. J Dent Res 2014; 93(11):1076-82. Doi: http://dx.doi.org/10.1177/0022034514549559.

20. von Arx T, Janner SF, Hänni S, Bornstein MM. Evaluation of New Cone-beam Computed Tomographic Criteria for Radiographic Healing Evaluation after Apical Surgery: Assessment of

Repeatability and Reproducibility. J Endod 2016; 42(2):236-42. Doi: http://dx.doi.org/ 10.1016/j.joen.2015.11.018.

21. von Arx T, Janner SF, Hänni S, Bornstein MM. Scarring of Soft Tissues Following Apical Surgery: Visual Assessment of Outcomes One Year After Intervention Using the Bern and Manchester Scores. Int J Periodontics Restorative Dent 2016; 36(6): 817-823. Doi: http://dx.doi.org/10.11607/prd.3010.

22. Delgado-Rodríguez M, Llorca J. Bias. J Epidemiol Community Health 2004; (58):635–641. Doi: http://dx.doi.org/10.1136/jech.2003.008466

23. Bland JM, Altman DG. Comparing two methods of clinical measurement: a personal history. Int J Epidemiol 1995;24 Suppl 1: S7–14. Doi: http://dx.doi.org/10.1093/ije/24.supplement_1.s7.

24. Kruse C, Spin-Neto R, Wenzel A, Kirkevang L-L. Cone beam computed tomography and periapical lesions: a systematic review analysing studies on diagnostic efficacy by a hierarchical model. Int Endod J 2015 Sep;48(9):815–28. Doi: http://dx.doi.org/10.1111/iej.12388.

DUAZARY