Duazary / Vol. 21, No. 4 – 2024 / 271 - 284
DOI: https://doi.org/10.21676/2389783X.6098

Scientific and technological research article

Validation of panoramic radiography as a diagnostic image to identify mandibular skeletal asymmetries

Validación de la radiografía panorámica como imagen diagnóstica para identificar asimetrías esqueléticas mandibulares

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How to cite this article: Giraldo-Morales K, Barreto-Franco FA, Ramírez-Molina M, Villegas-Trujillo LF, Rivera-Quiroz LH. Validation of panoramic radiography as a diagnostic image to identify mandibular skeletal asymmetries. Duazary. 2024;21:271-84. https://doi.org/10.21676/2389783X.6098

Received on September 08, 2024
Accepted on November 25, 2024
Posted online December 27, 2024

ABSTRACT

Introduction: Mandibular asymmetry is an imbalance between the right and left sides, diagnosed through photographs, tomography, posteroanterior (AP), and panoramic (PN) radiography. However, despite the higher distortion and magnification rates, the PN is still widely used in the initial diagnosis of skeletal asymmetries. **Objective:** Validate PN as a diagnostic image to identify mandibular skeletal asymmetries compared to AP. **Method**: Diagnostic validation study compared 51 PN (index test) and 51 AP (reference test) of the same patient. Points, planes, and measurements were traced on the right and left sides, identifying asymmetries (discrepancies >3mm). PN's prevalence, sensitivity, specificity, and non-conventional parameters were calculated when compared to AP. **Results:** According to PN and AP, the prevalence of asymmetries was 92.2% and 84%, respectively. The agreement in the diagnostic classification of both radiographs did not exceed 50% in any of the distances evaluated, except for total asymmetry (80%). PN showed higher sensitivity than specificity in most distances but had lower predictive values. **Conclusions:** PN identifies many false negatives, overestimating patients with at least one type of asymmetry.

Keywords: Radiography panoramic; Facial asymmetry; Diagnostic imaging; Jaw.

RESUMEN

Introducción: la asimetría mandibular es un desequilibrio entre el lado derecho y el izquierdo, diagnosticado mediante fotografías, tomografías, radiografías posteroanteriores (PA) y radiografías panorámicas (PN). Sin embargo, a pesar de los mayores índices de distorsión y magnificación, la PN sigue siendo ampliamente utilizada en el diagnóstico inicial de asimetrías esqueléticas. **Objetivo**: validar la PN como imagen diagnóstica para identificar asimetrías esqueléticas mandibulares en comparación con la PA. **Método:** Estudio de validación diagnóstica en el que se compararon 51 PN (prueba índice) y 51 PA (prueba de referencia) del mismo paciente. Se trazaron puntos, planos y medidas en los lados derecho e izquierdo identificando asimetrías (discrepancias >3mm). Se calculó la prevalencia, sensibilidad, especificidad y parámetros no convencionales de la PN en comparación con la PA. **Resultados**: la prevalencia de asimetrías fue del 92,2% y 84% según PN y PA, respectivamente. La concordancia en la clasificación diagnóstica de ambas radiografías no superó el 50% en ninguna de las distancias evaluadas, excepto para la asimetría total (80%). La PN mostró mayor sensibilidad que especificidad en la mayoría de las distancias, pero tuvo menores valores predictivos. **Conclusiones**: la PN identifica un elevado número de falsos negativos, sobreestimando a los pacientes con al menos un tipo de asimetría.

Palabras clave: radiografía panorámica; asimetría facial; diagnóstico por imagen; mandíbula.

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INTRODUCTION

Facial symmetry embodies a balance where tissue size, shape, and disposition create facial equilibrium and equivalence. Conversely, asymmetry signifies a quantitative imbalance.[1] Facial asymmetries are identified by comparing the right and left sides of the face, determining if the measurements deviate from the parameters established by some authors;[2] the primary causes range from congenital factors, such as syndromes, functional factors, such as occlusal interferences, to environmental factors, such as infections or trauma.[3,4]

At the mandibular level, the aforementioned etiological factors can lead to complex issues such as condylar hyperplasia, hemimandibular hypertrophy, hemimandibular elongation, coronoid hyperplasia, and temporomandibular joint disorders.[5] The appropriate treatment is determined depending on the magnitude and etiology of asymmetry. Earlier interventions tend to be less invasive; however, a rapid and effective diagnostic aid is necessary for detection.[6]

Facial asymmetries can be diagnosed through various diagnostic aids such as tomography, clinical photographs, and posteroanterior and panoramic radiography. Cone Beam Computed Tomography (CBCT) offers several advantages, including reduced radiation exposure compared to conventional tomography and a more precise representation of potential facial disharmonies.[7] Clinical photographs enable soft tissue analysis but lack conclusive parameters to distinguish asymmetries caused by soft tissues from those originating in the bony tissue.[7]

Posteroanterior skull radiography has been widely used to study dental-maxillofacial asymmetries, perform differential diagnoses of upper and lower midline deviations and posterior crossbites, identify occlusal plane alterations, determine the thickness of mandibular ascending branches, and establish indications for maxillary expansion and disjunction treatment.[8] Panoramic radiography, on the other hand, is used to assess the maxilla, mandible, and adjacent structures in a single image, and because of its ease of acquisition and accessibility, its use is becoming more common in developing countries. [9]

This observation suggests that the optimal way to diagnose mandibular asymmetry would be through tomography, as the advent of 3D images has led clinicians toward more accurate diagnoses.[10] Nonetheless, its high-cost limits accessibility for many individuals, and it is primarily used to confirm the asymmetry diagnosis.[7] However, for the initial diagnosis of mandibular asymmetries, posteroanterior and panoramic radiographs remain commonly used by general dentists and specialists, especially among students.[11] Nevertheless, posteroanterior radiography is less utilized due to analysis difficulties and exposes the patient to a higher radiation dose (0.03 mSv = 3 mrem) than panoramic radiography (7µSv = 0.7 mrem).[8,12]

Nevertheless, the literature must clarify how valid panoramic radiography is compared to anteroposterior radiography in detecting actual asymmetries for an initial diagnosis of mandibular asymmetry. Some authors, when comparing them, find heterogeneous results; for some, there is high concordance, concluding that panoramic radiography helps diagnose asymmetry,[13,14] while others suggest cautious use due to certain limitations as a diagnostic tool in general, such as having a magnification distortion in any region of 25% and measurements that may not be reliable[16]. Despite this, due to its ease of use as a diagnostic aid, it continues to be used as an element to suspect the presence of skeletal asymmetries.[17,18]

Therefore, this study was conducted to validate panoramic radiography as a diagnostic image to identify mandibular skeletal asymmetries in comparison with posteroanterior radiography and evaluate the performance of panoramic radiography in diagnosing mandibular asymmetries compared to posteroanterior radiography.

METHOD

Type of study

A retrospective diagnostic validation study was conducted.

Participants

Posteroanterior and panoramic radiographs were selected from a random sample of patients over 14 years old seeking orthodontic care in private practice. Patients with no more than three missing teeth (excluding third molars), without prior orthodontic or orthopedic treatments, and having both radiographs taken simultaneously were included. Patients with syndromes or previous jaw surgeries were excluded. None of the patients presented pathological asymmetry due to condylar hyperplasia. Fifty-one patients who met the inclusion criteria were selected; the sample size was calculated based on the study by Lim et al.[19]

Instruments

Diagnostic images were evaluated using a checklist and selected based on their quality (sharpness, minimal distortion, correct framing, absence of artifacts, and adequate density and contrast). Sixteen pairs of radiographs were excluded due to common errors such as absent condyles, magnification exceeding 25% in panoramic radiographs, and incorrect head positioning in posteroanterior radiographs. A final sample of 51 panoramic and 51 posteroanterior radiographs (from the same patient) was obtained. The research had the approval of the institutional ethics committee and permission to access the sample.

The panoramic radiograph was designated the index test (radiograph to be evaluated), while the posteroanterior radiograph served as the reference test (radiograph to be compared with the gold standard). Both were captured using the same Hyperion X9 X-ray equipment from Myray, managed through iRYS and DICOM 3.0 software (Medellín-Colombia) on the same day and at the same radiological center. Both radiographs were printed on an AGFA Drystar DT 2 B 8X10'' and Drystar5302 printer with CEPH TRACING PAPER acetate sheets ref. 630-020 Ortho Organizers brand.

Procedure and data collection

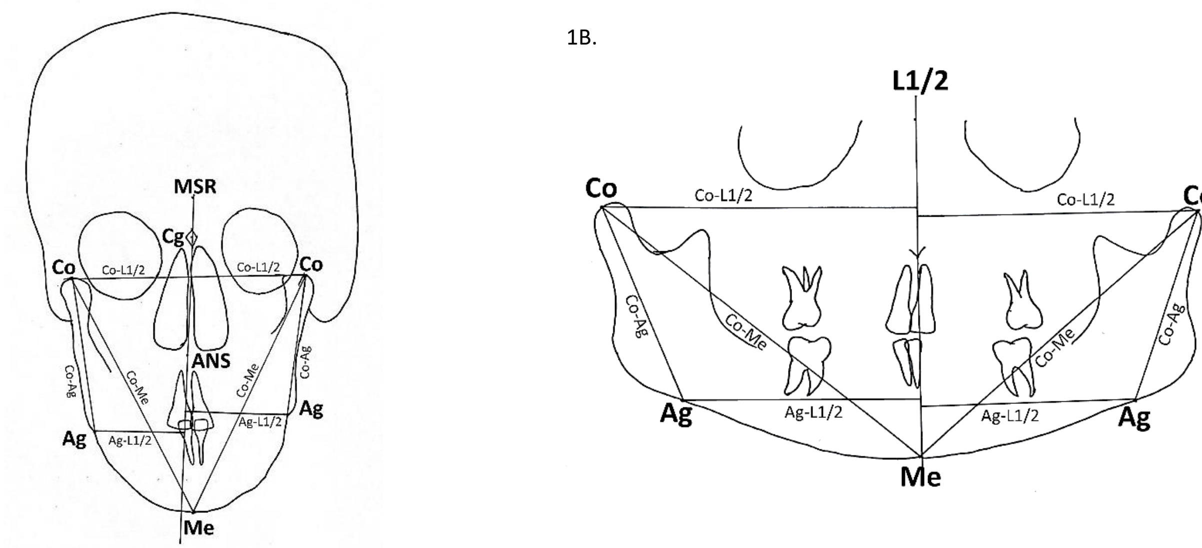
Manual tracing was performed to avoid distortion inherent in digital tracings, overlaying a 0.003-inch Ortho Technology cephalometric paper of 20.32 cm x 25.4 cm using a lightbox, aided by a Mirado number two pencil and a 30 cm Faber Castell square. Tracings were executed by a single evaluator, chosen based on interobserver agreement tests through Kappa index comparisons of points and measurements with a diagnostic imaging expert (interobserver Kappa index = 0.94). Subsequently, the chosen evaluator underwent training and calibration by the expert, repeating the points and measurements on three pairs of radiographs (intraobserver Kappa index = 0.96).

Table 1. The following reference points, planes, and measurements were considered for each radiograph.

References	Posteroanterior Radiograph	Panoramic Radiograph
Points	Condyle (Co): highest point of the condylar head, both right and left. Menton (Me): midpoint of the mandibular symphysis. Antegonial notch (Ag): deepest point of the antegonial notch on the mandibular border. Crista galli (Cg): a point between and above the two orbits at the apex of the ethmoid crista galli. Anterior nasal spine (ANS): most radiopaque point of the anterior nasal spine.	Condyle (Co): Highest and most posterior point of the condyle. Antegonion (Ag): Deepest point of the mandibular body contour depression. Menton (Me): Central point of the mandibular contour.
Planes	MSR: a line connecting the crista galli and ANS projected to the chin area, perpendicular to the zygomatic plane, considered the facial midline.	Midline: A line passing through the nasal septum and ANS. If there are doubts about reference points, the palatal plane is marked, followed by a perpendicular line passing through the septum and ANS.
Measurements	Condylion to Menton distance (Co-Me) Condylion to MSR distance (Co-L1/2) Antegonion to MSR distance (Ag-L1/2) Antegonion to Menton distance (Ag-Me) Condylion to Antegonion distance (Co-Ag)	Condylion to Menton distance (Co-Me) Condylion to midline distance (Co-L1/2) Antegonion to midline distance (Ag-L1/2) Antegonion to Menton distance (Ag-Me) Condylion to Antegonion distance (Co-Ag)

1A.

1B.



Posteroanterior

Panoramic

Source: Own elaboration

Figure 1. Traced Points and Measurements in Panoramic (1A) and Posteroanterior Radiographs (1B).
The Condyle to Menton distance (Co-Me) assessed the total hemimandibular length; the Condyle to Midline or MSR distance (Co-L1/2) evaluated the condylar distance, the Antegonion to Midline or MSR (Ag-L1/2) the distance to the lower border of the ramus, the Antegonion to Menton (Ag-Me) the hemimandibular body, and the Condyle to Antegonion (Co-Ag) the height of the mandibular ramus.

Statistical analysis

Distances were measured on both sides, subtracting the measurements from the right and left sides; if the difference exceeded 3mm, it was considered asymmetrical to establish the evaluation outcome of mandibular asymmetry.[7] Patients were considered asymmetric for total asymmetry if they presented at least one asymmetry in the evaluated distances.

The prevalence of mandibular asymmetries was assessed using frequency distributions (absolute and relative), and the difference between both radiographs was evaluated using a proportion difference, considering statistically significant differences in those tests presenting a p-value <0.05, or where the confidence interval (95% CI) did not contain 1. The diagnostic capability of the panoramic radiograph was evaluated through statistical analyses of sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), accuracy, concordance (assessed by the percentage agreement of the Kappa index), the odds of detecting asymmetry following the panoramic radiograph, and likelihood ratios; accompanied by graphical representation using Fagan's nomograms.

Statement of ethical issues

This study was conducted with secondary sources, and no experimentation or direct collection with patients was performed. A radiological center provided the radiographic images with the patient's permission to use them for research purposes. The radiographs were handled, maintaining the participants' anonymity; the data collected were only used for this research. This study was approved by the Program Committee of Institución Universitaria Visión de las Américas.

RESULTS

The prevalence of asymmetries was 92% (47) according to the panoramic radiograph and 80% (41) according to the posteroanterior radiograph, demonstrating a higher prevalence detected by the panoramic radiograph (Table 2).

The measurements of total hemimandibular length (Co-Me), hemimandibular body (Ag-Me), and mandibular ramus height (Co-Ag) showed statistically significant differences in the proportion of asymmetries detected by the two radiographs, specifically with a difference of 31%, 24%, and 29%, respectively. The panoramic radiograph identified a higher prevalence of asymmetries than the posteroanterior radiograph, indicating diagnostic overestimation by the panoramic radiograph in each evaluated distance (Table 2).

Table 2. Prevalence of asymmetries detected by posteroanterior and panoramic radiographs

Distance	Radiograph	Asymmetric		Symmetric		p-value	Z-score	Difference in proportions	IC 95%
		n	%	n	%				
Hemimandibular total length (Co-Me)	Posteroanterior	17	33,3	34	66,7	0,002*	-3,17	-0,31	-0,50 - -0,13
	Panoramic	33	64,7	18	35,3				
Condylar distance (Co-L1/2)	Posteroanterior	26	51	25	49	0,32	-1,00	-0,10	-0,29 - 0,09
	Panoramic	31	60,8	20	39,2				
Distance to the lower edge of the branch (Ag-L1/2)	Posteroanterior	24	47,1	27	52,9	0,111	-1,59	-0,16	-0,35 - 1,16
	Panoramic	32	62,7	19	37,3				
Hemimandibular body (Ag-Me)	Posteroanterior	14	27,5	37	72,5	0,015*	-2,43	-0,24	-0,42 - -0,05
	Panoramic	26	51	25	49				
Branch height (Co-Ag)	Posteroanterior	15	29,4	36	70,6	0,003*	-2,99	-0,29	-0,48 - -0,11
	Panoramic	20	58,8	21	41,2				
Total asymmetry	Posteroanterior	41	80	10	20	0,084	-1,73	-0,12	-0,25 - 0,01
	Panoramic	47	92	4	8				

*Significant statistical difference.

The concordance in the diagnostic classification of both radiographs (posteroanterior and panoramic) did not exceed 50% in any of the evaluated distances, indicating a high discrepancy between both tests, except for total asymmetry, which showed a close to 80% agreement (Table 3).

In conventional parameters, sensitivity is understood as those patients classified as asymmetrical, and specificity as those classified as symmetrical by the panoramic radiograph. In the measurements of total hemimandibular length (Co-Me), condylar distance (Co-L1/2), distance to the lower border of the ramus (Ag-L1/2), and height of the hemimandibular ramus (Co-Ag), the panoramic radiograph exhibited higher sensitivity than specificity, detecting a prevalence of asymmetry of 33.3%, 51%, 47.1%, and 29.4%, respectively. Meanwhile, in the measurement of the hemimandibular body (Ag-Me), higher specificity than sensitivity was found, with a prevalence of asymmetry of 27.5%. All evaluated distances showed precision below 50%, except for total asymmetry, which was accurate at 76% (Table 3).

Regarding non-conventional parameters, the positive predictive value, corresponding to patients who genuinely had asymmetry, contrary to the negative predictive value, corresponding to those who were genuinely symmetrical, were lower in all individual distances compared to sensitivity and specificity, indicating an overestimation of diagnosis by the panoramic radiograph. Specifically, the lowest positive predictive values were found in the vertical measurements, i.e., total length (Co-Me), ramus (Co-Ag), and body (Ag-Me) of the hemimandibular, correctly classifying very few patients as accurate asymmetrical. Conversely, total asymmetry exhibited a similar behavior concerning sensitivity (higher) and positive predictive value (lower) but, on the contrary, showed lower specificity and higher negative predictive value, indicating that the panoramic radiograph for evaluating total asymmetry overestimates asymmetrical cases and underestimates symmetrical ones (Table 3).

Table 3. Diagnostic accuracy of mandibular asymmetries using panoramic radiography

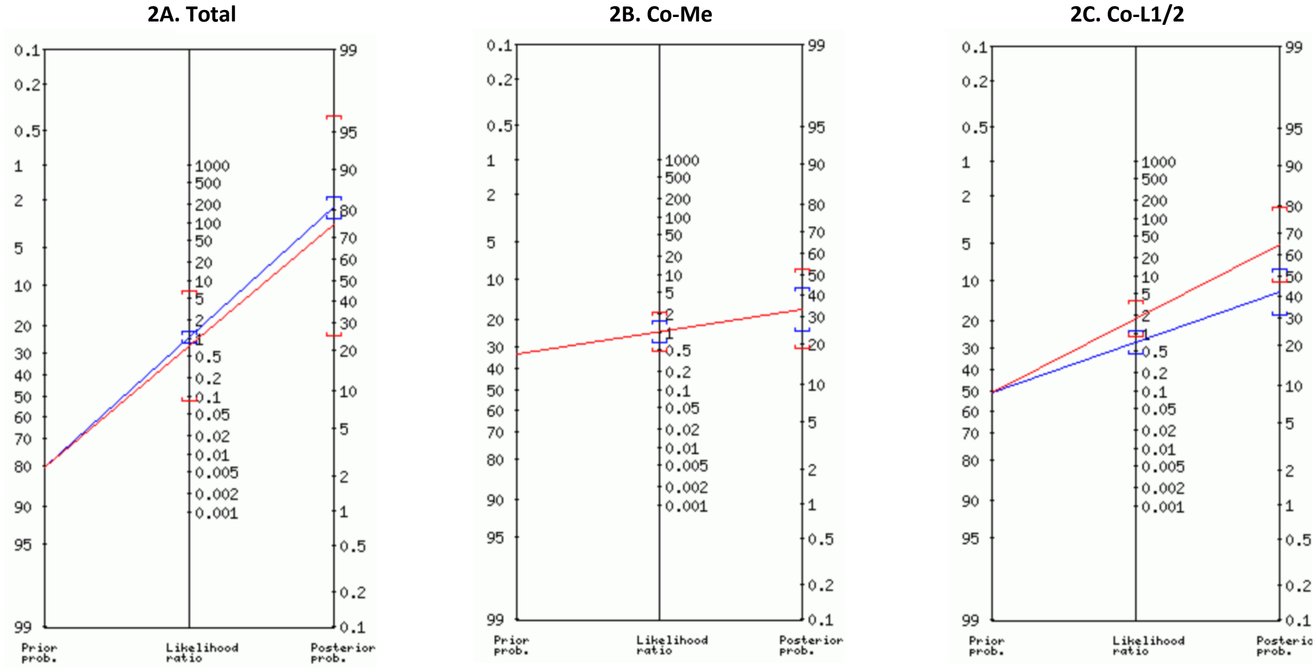
Classification and concordance	**Co-Me***	**Co-L ½***	**Ag-L1/2***	**Ag-Me***	**Co-Ag***	**Total**
	n	**n**	**n**	**n**	**n**	**n**
Asymmetric	17	26	24	14	15	41
Symmetric	34	25	27	37	36	10
Positive tests	33	31	32	26	30	47
Negative tests	18	20	19	25	21	4
True test	23	20	25	21	22	39
Incorrect test	28	31	26	30	29	12
Kappa Index	0,00	-0,22	-0,004	-0,016	-0,06	0,03
Kappa p-value	1,00	0,108	0,97	0,18	0,60	0,77
Asymmetric	45	39	49	41	43	76
Conventional and non-conventional parameters	**%(IC95%)**	**%(IC95%)**	**%(IC95%)**	**%(IC95%)**	**%(IC95%)**	**%(IC95%)**
Prevalence	33,3 (19,4-47,3)	51,0 (36,3-65,7)	47,1 (32,4-61,4)	27,5 (14,1-40,7)	29,4 (15,9-42,9)	80,0 (66,8-90,2)
Sensitivity	64,7 (39,1-90,4)	50,0 (28,9-71,1)	62,5 (41,1-83,9)	35,7 (7,0-64,4)	53,3 (24,8-81,9)	93.0 (80,1-98,5)
Specificity	35,3 (17,8-52,8)	28,0 (8,4-47,6)	37,0 (17,0-57,1)	43,2 (25,9-60,6)	38,9 (21,6-56,2)	10,0 (0,25-44,5)
Accuracy	45,1 (30,5-59,7)	39,2 (24,8-53,6)	49,0 (34,3-63,7)	41,2 (26,7-55,7)	43,1 (28,6-57,7)	76,0 (62,5-87,2)

Positive predictive value	33,3 (15,7-50,9)	41,9 (22,9-60,9)	46,9 (28,0-65,7)	19,2 (2,2-36,3)	26,7 (9,2-44,2)	81,0 (77,1-84,1)
Negative predictive value	66,7 (42,1-91,2)	35,0 (11,6-58,4)	52,6 (27,5-77,7)	64,0 (43,2-84,8)	66,7 (44,1-89,2)	25,0 (3,72-74,2)
Probability of asymmetry after the test	33,3 (25-44)	41,9 (31-53)	46,9 (37-57)	19,2 (10-34)	26,7 (18-38)	81,0 (77-84)
Probability of symmetry after the test	66,7	35,0	52,6	64,0	66,7	25,0
Positive likelihood (LR+)	1,00 (0,65-1,54)	0,69 (0,44-1,10)	0,99 (0,65-1,52)	0,63 (0,30-1,34)	0,87 (0,51-1,50)	1,03 (0,82-1,29)
Negative probability (LR-)	1,00 (0,45-2,2)	1,79 (0,85-3,73)	1,01 (0,50-2,07)	1,49 (0,87-2,54)	1,20 (0,61-2,37)	0,73 (0,18-2,93)

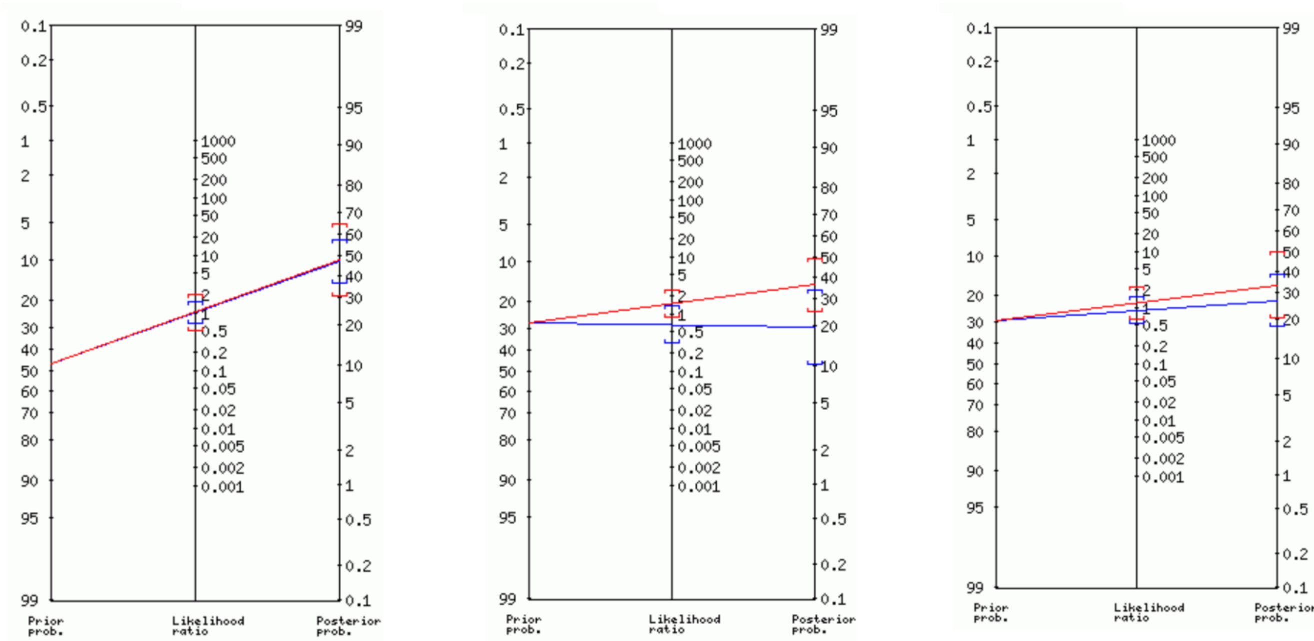
*Co-Me: Condyle to Menton, Co-L1/2: Condyle to Midline, Ag-L1/2: Antegonion to Midline, Ag-Me: Antegonion to Menton, Co-Ag: Condyle to Antegonion, LR: Likelihood Ratio.

The likelihood ratio in the measurements of total hemimandibular length (Co-Me), distance to the lower border of the ramus (Ag-L1/2), and total asymmetry indicated that the probability of diagnosing asymmetry does not change after conducting the panoramic radiograph once the patient has been diagnosed with a posteroanterior radiograph. However, in the measurements of condylar distance (Co-L1/2), the body (Ag-Me), and the hemimandibular ramus (Co-Ag), the probability of being classified as asymmetrical when the patient did have this condition decreased by 31%, 37%, and 13%, respectively, becoming false negatives (Table 3, graph 2).

2A. Total **2B. Co-Me** **2C. Co-L1/2**



2D. Ag-L1/2 **2E. Ag-Me** **2F. Co- Ag**



Graph 2A. Fagan's Nomograms for Total Asymmetry and Fagan's Nomograms for Discrimination by Distances: 2B. The Condyle to Menton distance (Co-Me) assessed the total hemimandibular length; 2C. The Condyle to Midline or MSR distance (Co-L1/2) evaluated the condylar distance; 2D. The Antegonion to Midline or MSR (Ag-L1/2) is the distance to the lower border of the ramus; 2E. The Antegonion to Menton (Ag-Me) the hemimandibular body; 2F. The Condyle to Antegonion (Co-Ag) is the height of the mandibular ramus.

DISCUSSION

Panoramic radiography is a diagnostic tool that provides an overview of the dental-maxillofacial structure.[20] However, it presents distortion and magnification factors, especially in areas that deviate from the central plane compared to actual structures.[21-23] Hence, it is essential to validate in which areas or lengths it is most accurate to determine its reliability.

In the current study, a high prevalence of asymmetry (total asymmetry) was found, in stark contrast to the results of other investigations, one of them carried out in Quito, Ecuador, which included 680 panoramic radiographs and reported a prevalence of 30.7%[24] and another conducted in Bogotá, Colombia, evaluating 500 radiographs, where the prevalence in adults over 18 years old was only 6%.[25] The disparity in the prevalence percentages can be attributed to using the Bezuur formula for classifying asymmetrical patients in both studies. This technique could lead to underreporting, as it considers asymmetry in cases with high discrepancies. In contrast, this study adopted a stricter criterion to classify a patient as asymmetrical, indicating that the difference lies not in the diagnostic tool but in the method used to diagnose asymmetry.

Regarding the specific prevalence by distances, it was found that panoramic and posteroanterior radiography had more remarkable similarities in horizontal measurements, while vertical measurements showed statistically significant differences. Some studies suggest that asymmetries in specific measures are due to magnification present in panoramic radiography or poor placement of anatomical points;[26, 27] therefore, Tronje[20] and Lester *et al.*,[28] justify more significant distortion in horizontal measurements due to non-uniform variation in enlargement at different depths of the object, leading to suspicions of asymmetry without actually having it, since according to Srivastava *et al.*,[29] vertical measurements are more stable in the panoramic. These results contrast with the vertical and non-horizontal discrepancies found in this study.

The percentage of agreement between both radiographs in identifying patients with and without asymmetry in each of the individual measurements ranged from 39% to 49%; however, scientific evidence presents a wide range of results. Some studies show remarkably high agreement in specific measurements; Lim et al.,[30] reported an 88% agreement in total ramal length; Kambylafkas *et al.*,[31] a 95% agreement in total ramal height, and Agrawal *et al.*,[32] an agreement of more than 60% in the body, ramus, condyle, and total length of the mandible; however, others, like Türp *et al.*,[33] found only a 26% agreement. Considering that the comparisons in all studies are made with different sources, such as tomographies, laminography, or real skulls, only the study by Agrawal *et al.*,[32] makes a direct comparison with posteroanterior radiography.

The diversity of concordance between the panoramic radiograph and the posteroanterior radiograph may be due, in addition to the inherent magnification of the panoramic radiograph, to differences between X-ray equipment and the various vertical or horizontal enlargements recommended by the manufacturer for adjustments and impressions that could lead to inaccuracies in some regions of the panoramic radiograph.[34] However, considering the magnification and distortion inherent in panoramic radiography, this study refutes what was found in other research identifying high concordances of panoramic radiography with different types of diagnostic aids, a feature only found when evaluating total asymmetry and not in specific measurements, as total asymmetry is a combination of different distances and is defined by at least one discrepancy.

The sensitivity (ability to detect asymmetry) of panoramic radiography in this study ranged from moderate to high, fluctuating between 35.7% and 64.7% for specific measurements and 93% for total asymmetry. On the other hand, the specificity (ability to detect symmetry) varied between moderate and low, ranging from 28% to 43.2% for specific measurements and dropping to 10% for total symmetry. These percentages are higher in the study by Lim *et al*.,[30] which compared panoramic radiography with tomography, reporting a sensitivity ranging from moderate to high (67% to 93%) and high specificity (82% to 94%), contrasting with the findings of Laster *et al.*,[28] who compared it with real skulls, yielding low sensitivity (13%) and high specificity (86%). The percentages were closer to those reported by Kambylafkas et al.,[31] who identified moderate sensitivity (62%) and low specificity (10%), comparing panoramic radiography with laminography. This notable difference between total sensitivity and assessment by specific regions, not only in this study but in others, underscores the importance of evaluating the diagnostic capability of panoramic radiography specifically for each area rather than just total symmetry. This approach yields more precise results, allowing for a more accurate identification of asymmetries in different areas.

In terms of accuracy, the results of this investigation indicate it could be higher (ranging from 39% to 49%). This finding aligns with the study by Markic *et al.*, [35] which found discrepancies larger than 4mm and low precision of panoramic radiography when compared to various diagnostic tools such as computed tomography (CT), cone-beam computed tomography (CBCT), MRI, and lateral cephalometric radiography. However, this contrasts with reports by Laster *et al.*[27] and Lim *et al.*,[29] indicating that panoramic radiography was moderate to highly accurate (67% and 86%, respectively).

Other authors report fewer positive predictive values (PPV) and negative predictive values (NPV) as safety parameters for panoramic radiography. This observation might be due to their direct influence on the prevalence of asymmetry in each population.[36] Nonetheless, Lim *et al.*[29] reported higher PPV (69% to 80%) and NPV (88% to 96%) compared to those found in this study (19% to 46% and 36% to 65%, respectively).

Consequently, studies such as Lim *et al.*,[30] exhibit consistency in sensitivity, specificity, accuracy, PPV, and NPV, contrary to the findings of this study, where PPV is significantly lower than sensitivity figures and NPV significantly higher than specificity figures. Therefore, considering that predictive values can be sensitive to the prevalence of asymmetry in a specific population, the likelihood ratios (LR) are considered decisive parameters in assessing the performance of panoramic radiography for detecting mandibular asymmetries, as they are not influenced by prevalence. They provide more precision, as patients will likely have asymmetry before the panoramic radiography, indicating how much the diagnosis changes after obtaining it, regardless of disease prevalence. These ratios also allow extrapolating the results of this research to other populations, where only the prevalence of the disease changes while the LR remains the same.[36]

The overall performance capacity of panoramic radiography in this study can be concluded through the likelihood ratio, indicating no significant changes in the diagnosis after obtaining it beyond the diagnosis already made with posteroanterior radiography, therefore exhibiting limited power. However, panoramic radiography was to be used as an initial diagnostic aid to identify asymmetries. In that case, sensitivity and specificity are intrinsic characteristics of panoramic radiography, suggesting that similar results to those found in this study will be encountered when performed in a similar population regardless of the patient. Predictive values vary with the prevalence of asymmetry in the population; in populations where asymmetry is highly prevalent, finding a true asymmetry confirms the diagnosis. Conversely, if asymmetry is less prevalent, finding a proper symmetry helps dismiss the diagnosis, both with sufficient reliability. Clinicians' primary interest should be to increase the likelihood of making the correct diagnosis to justify treatment.

Considering the potential for panoramic radiography to overestimate asymmetries and underestimate symmetries, making a definitive decision based on it becomes a risk factor, as it would be more dangerous to classify a patient as asymmetric when they are not (false positive), leading to an intervention. Therefore, panoramic radiography does not surpass tomography for an accurate diagnosis.[29] In view of the cost-benefit and the performance of the panoramic radiograph identified in this study, it might be more appropriate to perform a posteroanterior radiograph for an initial diagnosis of asymmetry, as the probability of finding an asymmetry does not change once the diagnosis has been reached with a posteroanterior.

As a limitation of this study, it was found that the sample had a higher percentage of asymmetric patients than symmetric patients in the sample, potentially rendering sensitivity and PPV values more reliable than specificity and NPV percentages. Moreover, the sample size was small, which could influence prevalence. Furthermore, this study discusses the discriminatory capacity of the test, but studies contrasting the results have different comparators, such as tomographies, laminographies, or real skulls. The quantity of articles comparing panoramic radiography with posteroanterior radiography is limited, and some reviewed articles present differences in measurements but need more diagnostic evaluation data such as sensitivity, specificity, accuracy, PPV, NPV, and LR. This heterogeneity in the studies found, potentially due to different comparators, does not allow for more robust discussions.

Consequently, given the variation in applying the Bezuur formula among different investigations, it is necessary to establish a critical consensus for defining an asymmetric patient, as well as the inclusion of horizontal points in the analysis to control the distortion of the panoramic radiograph. Additionally, evaluating the diagnostic capacity of posteroanterior radiography would be an opportunity to consolidate it as the preferred aid for the initial diagnosis of mandibular asymmetries.

CONCLUSIONS

The panoramic radiography used to detect mandibular asymmetries showed a high discrepancy concerning anteroposterior radiography, which overestimated the classification of asymmetric patients and underestimated symmetric ones. Sending the patient, a panoramic radiograph does not change, and in some cases, decreases the probability of being classified with asymmetry after being diagnosed with an anteroposterior.

CONFLICT OF INTEREST STATEMENT

The authors declare that there are no conflicts of interest.

AUTHORS' CONTRIBUTION

KGM participated in the study's conceptualization and design, data collection, literature review, drafting, and final approval of the manuscript.
FABF collaborated in study design, data collection, writing, and final approval of the manuscript.
MRM participated in study design, instrument validation, data collection (final tracings), and final approval of the manuscript.
LFVT worked on the study design, writing, and final approval of the manuscript.
LHRQ participated in study design, instrument validation, statistical analysis, drafting, and final approval of the manuscript.

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