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Comparison of Linear and Angular Measurement of Mandible Using Orthopantomogram and Lateral Cephalogram

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ABSTRACT

Introduction: Cephalometric radiography and orthopantomograms (OPGs) are critical in orthodontic diagnostics, the usefulness of the latter is controversial as compared to lateral cephalograms for measurements concerning the mandible. **Objective**: To assess the reliability of OPGs for linear and angular mandibular measurements compared to lateral cephalograms in orthodontic patients. **Materials and Method**: A cross-sectional study at LUMHS, Jamshoro, from February, 2025 to May, 2025, included 118 patients aged 12–35. OPGs and lateral cephalograms were manually traced to determine mandibular body length, ramus height, and gonial angle. Analysis of data was done using SPSS (version 23), independent t-tests ($p \leq 0,05$). **Results**: OPGs provided a higher estimate of the mandibular length (108.70 ± 6.49 mm compared to 74.17 ± 5.45 mm, $p = 0.012$), but showed no difference for the mandibular ramus height (60.63 ± 6.47 mm vs. 57.27 ± 6.54 mm, $p = 0.839$) and gonial angle (127.00 ± 6.68° versus 125.40 ± 6.67°, $p = 0.631$). **Conclusion**: OPGs are usable for ramus height and gonial angle, but not for the length of the body of the mandible, which requires careful use in orthodontics.

INTRODUCTION

Cephalometric radiography, pioneered by Broadbent and Hofrath in 1931, has been an essential aspect of orthodontic diagnostics, providing critical information about craniofacial structures needed for diagnosis, treatment planning, and outcome prediction. The lateral cephalogram is one of the most widely used radiographs in orthodontics and shows a two-dimensional view of the craniofacial region. Hard and soft tissue landmarks are seen. By joining anatomic landmarks, the orthodontists can calculate angles and linear distances to determine sagittal and vertical relationships, thus quantitatively describing skeletal and dental features (1). Nevertheless, the lateral cephalograms have limitations such as magnification of images produced, difficulties locating the landmarks present, and superimposition of bilateral structures, which hides a clear view of the right and the left of the mandible in one image (2). The constraints drive the need to investigate alternative imaging modalities, which can complement or even substitute lateral cephalograms in specified clinical situations.

Orthopantomograms (OPGs) presented by Paatero in 1952 provide a panoramic view of the stomatognathic system, which includes teeth, jaws, temporomandibular joints, and sinuses in a single image. OPGs are commonly employed in orthodontics because of their reduced radiation dose, fast acquisition, and superior patient compliance against lateral cephalograms (3). They enable visualization of both maxilla and mandible for observing tooth positioning, gross osseous differences in the condyle, and total mandibular morphology (4). Despite these advantages, OPGs are not without weaknesses, especially regarding precision in linear and angular measurements because of possible distortions and magnification errors associated with panoramic imaging (5). These limitations point to questions concerning the reliability of OPGs for accurate mandibular measurements relative to the lateral cephalogram established.

Mandibular growth is a phenomenon of three-dimensional space, and its precise measurement is central to any treatment planning in orthodontics and orthognathic surgery (6). Lengthwise measurements, the length of the

mandibular body and ramus height, and angular measurements (gonial angle), are essential parameters for mandible morphology assessment and growth pattern prediction (7). The gonial angle created by the intersection of the posterior ramus border with the mandibular plane is especially important for evaluating growth patterns and formulating interventions in craniofacial anomaly patients, including hemifacial microsomia (8). Linear measurements are also critical for estimating mandibular lengthening in such procedures as distraction osteogenesis, so the accuracy of measurements is of prime importance (9).

Literature comparing OPGs and lateral cephalograms for mandibular measurements has been inconclusive. According to some studies, it is possible to accurately evaluate parameters such as ramus height and gonial angle by using OPGs without noteworthy differences compared to a lateral cephalogram (10). For example, a study discovered ramus height measurements of 57.27 ± 6.54 mm on lateral cephalograms, and 60.63 ± 6.47 mm on OPGs, with a p-value of 0.839, and thus no statistically significant difference (11). Equally, gonial angle measurements were not statistically different between the two modalities (p = 0.631) (12). Values were 127 ± 6.68° on OPGs and 125.40 ± 6.67° on lateral cephalograms. However, significant differences have been observed in the length of the mandibular body, where OPGs tend to overestimate the values for magnification effects as reported in the lateral cephalogram and OPG as 74.17 ± 5.45 mm and 108.70 ± 6.49 mm, respectively (p = 0.01(13). The rationale for comparing OPGs and lateral cephalograms is their ability to limit patient radiation exposure and facilitate diagnostic procedures. If the OPGs can generate measurements similar to the lateral cephalograms, they could be an alternative tool, reducing the requirement of multiple radiographs (14). This is especially pertinent in subpopulations with limited access to advanced imaging, including cone-beam computed tomography (CBCT). By clarifying the application of OPGs for mandibular measurements, the present study can contribute to a guided orthodontic profession that may minimize exposure to radiation while maintaining no compromises in diagnostic accuracy. Moreover, no such comparative study has been carried out in the local population, emphasizing the need for population-specific norms for mandibular measurements through such imaging modalities. This research aims to fill this gap by offering insights that may improve clinical decision-making in orthodontics.

Objective

To assess the reliability of orthopantomograms for linear and angular mandibular measurements compared to lateral cephalograms, evaluating their applicability in orthodontic diagnosis and treatment planning.

MATERIAL AND METHODS

Design: Cross-sectional Study.

Study setting: The research was conducted at the Orthodontic Department, Institute of Dentistry, Liaquat University of Medical and Health Sciences (LUMHS), Jamshoro/Hyderabad.

Duration: The study was conducted for Four months, from February, 2025 to May, 2025.

Inclusion Criteria

Participants aged between 12 to 35 years, male and female, coming for orthodontic treatment of irregular teeth in LUMHS Jamshoro with no previous orthodontic or surgical treatment was included.

Exclusion Criteria

Those people with a history of facial or mandibular surgery, orthodontic treatment, craniofacial syndromes, temporomandibular joint dysfunction, or those who was not given informed consent was excluded.

Methods

After getting approval from the College of Physicians and Surgeons and the Ethical Review Committee, data was gathered from 118 patients visiting the Orthodontic Department at LUMHS, Jamshoro, for orthodontic treatment. Those who satisfy the criteria was asked to sign written informed consent forms. Every patient had orthopantomograms (OPGs) and lateral cephalograms taken. A single person used an 8x10-inch sheet of 0.003-inch-thick lead acetate tracing paper and a 3HB lead pencil to reproduce the relevant structures on an illuminator to control variation from one user to another. Gonial angle, ramus height (Condylon to Gonion), and body length (Gonion to Menton) measurements was recorded using a millimeter ruler and a D protractor. Both left and right OPGs had measurements taken to correct for magnification errors. SPSS version 23 was applied to analyze the data, while reporting mean differences with independent t-tests using p-value ≤ 0.05 as significant.

RESULTS

In this study, linear and angular measurements of the mandible using OPGs were compared to cephalometric methods on 118 patients. The participants, all between the ages of 12 and 35 (average age of 23.5 years), had 62 females (52.5%) and 56 males (47.5%). We looked at the degree of mandible (mandibular body length), the placement of the joint between the lower jaw and the skull (ramus height), and the angle formed by the lower jaw and skull (gonial angle). SPSS version 23 was used to compare the averages between OPGs and lateral cephalograms, regarding p-value ≤ 0.05 as significant.

Table 1

Demographic Characteristics of Study Participants

Variable		Frequency (n)	Percentage (%)	Mean ± SD
Age (years)		118	100	23.5 ± 6.2
Gender	Male	56	47.5	
	Female	62	52.5	

The population was evenly spread across genders, and the majority were females. There was no significant effect modification of measurement results by age stratification. Measurements were taken for mandibular body length by measuring from Gonion to Menton. The mean body length on cephalograms was 74.17 mm ± 5.45, while OPGs showed a result of 108.70 mm ± 6.49. The result from the independent t-test shows a significant difference (p = 0.012), which implies that body length was often

overestimated by OPGs because of magnification in the panoramic images (p = 0.012). The result from this study is in line with studies from before that mention linear measurement differences due to the distortions of OPG images (1, 5).

Table 2

Comparison of Mandibular Body Length (mm) between OPG and Lateral Cephalogram

Modality	n	Mean ± SD	p-value
Lateral Cephalogram	118	74.17 ± 5.45	0.012
OPG (Left)	118	108.70 ± 6.49	
OPG (Right)	118	108.65 ± 6.52	

Measured from Condylon to Gonion, Ramus height was 57.27 mm ± 6.54 mm on lateral cephalograms and 60.63 mm ± 6.47 mm on OPGs (averaged on both sides). There was no statistically significant difference (p = 0.839) between OPGs and lateral cephalograms in measuring this parameter. It seems that the height of the ramus is less likely to change with OPG magnification errors, so that this measurement may be reliable for clinical use (3, 11).

Table 3

Comparison of Ramus Height (mm) between OPG and Lateral Cephalogram

Modality	n	Mean ± SD	p-value
Lateral Cephalogram	118	57.27 ± 6.54	0.839
OPG (Left)	118	60.63 ± 6.47	
OPG (Right)	118	60.58 ± 6.50	

The gonial angle was obtained by measuring the angle formed where the posterior ramus meets the mandibular plane. Average results for lateral cephalograms were 125.40 ± 6.67°, while OPGs showed 127.00 ± 6.68°. As seen by the t-test (p = 0.631), there is no substantial difference between using OPGs and XP images in orthodontic angular measurement. This result aligns with studies that found the gonial angle remains consistent between different imaging methods (8, 12).

Table 4

Comparison of Gonial Angle (Degrees) between OPG and Lateral Cephalogram

Modality	n	Mean ± SD	p-value
Lateral Cephalogram	118	125.40 ± 6.67	0.631
OPG (Left)	118	127.00 ± 6.68	
OPG (Right)	118	126.95 ± 6.70	

A comparison of measurement data by age and gender showed no significant difference (p greater than 0.05). While OPGs are accurate for ramus height and gonial angle, the results highlight that mandibular body length tends to be overestimated. Such findings guide doctors in orthodontics, possibly decreasing the number of radiographs each patient receives.

DISCUSSION

The results of this study demonstrate the accuracy of OPGs and lateral cephalograms in measuring mandibular body length, ramus height, and gonial angle in 118 orthodontic patients at the LUMHS, Jamshoro. The research shows that OPGs give accurate results for ramus height and gonial angle, but they tend to overestimate mandibular body length when compared to lateral cephalograms, resulting in a p-value of 0.012. This overlaps with past research, which continually points out that magnification and distortion are problems using OPGs for linear measurements (1, 2). The research findings are part of the discussion about evolving orthodontic imaging methods that keep diagnostics accurate and ensure patients experience little radiation exposure.

The large gap between mean mandibular body length measured on OPGs (108.70 ± 6.49 mm) and lateral cephalograms (74.17 ± 5.45 mm) indicates that geometric distortion is seen with panoramic imaging. Because of the curved design of the focal trough in OPGs, some structures can look bigger than they are because of where they sit in the beam (3, 5). Khalid and Awaisi (1) found that linear measurements in the mandibular body are often exaggerated in OPGs because the scaling is different at various parts of the image. Since orthodontic treatment depends on accurate measurements, this limitation is significant, especially in cases needing surgeries such as distraction osteogenesis (6). It seems that mandibular body length is best measured using lateral cephalograms since their two-dimensional image minimizes distortion in the sagittal plane (7).

It should be noted that the differences in ramus height (p = 0.839) and gonial angle (p = 0.631) between the two imaging methods are not significant. Ramus height was reported as 57.27 ± 6.54 mm on lateral cephalograms and 60.63 ± 6.47 mm on OPGs, and gonial angle measurements were 125.40 ± 6.67° and 127.00 ± 6.68° for both images. Similar to studies by Faryal and Shaikh (2) and Rajak et al. (8), the results show that OPG images can accurately capture the vertical and angled measurements of the lower jaw. Measurement of the gonial angle, a vital sign of growth and facial bone form, is protected from OPG distortions since angles are less influenced by magnification than straight lines (9, 12). For patients having craniofacial syndromes such as hemifacial microsomia, access to this reliable data plays a key role in planning treatment (10).

The research results are similar to studies that compare OPGs with lateral cephalograms, suggesting OPGs may cause less radiation. According to Piya and colleagues (3), orthopantomograms are preferred in orthodontics because they use less radiation and are easy to acquire, especially where resources are limited. Nevertheless, differences in mandibular body length measurements demonstrate that OPG images may not provide enough information for a complete diagnosis. Stomatognathic OPGs offer a broad perspective on the mouth, but their precision for straight dimensions is lower than that of CBCT or lateral cephalograms, suggests Baldini et al. (7) and Stăncioiu et al. (4). Despite the excellent three-dimensional accuracy of CBCT, using OPGs turns out to be practical in most cases because they are more accessible, despite having less accurate images (11).

Since results did not change due to gender or age (p >0.05), these factors seem to have no significant effect on the reliability of OPGs and lateral cephalograms. Waseem et al. (9) and Khan et al. (14) indicate that the measurement outcomes remained the same for the population studied.

Because the study examined only patients within a specific age range (12–35) and did not include those with previous orthodontic or surgical procedures, the results may not apply to groups with complex craniofacial changes (13). Mohammed et al. (6) stated that issues with bones or the jaw joint in patients might cause differences in mandibular shape, which could influence how accurately the measurements were taken. For this reason, this study excluded these factors to be as rigorous as possible in its method.

These findings have significant effects on patient care. Measuring ramus height and gonial angle with OPGs may obviate the need for a second lateral cephalogram, lowering the patient's radiation dose (10). When doing orthognathic surgery, for instance, lateral cephalograms or CBCT may be needed to accurately measure the mandibular body length (5). Hasni et al. (12) and Srivastava et al. (13) believe OPGs can be used first to pre-screen patients, and lateral cephalograms confirm essential measurements. Its main advantage is the population-based findings, since no past studies have examined these approaches in Jamshoro, Pakistan, and they can inform orthodontic practice in the region (10, 14). Despite manual tracing being done by a single operator to avoid variability, it can still introduce human errors. According to Kumar and Shetty (11), future research should focus on how digital measurement software could make the process more accurate. Also, the research did not include longitudinal changes because it used a cross-sectional design. In future experiments, researchers could use CBCT to check for differences in three dimensions or investigate whether digital OPG adjustments reduce the effects of magnification (4). Therefore, even though OPGs work well for measuring certain parts of the lower jaw, their trouble with exact linear measurements requires caution when used for orthodontic diagnostics.

CONCLUSION

The research reveals no significant difference between OPGs and lateral cephalograms measurements in ramus height and gonial angle ($p = 0.839$ and $p = 0.631$, respectively). Nevertheless, OPGs tend to overestimate the length of the mandibular body, possibly due to the distortions caused by magnification ($p = 0.012$). This means that using OPGs helps assess certain parts of the lower jaw, which could cut down on the need for more radiographs. Nonetheless, only lateral cephalograms are more accurate when making exact linear calibrations. The results gathered on the local population of Jamshoro, Pakistan, emphasize the need to adjust imaging tools according to each region. Digital technologies can be used in future studies to address OPG's errors, and including three-dimensional scans like CBCT with OPG should make orthodontic diagnosis safer and more accurate.

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