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Orthopantomogram as a tool for morphometric study: Advancing dental diagnostics with a novel approach

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Abstract
Introduction: The Orthopantomogram (OPG) is a widely used imaging modality in dental diagnostics, offering panoramic visualization of the jaws, teeth, and associated structures. With advancements in technology, OPG has emerged as a tool for morphometric studies, providing reliable and quantitative data on craniofacial structures. Morphometry in dental diagnostics can play a crucial role in analyzing tooth size, bone density, and maxillofacial dimensions, contributing to the detection of abnormalities and the planning of dental treatments. This study explores the application of OPG in morphometric analysis and its advantages over traditional diagnostic tools.
Methodology: A cross-sectional study was conducted using OPGs of 150 patients aged between 20-60 years, who underwent routine dental examinations. The OPGs were analysed for morphometric parameters, including mandibular height, tooth size, and alveolar bone density. Data were categorized based on age, gender, and dental health status. Standard calibration techniques were applied to ensure accuracy, and statistical analyses were conducted using SPSS software.
Results: OPGs provided clear and reliable data for all parameters. Mandibular height, tooth size, and bone density measurements showed significant variations across different age groups and between genders. Patients with compromised dental health had markedly reduced alveolar bone density. The tool proved effective in identifying both normal morphometric patterns and deviations associated with pathological conditions.
Discussion: The study demonstrated that OPG is a valuable tool in dental morphometry, offering precision in measurement and ease of use. It surpasses traditional X-rays in terms of panoramic coverage and the ability to provide quantitative assessments. However, certain limitations such as distortion in specific regions and the dependency on the operator's skill require attention.
Conclusion: Orthopantomogram is a reliable and efficient tool for morphometric analysis in dental diagnostics. Its ability to provide panoramic views and detailed measurements makes it a valuable asset in the planning and execution of dental treatment, particularly in cases requiring detailed craniofacial assessment. Further advancements in imaging technology could enhance the precision of OPG-based morphometric studies.

Keywords: Advancements, imaging, enhance

Introduction
The Orthopantomogram (OPG), also known as a panoramic radiograph, has long been a cornerstone in dental diagnostics, providing a comprehensive view of the maxilla, mandible, teeth, and adjacent structures in a single, two-dimensional image. Traditionally, OPGs have been used to identify pathologies such as dental caries, impacted teeth, and bone lesions. However, with the growing emphasis on precision in dental and maxillofacial diagnostics, OPG has evolved as a tool for morphometric analysis, which involves the measurement and quantification of craniofacial structures. The ability to gather morphometric data from OPGs offers dental professionals a novel approach to diagnosis and treatment planning, especially in orthodontics, implantology, and maxillofacial surgery.
Morphometry is defined as the quantitative analysis of form, a concept widely applied in biology, anthropology, and medical sciences. In dentistry, morphometry can be particularly useful for assessing the size, shape, and density of various craniofacial structures, including teeth, mandibles, and alveolar bone. Accurate morphometric measurements are crucial for detecting deviations from normal growth patterns, diagnosing systemic conditions affecting the bone, and planning complex dental treatments such as implants, orthodontic corrections, and prosthetics.

The traditional reliance on cephalometric X-rays and intraoral radiographs has limitations in terms of coverage and measurement precision, especially when compared to the panoramic scope of OPG.

With the advent of digital radiography and software enhancements, OPGs have become more than just a diagnostic tool; they now serve as an instrument for precise morphometric analysis. The integration of digital imaging has allowed for better calibration of measurements, reducing errors due to magnification or distortion. Several studies have demonstrated the utility of OPGs in measuring mandibular height, tooth dimensions, and alveolar bone density. These parameters are important not only for routine dental care but also for forensic identification, gender estimation, and assessment of skeletal maturity.

Despite these advantages, challenges such as image distortion, particularly in the anterior and lateral regions, persist. These distortions can result from patient positioning errors or variations in the machine's arc of rotation. Additionally, OPG measurements are influenced by factors such as age, gender, and dental health status, necessitating the need for standardization in measurement techniques. Nevertheless, when used with proper calibration and standardized protocols, OPG morphometric studies can provide highly reliable and reproducible data, making them an invaluable tool in the contemporary practice of dentistry.

This study aims to explore the application of OPG as a tool for morphometric analysis by measuring mandibular height, tooth size, and alveolar bone density across a diverse population. The study also seeks to evaluate the variations in these parameters based on age, gender, and dental health status, thereby advancing the use of OPG in dental diagnostics and treatment planning.

Materials and Methods

A cross-sectional study was conducted at the Department of Dentistry, involving 150 patients who underwent routine dental examinations. The inclusion criteria were patients between 20-60 years of age with no significant history of craniofacial trauma or systemic bone diseases. The sample was evenly distributed across age groups and genders. Ethical approval was obtained, and informed consent was taken from each patient.

OPG Procedure

- All OPGs were performed using a digital panoramic X-ray machine (Planmeca ProMax®, Finland).
- Patients were positioned according to standard protocols to minimize distortion. Head alignment was ensured using a cephalostat, and bite blocks were used to maintain the occlusal plane parallel to the floor.
- OPG images were taken with a standardized exposure of 66–70 kVp and 8–12 mA, depending on patient size.

Morphometric Parameters

- **Mandibular height**: Measured as the distance from the gonion (Mandibular angle) to the condylion (head of the mandible).
- **Tooth size**: Determined by measuring the mesiodistal width of selected teeth (central incisors and molars).
- **Alveolar bone density**: Measured using gray scale intensity of the bone around the mandibular first molars. A reference point of the highest bone density was calibrated using proprietary software (Planmeca Romexis®).

Calibration and Standardization

- All measurements were calibrated using digital software. To reduce observer bias, two radiologists independently analyzed the images, and inter-observer variability was calculated using Cohen's kappa. Discrepancies were resolved through mutual discussion.

Statistical Analysis

- Data were analyzed using SPSS version 26. ANOVA was employed to compare morphometric parameters across age groups and genders. Pearson's correlation was used to analyze the relationship between bone density and dental health status.

Results

The study included 150 OPG images analyzed for mandibular height, tooth size, and alveolar bone density. The results are presented in the following tables and graphs.

Table 1: Mandibular Height Across Age Groups

Age Group	Mandibular Height (Mean ± SD)	p-value
20-30 yrs	35.5±2.1 mm	<0.05
31-40 yrs	34.2±2.0 mm	<0.05
41-50 yrs	33.0±2.3 mm	<0.01
51-60 yrs	32.1±2.5 mm	<0.01

Graph 1: Alveolar Bone Density vs Age

The measurements revealed a significant reduction in mandibular height and alveolar bone density with age ($p < 0.01$). Tooth size remained relatively constant across age groups, with minor variations.

Table 2: Tooth Size Between Genders

Gender	Central Incisor Width (Mean ± SD)	Molar Width (Mean ± SD)	p-value
Male	8.1±0.3 mm	10.5±0.4 mm	<0.05
Female	7.8±0.2 mm	10.2±0.3 mm	<0.05

Males showed a statistically significant larger tooth size compared to females ($p< 0.05$).

Discussion

The use of Orthopantomogram (OPG) as a tool for morphometric analysis has proven to be highly effective in this study, providing detailed insights into the morphometry of craniofacial structures. OPG has traditionally been used for routine dental diagnostics, but its application in quantitative morphometric studies offers new dimensions in understanding both normal and pathological variations in dental and maxillofacial anatomy.

The findings of this study align with previous research, indicating that mandibular height decreases with age due to resorption of the alveolar bone and changes in the overall bone structure [1, 2]. Studies have shown that the mandibular bone undergoes atrophy with advancing age, particularly in individuals with edentulism or poor oral hygiene [3, 4]. The reduction in alveolar bone density in patients with compromised dental health, as seen in this study, further supports the role of periodontal disease and other systemic conditions in accelerating bone loss [5–7]. This is consistent with findings from authors who have demonstrated a correlation between bone mineral density

and systemic conditions such as osteoporosis [8–9].

Moreover, the gender differences in tooth size observed in our study are well-documented in the literature [10–11]. Males generally exhibit larger tooth dimensions than females, a finding that has implications in fields such as forensic odontology and gender estimation [12–13]. The measurement of the mesiodistal width of teeth is particularly useful in forensic investigations, where identification based on dental records plays a crucial role [14].

One of the most significant advantages of using OPG for morphometric analysis is its ability to provide a panoramic view of the dental arches, allowing for comprehensive evaluation of both jaws in a single image [15–16]. This eliminates the need for multiple intraoral radiographs, reducing radiation exposure and patient discomfort [17]. Additionally, the digital nature of modern OPGs allows for precise measurements with the aid of specialized software [18, 19]. However, challenges such as image distortion, particularly in the anterior region, need to be addressed. Distortion can be caused by improper patient positioning or variations in the machine's arc of rotation, as highlighted by several authors [20, 22].

In terms of clinical application, OPG morphometry can be invaluable in orthodontics and implantology. Accurate measurements of mandibular height and alveolar bone density are essential in planning dental implants, particularly in older patients with reduced bone density [23–24]. The ability to assess bone quality through OPG can help clinicians determine the suitability of implant placement and predict the likelihood of implant success. In orthodontics, morphometric data on tooth size and jaw dimensions can aid in treatment planning for malocclusions and crowding.

Despite its advantages, OPG-based morphometric studies have limitations. The inherent two-dimensional nature of OPGs means that certain three-dimensional features of the jaw and teeth cannot be fully captured. Cone Beam Computed Tomography (CBCT), which provides three-dimensional imaging, has been proposed as a superior alternative for detailed morphometric analysis. However, CBCT involves higher radiation doses and is not always accessible in routine dental practice. As such, OPG remains a practical and efficient tool for initial assessments, especially in general dental clinics where access to CBCT may be limited.

In conclusion, this study highlights the potential of OPG as a reliable tool for morphometric analysis in dental diagnostics. The data obtained from OPGs can assist clinicians in making informed decisions regarding treatment planning, particularly in implantology, orthodontics, and prosthetics. Future studies should focus on improving the accuracy of OPG measurements through better calibration techniques and exploring the integration of three-dimensional imaging for more comprehensive morphometric studies.

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