

Utility of Panoramic Radiographs in the Screening of Individuals with Edentulous Arches: A Need-Analysis Study

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ABSTRACT

Objective: To evaluate the utility of panoramic radiographs in pre-prosthetic screening of edentulous arches.

Material and Methods: Panoramic radiographs taken for three years were retrospectively analyzed.

Observations from the radiographs shall be categorized and classified into either of the two categories, namely: 'findings with minimal impact on denture fabrication' and 'findings which affect denture fabrication and require further evaluation.' Anatomic variations, jaw pathologies, and residual ridge resorption patterns were assessed.

Results: This study included the initial screening of 23,020 panoramic radiographs, out of which 505 (showing either one or both edentulous arches) were included for the study purpose. The age range of the subjects was from 21 to 94 years. 52.6% of the radiographs showed positive findings. More than half of the radiographs belonged to the males (52.5%). Hyperpneumatization of the maxillary sinus, crestal position of the mental foramen, and retained root fragments were the most common entities noted in the radiographs. Changes in the mental foramen were significantly higher in males than females ($p=0.002$). **Conclusion:** Observations from this study showed that panoramic radiographs have high utility for screening edentulous arches, and they should be used in routine clinical practice before denture fabrication.

Keywords: Denture, Complete; Prosthodontics; X-Rays.

Introduction

Prosthetic rehabilitation of missing teeth is quintessential for restoring the aesthetics and functional quality of the person. Rehabilitation methods commonly adopted are the fabrication of fixed or removable dentures and, more recently, implant-supported dentures. Stability and retention of the removable prosthesis form the two key features that influence the functionality, and for this, a healthy alveolar ridge is essential. The adequate alveolar bone height, shape of the bone, and absence of alveolar ridge pathologies are quite important for successful rehabilitation. Even though careful clinical examination is mandated before denture fabrication, more than this may be required as asymptomatic intra-osseous pathologies and abnormalities may be missed. Radiographic screening of edentulous arches is often suggested to rule out such clinically inconspicuous pathologies before denture fabrication. Radiographs may reveal undetected jaw pathologies, hyperpneumatization, or resorptive changes, which can adversely affect the quality and longevity of prosthesis.

The need for pre-prosthetic radiographic examination was first proposed by Logan and Eusterman [1,2]. Radiographs are valuable diagnostic tools in screening, diagnosis, and monitoring of tooth and bone-related pathologies. The various radiographic techniques include intraoral periapical projection, occlusal projection, Panoramic Radiography (PR), lateral oblique projection of the mandible, and cone beam computed tomography (CBCT). Periapical radiographs provide straightforward, clear information about the bone trabeculae and the tooth structure; however, they cover a small area of the arches, and a complete radiographic examination of the jaw would require multiple periapical projections. This demands various radiation doses, patients in compliance, and broad coverage of bone still needs to be achieved. Occlusal projections provide information mainly in bucco lingual aspect and bone width and have limited scope for screening purposes. They are usually used with periapical or panoramic radiographs to provide a three-dimensional perspective of the structures viewed [3].

CBCT has the advantage of providing in-depth information on the jaws in all three dimensions and multiplanar reconstruction [4]. It provides objective information regarding the bone width, height, and internal trabecular density, as well as any bony abnormalities. However, this involves increased radiation exposure compared to conventional radiographs and is not deemed fit for routine screening. Other disadvantages of CBCT are the poor contrast resolution of the images, motion artifacts, and technical difficulty in interpreting the radiographs to assess possible pathologies. CBCT is now routinely used as the imaging for routine pre-implant planning as the benefits outweigh the risk of exposure [5].

Despite the advent of three-dimensional imaging, panoramic radiographs are still the accepted imaging modality for the initial evaluation of maxillary and mandibular arches in edentulous patients due to the various advantages, such as the low cost, low radiation dose, and high patient acceptability. It provides comprehensive information about the maxillary and mandibular jaw bones, the teeth, the maxillary sinus, and the nasal fossae in a single image. It also serves as an effective tool for patient education. It also demonstrates the impacted teeth, bony pathologies, and root remnants that may be missed in regular clinical examination [2]. These inconspicuous abnormalities within the bone are often overlooked when found asymptomatic. Still, few complications are reported in later years that needed surgical intervention. However, these incidents are not routinely encountered. Hence, the panoramic radiographic evaluation for an asymptomatic edentulous patient is often questioned due to the radiation exposure and financial burden to the patients.

Keeping in view the changing pattern of incidence of jaw pathologies, evidence-based diagnosis and management protocols are the need of the hour. The prevalence of positive incidental findings within the jaws, the common alveolar ridge patterns, and the changes in anatomical structures like maxillary sinus and mental

foramen, which can interfere with the prosthesis fabrication, was evaluated [6]. Thus, this study aimed to assess the utility of panoramic radiography in pre-prosthetic screening of edentulous arches.

Material and Methods

Study Design and Ethical Clearance

This retrospective study was conducted by retrieving the radiographs from the Digital archives of Oral Radiology after clearance from the Kasturba Medical College and Kasturba Hospital Institutional Ethics Committee (IEC 565/2019).

Data Collection

The demographic details, namely the age, gender, the edentulous site, bone pattern, and pathologies observed, were recorded systemically in a specially designed proforma. The radiographs obtained between 2016 and 2019 were retrieved for the study's purpose. A person who was not a part of the study anonymized the radiographs. Only radiographs with edentulous maxillary, mandibular, or both arches were included in the study. Radiographs with partially edentulous arches, developmental anomalies of the jaws, surgical evidence of jaw pathologies, and radiographs with artifacts were excluded. Two Radiologists independently scrutinized the images under standard viewing conditions in the workstation monitor. Observations from the radiographs shall be categorized and classified into either of the two categories, namely: 'findings with minimal impact on denture fabrication' and 'findings which affect denture fabrication and require further evaluation with CBCT/CT'. The radiographs were assessed for the findings depicted in Table 1.

Table 1. Table showing the radiographic findings and their impact on denture fabrication.

Radiographic findings with minimal impact on denture fabrication	Radiographic findings which may affect the denture fabrication/requiring further evaluation with CBCT/ CT
Mild hyperpneumatization of the maxillary sinus with the presence of residual ridge	Severe hyperpneumatization of the maxillary sinus with minimal residual ridge
Enostosis, Idiopathic radiopacities	Impacted tooth, Radiopacities like Odontomes, Pathologic radiolucencies suggestive of Cysts/ tumors/ osteomyelitis
Deep-seated root fragments	Root fragments with periapical infection/positioned in the alveolar crest region
Mild condylar changes	Severe condylar changes
Anatomic Variants like Stafne cyst, bifid mandibular canal Accessory Mental Foramen	Crestal positioning of Mental Foramen

The height and quality of the alveolar ridge bone in the edentulous areas are crucial in pre-implant assessment and complete denture fabrication. Hence, radiographic evaluation of the type of alveolar ridge pattern in the edentulous areas is vital for better treatment outcomes.

Atwood [7] proposed a clinical classification for post-extraction edentulous sites. An attempt was made to adopt this classification system in a modified format for its utility in panoramic radiographs. The ridge patterns of the edentulous sites shall be categorized into one of the following patterns namely post-extraction status, high and regular, high and irregular, and low and depressed (Figure 1).

Statistical Analysis

All the analysis was done using SPSS version 20 (IBM Corp. Released 2011. IBM SPSS Statistics for Windows, Version 20.0. Armonk, NY: IBM Corp.). A p-value of <0.05 was considered statistically significant. Comparison of categorical variables was done using Fisher's exact test or Chi-Square test.

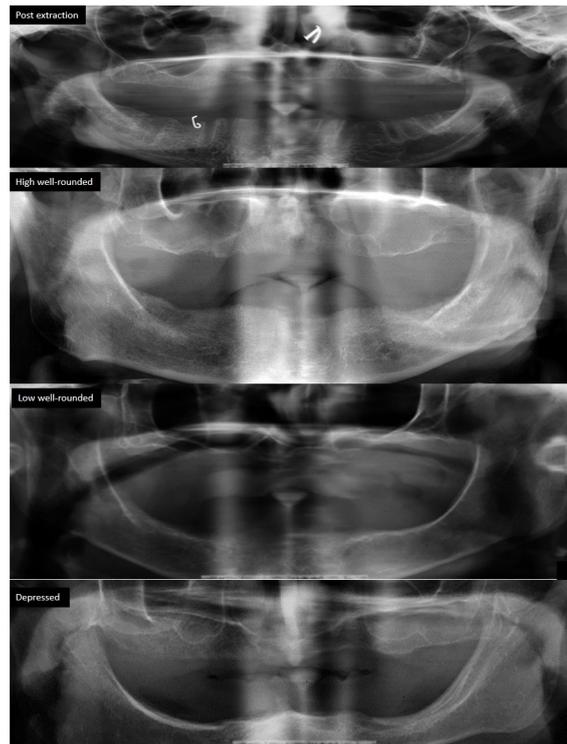


Figure 1. Panoramic radiographs depicting types of residual ridge patterns.

Results

This study included the initial screening of 23,020 panoramic radiographs, out of which 505 radiographs (showing either one or both edentulous arches) were included. The age ranged from 21 to 94 years, with a mean age of 62.83. More than half of the radiographs belonged to the males (52.5%). The 201 radiographs showed completely edentulous maxillary and mandibular arches, 167 showed edentulous maxillary arches and 137 radiographs showed edentulous mandibular arches.

Changes in the mental foramen were significantly higher in males than females ($p=0.002$). Impacted tooth and bony enostosis were significantly higher in females than in males ($p=0.02$ and $p=0.012$, respectively). Maxillary high, well-rounded residual alveolar bone and mandibular depressed patterns were significantly higher in females ($p=0.006$) (Table 2).

Table 2. Types of anomalies and pathologies between males and females.

Type of Anomaly/Pathology	Gender				p-value
	Male		Female		
	N	%	N	%	
Hyperpneumatization of the maxillary sinus	140	74.1	140	78.7	0.303
Mental Foramen	106	63.9	81	47.1	0.002*
Condylar Changes	55	20.8	41	17.1	0.294
Retained root stumps	39	14.7	30	12.5	0.469
Impacted teeth	5	1.9	14	5.8	0.02*
Bony enostosis	2	0.8	10	4.2	0.012*
Unilocular radiolucencies	12	4.5	8	3.3	0.492

*Statistically significant.

No significant differences were seen in the radiographic bone patterns between males and females (Table 3). Table 4 shows the type of anomaly/pathology according to the arch. It is possible to observe that hyperpneumatization of the maxillary sinus was more frequent in the maxilla (75.4%).

Table 3. Comparison of bone patterns between males and females.

Bone Pattern	Gender				p-value
	Male		Female		
	N	%	N	%	
Maxillary Post-Extraction	45	17.0	41	17.1	0.976
Maxillary High, well-rounded	22	8.3	39	16.2	0.006*
Maxillary Low, well-rounded	105	39.6	97	40.4	0.856
Maxillary Depressed	117	44.2	106	44.2	0.997
Mandibular Post-Extraction	36	13.6	29	12.1	0.615
Mandibular High, well-rounded	67	25.3	63	26.2	0.804
Mandibular Low, well-rounded	95	35.8	98	40.8	0.25
Mandibular Depressed	48	18.1	68	28.3	0.006*

*Statistically significant.

Table 4. Comparison of the type of anomaly or pathology between single and completely edentulous arches.

Type of Anomaly/Pathology	Arch						p-value
	Maxilla		Mandible		Both		
	N	%	N	%	N	%	
Hyperpneumatization of the maxillary sinus	126	75.4			154	77.0	0.728
Mental Foramen	NA	NA	82	59.4	105	52.5	0.208
Condylar Changes	39	23.4	25	18.1	32	16.0	0.193
Retained root stumps	23	13.8	22	15.9	24	12.0	0.583
Impacted teeth	7	4.2	3	2.2	9	4.5	0.51
Bony enostosis	1	0.6	3	2.2	8	4.0	0.102
Unilocular radiolucency	2	1.2	7	5.1	11	5.5	0.08

NA: Not Applicable.

No significant differences were seen in the distribution of the type of anomaly or pathology with respect to age groups (Table 5). Maxillary and mandibular post-extraction patterns were significantly higher in young adults than older adults ($p=0.028$ and $p<0.001$), respectively. No significant differences were seen in the radiographic bone patterns between young and older adults (Table 6).

Table 5. Comparison of the type of anomaly or pathology between different age groups.

Type of Anomaly/ Pathology	Age Group				p-value
	Young Adults		Older Adults		
	N	%	N	%	
Hyperpneumatization of the maxillary sinus	130	75.1	150	77.3	0.625
Mental Foramen	88	54.3	99	56.2	0.722
Condylar Changes	44	18.0	52	20.0	0.559
Retained root fragments	28	11.4	41	15.8	0.156
Impacted teeth	8	3.3	11	4.2	0.569
Bony enostosis	6	2.4	6	2.3	0.917
Unilocular radiolucency	11	4.5	9	3.5	0.554

Table 6. Comparison of bone patterns between different age groups.

Bone Pattern	Age Group				p-value
	Young Adults		Older Adults		
	N	%	N	%	
Maxillary Post-Extraction	51	20.8	35	13.5	0.028*
Maxillary High, well-rounded	26	10.6	35	13.5	0.326
Maxillary Low, well-rounded	101	41.2	101	38.8	0.586
Maxillary Depressed	102	41.6	121	46.5	0.267
Mandibular Post-Extraction	46	18.8	19	7.3	<0.001*
Mandibular High, well-rounded	61	24.9	69	26.5	0.673
Mandibular Low, well-rounded	95	38.8	98	37.7	0.802
Mandibular Depressed	49	20.0	67	25.8	0.123

*Statistically significant.

The most prevalent results from similar studies across the globe are depicted in Table 7.

Table 7. Table depicting various studies on the prevalence of findings on panoramic radiographs of completely edentulous arches.

Authors	Year	Country	Sample	Prevalence of Positive Findings on Edentulous Radiographs (%)	Most Noted Findings	Recommendation of Screening with Panoramic Radiographic
Perrelet and Bernhard [18]	1977	Switzerland	287	41.1	Retained root fragments Radiolucent lesions Impacted teeth Reduced alveolar ridge height	Recommended
Jones et al. [19]	1985	United States	114	34.4	Retained root fragments Radiopaque lesions Foreign bodies Impacted teeth	Recommended
Angulo [20]	1989	Spain	200	38.5	Impacted teeth Radiopaque lesions Foreign bodies	Recommended
Edgerton and Clark [16]	1991	United States	308	23.0	Radiopaque lesions Retained root fragments Radiolucent lesions Impacted teeth	Not recommended
Seals et al. [21]	1992	United States	448	11.6	Changes in the position of mental foramen Foreign bodies Radiopaque lesions Impacted teeth	Recommended
Masood et al. [12]	2007	United States	327	42.5	Retained root fragments Impacted teeth Radiolucent lesions Foreign bodies	Recommended
Sumer et al. [9]	2007	United States	338	47.6	Retained root fragments Radiopaque lesions Hyperpneumatization of the maxillary sinus	Recommended
Ezoddini Ardakani and Navab Azam [14]	2007	Iran	447	-	Hyperpneumatization of the maxillary sinus Displacement of mental foramen Retained root fragments Impacted teeth	Recommended
Jindal et al. [10]	2011	India	525	32	Retained root fragments Impacted teeth	Recommended

						Radiopaque lesions in edentulous sites Radiolucent jaw lesions	
Reddy et al. [6]	2013	India	705	29.07		Hyperpneumatization of the maxillary sinus Changes in the position of mental foramen Retained root fragments Impacted tooth	Recommended
Avsever et al. [22]	2014	Turkey	845	40.47		Hyperpneumatization of the maxillary sinus Changes in the position of mental foramen Retained root fragments Soft tissue calcifications	Recommended
Kose et al. [15]	2015	Turkey	743	34.4		Hyperpneumatization of the maxillary sinus Retained root fragments Mucous retention cysts Impacted tooth	Recommended
Ouma et al. [23]	2018	Kenya	163	20.9		Retained root fragments Radiopaque lesions in edentulous sites Impacted tooth	Recommended
Present study	2021	India	505	52.6		Hyperpneumatization of the maxillary sinus Changes in the position of mental foramen Retained root fragments	Recommended

Discussion

Panoramic radiographs serve as an essential tool for visualizing underlying undiagnosed maxillary and mandibular lesions. It has gained popularity over time as a preferred radiograph of choice before completing denture fabrication and implant placement [2,8]. Studies have addressed the significance of pre-prosthetic screening radiographs in assessing the alveolar ridge height position of vital structures as asymptomatic jaw pathologies [9,10]. Findings from previous studies highlighted the need for pre-prosthetic screening with panoramic radiographs. They advocated the significance of panoramic radiographs in detecting unseen pathologies in edentulous sites [10-12]. However, Lyman and Boucher [13] reported only one impacted tooth, which required extraction among 300 edentulous patients. They did not suggest routine panoramic radiography for edentulous patients [13].

The most common findings noted in the radiographs of the present study reflect the age changes, condylar changes, changes in the position of the mental foramen, and hyperpneumatization of the maxillary sinus. Ezoddini Ardakani and Navab Azam [14] observed migrated sinuses and mental foramen changes as the most common findings on panoramic radiographs of edentulous mouths in the Iranian population. Various studies reported that impacted teeth and retained root stumps were the most common finding on pre-prosthetic panoramic radiographs [6,10,15].

Clinically un-diagnosable conditions but of significant importance prior to prosthetic treatment include radiopaque and radiolucent jaw lesions. These include entities like impacted teeth, dense bone islands, cystic lesions, and retained root fragments of teeth. In the present study, impacted teeth and unilocular radiolucency were the least noted findings in the present study. Multiple retained root fragments were the most common condition that required evaluation with panoramic radiographs.

In the present study, impacted teeth in the edentulous sites accounted for only about 10% of the findings on panoramic radiographs. Impacted teeth can pose challenges in pre-prosthetic planning for edentulous sites and may be associated with carious lesions, dentigerous cysts, and infections. These findings were per Sumer et al. [9] and Jindal et al. [10], who also reported a low incidence of impacted teeth.

Radiolucent lesions were the least commonly noted finding (3.9%) on the panoramic radiographs of the present study. Similar findings were reported in the studies by Jindal et al. [10], Masood et al. [12], and Edgerton and Clark [16].

Pre-implant planning for the maxillary posterior region necessitates a thorough evaluation of the alveolar ridge height, the position of the floor of the maxillary sinus to the edentulous site, and the extent of pneumatization. The assessment of the vertical dimension of the alveolar ridge can be well-measured on panoramic radiographs [15]. Hyperpneumatization of maxillary sinuses was noted in 75.4% of the radiographs in the present study. This requires an intervention through a sinus-lift procedure so that the edentulous site becomes ideal for implant placement.

Residual ridge assessment using panoramic radiography can be used for screening purposes. Residual alveolar ridge height is an important parameter that dictates the retention of mandibular removable dentures. However, in the case of maxillary removable dentures, negative pressure, and peripheral seal are more crucial factors that add to the retention of maxillary dentures than the height of residual alveolar ridge. In the case of implant-supported prostheses, ridge evaluation remains vital for successful outcomes. The mandible's residual ridge resorption causes the mental foramen to migrate toward the crest, creating challenges in denture fabrication. It can cause pressure on the mental nerve, leading to discomfort and pain [17].

The findings noted on the panoramic radiographs in the present study reflect the age changes occurring in the maxillofacial skeleton. The results were categorized into those seen in young adults and older adults. Observations like hyperpneumatization of the sinus, changes in the position of the mental foramen, and morphological changes of the condyle were commonly noted in the radiographs of older adults. At the same time, unilocular radiolucent lesions and elongated styloid process was noted in young adults.

The limitations of the present study include the analysis of a hospital-based population and the retrospective nature of this study design. Analysis of soft tissue exophytic lesions (epulis, fibroma, or flabby ridges), which also warrant pre-prosthetic assessment, requires clinical examination of edentulous subjects.

Hence, panoramic radiographs serve as a valuable screening tool for pre-prosthetic assessment of edentulous sites. Panoramic radiographs may act as a reliable guide to decision-making for subjects who require detailed evaluation of pre-implant sites with Cone Beam Computed Tomography (CBCT).

Conclusion

Panoramic radiographs are well-suited for screening individuals with edentulous arches. Most radiographic findings require pre-prosthetic intervention, justifying its use.

Authors' Contributions

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All authors declare that they contributed to a critical review of intellectual content and approval of the final version to be published.			

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Conflict of Interest

The authors declare no conflicts of interest.

Data Availability

The data used to support the findings of this study can be made available upon request to the corresponding author.

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