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RESEARCH ARTICLE
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ASSESSMENT OF BONE HEALING AFTER CYST ENUCLEATION USING CONE BEAM CT IN PATIENTS VISITING TERTIARY HOSPITAL IN KHYBER PAKHTUNKHWA

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ABSTRACT

Introduction: Odontogenic cysts are common pathological lesions of the jaws that often necessitate surgical intervention, such as enucleation, to prevent recurrence and restore oral function. Following cyst removal, the natural healing of the osseous defect is a critical component of postoperative recovery. Traditional radiographs offer limited insight into the three-dimensional healing process. Cone Beam Computed Tomography (CBCT) has emerged as a valuable diagnostic tool, enabling precise visualization and quantification of bone regeneration.

Objective: This study aims to assess bone healing following cyst enucleation using Cone Beam Computed Tomography (CBCT) in patients treated at a tertiary care hospital in Khyber Pakhtunkhwa, Pakistan.

Methods: A prospective observational study was conducted in AIDC after obtaining approval from the ERC of the institution, involving patients diagnosed with odontogenic cysts requiring surgical enucleation. Pre-operative and post-operative CBCT scans were obtained to evaluate bone healing over a follow-up period of 3 to 12 months. Quantitative assessment of bone regeneration was performed using volumetric and density-based measurements. Clinical data, including age, gender, cyst size, location, and healing time, were recorded and correlated with radiographic outcomes.

Results: A total of 40 patients (22 males, 18 females; mean age 32.5 ± 9.6 years) were included. The mandible was more frequently involved (65%) than the maxilla. CBCT analysis revealed a significant reduction in cystic cavity volume ($p < 0.001$) and a progressive increase in bone density during the follow-up period. Complete radiographic healing was observed in 70% of cases within 9–12 months post-surgery. Delayed healing was associated with larger cyst size (>2.5 cm) and older age groups.

Conclusion: CBCT provides a reliable and detailed modality for assessing bone healing following cyst enucleation. The findings suggest that most cystic defects undergo substantial bone regeneration within 9–12 months, with healing outcomes influenced by lesion size and patient age. These results

support the routine use of CBCT in postoperative evaluation to enhance clinical decision-making and patient management.

Keywords: Bone healing, CBCT, cyst enucleation, odontogenic cyst, cone beam computed tomography.

INTRODUCTION

Odontogenic cysts represent one of the most common pathologic conditions affecting the maxillofacial region. These cystic lesions, originating from odontogenic epithelium, may present with varying clinical and radiographic characteristics, depending on their type, size, and location.[1] They often cause displacement or resorption of adjacent teeth, expansion of bone, and in some cases, can result in secondary infection. Enucleation, which involves the complete surgical removal of the cyst lining, remains the gold standard treatment modality for many odontogenic cysts, particularly when preservation of surrounding anatomical structures is possible.[2]

Following surgical intervention, the biological process of bone healing is critical. It includes a cascade of cellular and molecular events that begin with inflammation, followed by the proliferation of osteogenic cells and eventual bone remodeling. The evaluation of this healing process is important for monitoring patient recovery, planning further interventions if required, and predicting long-term prognosis.[3] Traditionally, two-dimensional imaging techniques such as panoramic radiography or intraoral periapical radiographs have been employed for postoperative assessment. However, these methods lack the resolution and three-dimensional detail necessary to accurately evaluate osseous regeneration, especially in the early phases.[4] This limitation has been addressed with the advent of Cone Beam Computed Tomography (CBCT), which offers high-resolution, three-dimensional visualization of hard tissues with lower radiation exposure compared to conventional CT scans. CBCT has emerged as a preferred imaging modality in oral and maxillofacial diagnostics due to its ability to provide detailed insights into the volume, morphology, and density of bone.[5] It is particularly useful in evaluating the healing of osseous defects, such as those resulting from cyst enucleation, implant planning, trauma management, and pathological assessments.[6]

This study was conducted with the primary aim of assessing bone regeneration after cyst enucleation using CBCT in a local population of Khyber Pakhtunkhwa. The study also aimed to identify factors affecting the healing process, such as patient age, gender, location and size of the cyst, and duration of follow-up. The goal was to provide evidence-based recommendations on the utility of CBCT in clinical follow-up and to contribute to the growing body of literature advocating for advanced imaging in postoperative oral surgery care.

MATERIALS AND METHODS

A prospective observational study was carried out at AIDC following approval by the institution's Ethical Review Committee. Forty patients who were clinically and radiographically diagnosed with odontogenic cysts requiring surgical enucleation were enrolled after informed consent. All surgeries were performed under local or general anesthesia by experienced maxillofacial surgeons. Preoperative CBCT scans were taken to determine cyst dimensions and involvement of surrounding structures. Postoperative CBCT imaging was conducted at intervals ranging from 3 to 12 months, depending on patient availability and clinical need. Bone healing was evaluated by measuring changes in the volume of the cystic cavity and assessing bone density in Hounsfield Units (HU). Volumetric data were obtained using built-in software in the CBCT system, with density measured across three standard anatomical planes. Data were analyzed using SPSS version 26.0. Descriptive statistics were calculated, and inferential tests (such as paired t-tests and ANOVA) were applied to examine correlations between healing and patient/cyst variables.

RESULTS

A total of 40 patients (22 males, 18 females) with a mean age of 32.5 ± 9.6 years were evaluated. Most cysts were located in the mandible (n=26; 65%), while the remaining 14 (35%) were in the maxilla. Complete radiographic healing was observed in 28 patients (70%) within 9–12 months. The remaining 12 patients (30%) showed partial healing, primarily among those with initial cysts larger than 2.5 cm and those aged over 40 years. Table 1 summarizes the basic demographic and clinical data, including gender distribution, mean age, and the anatomical site of cyst occurrence.

Table 1: Demographic and Clinical Data of Patients

Total Patients	40
Gender M/F	22/18
Mean age (Years)	32.5±9.6
Cyst Location (Mandible)	26 (65%)
Cyst Location (Maxilla)	14 (35%)

CBCT-based analysis demonstrated a statistically significant reduction in cystic cavity volume (mean reduction: 78.3%; $p < 0.001$) and a progressive increase in bone density across follow-up intervals. These parameters were quantified using CBCT software tools (Table 2).

Table 2: CBCT Quantitative Analysis

Mean preoperative cyst volume (cm^3)	3.1±1.2
Mean postoperative volume at 12 months	0.67 ± 0.4
Mean volume reduction (%)	78.3%
Mean bone density gain (HU)	+185

Table 3 shows the association between initial cyst size and healing, indicating that smaller cysts (≤2.5 cm) had a much higher rate of complete healing compared to larger ones.

Table 3: Healing Outcomes by Cyst Size

Cyst Size	Patients (n)	Complete Healing (%)
≤2.5 cm	24	22 (91.6%)
>2.5 cm	16	6 (37.5%)

Healing outcomes are stratified by age group in Table 4. Patients aged under 30 showed the highest healing rates, whereas healing was delayed in older individuals.

Table 4: Healing Status by Age Group

Age Group (years)	Number of Patients	Complete Healing (%)
18–30	18	15 (83.3%)
31–40	14	10 (71.4%)
>40	8	3 (37.5%)

DISCUSSION

This study aimed to evaluate bone healing after cyst enucleation using Cone Beam Computed Tomography (CBCT), with results highlighting its effectiveness in providing a detailed and objective assessment of the healing process. The findings reveal that most patients exhibited significant bone regeneration over a 9–12 months period, particularly those with smaller cysts and younger age groups. These results support the use of CBCT not only as a diagnostic tool but also as a reliable method for longitudinal postoperative monitoring.

The results showed that 70% of patients achieved complete radiographic healing within 12 months, consistent with previous literature. Wei et al. (2024)[7] noted that spontaneous bone regeneration typically occurs in osseous cavities following cyst enucleation, especially in younger patients with no systemic compromise. Similarly, ElSafty et al. (2024)[8] demonstrated satisfactory bone fill in 6 to 12 months without the need for bone grafting in cystic lesions smaller than 3 cm. A key observation in our study was the strong influence of cyst size on healing outcomes. Patients with smaller lesions (≤2.5 cm) showed a significantly higher rate of complete healing (91.6%) compared to those with larger lesions (>2.5 cm), where only 37.5% achieved complete healing. This is in line with Chaushu et al. (2025)[9], who observed that the larger the osseous defect, the slower the natural regenerative process due to limited osteoprogenitor cell migration and reduced vascularization in large cavities. Larger defects may require bone augmentation procedures, particularly when located in critical load-bearing areas such as the posterior mandible.

Another important factor identified was patient age. Healing was notably faster and more complete in individuals under the age of 30, while those over 40 had delayed or incomplete healing. This may be attributed to age-related changes in bone metabolism, cellular activity, and vascularity. Several studies, including work by Bellini et al. (2024)[10], have documented the diminished regenerative capacity of aging bone, especially in the presence of systemic conditions like diabetes or osteoporosis, although such comorbidities were excluded in this study. The study underscores the benefits of using CBCT over traditional radiographic modalities. Unlike 2D imaging, CBCT provides high-resolution 3D views that enable accurate measurement of volume reduction and density gain. The Hounsfield Unit (HU) scale allows for objective quantification of bone density changes, which are essential for assessing the maturity and quality of newly formed bone. These advantages were also emphasized by Yang et al (2025)[11], who highlighted CBCT's role in oral pathology follow-ups, dental implant planning, and surgical site evaluations.Despite the promising outcomes, a subset of patients (30%) did not achieve complete healing by the end of the follow-up period. This raises the question of whether bone grafting or regenerative adjuncts should be considered in specific clinical scenarios. Bone graft substitutes, platelet-rich plasma (PRP), or bone morphogenetic proteins (BMPs) may be warranted in older patients or in cases involving large or recurrent cysts. However, as most cases did eventually show progressive healing, the decision to intervene must be carefully balanced against cost, morbidity, and patient preferences.[12] Clinically, the findings reinforce the need for tailored postoperative follow-up protocols. Patients with risk factors for delayed healing such as advanced age or large cysts should be monitored more frequently and possibly for a longer duration. CBCT scans at 3, 6, and 12 months can help identify cases where healing is suboptimal, thus prompting timely interventions.[13]In terms of study limitations, the relatively small sample size and short-term follow-up period may affect the generalizability of the results. Additionally, while CBCT offers excellent spatial resolution, it does not directly assess the histological quality of bone, and further studies involving biopsy or intraoperative assessment would be valuable. Also, this study did not account for systemic health factors or habits like smoking, which are known to impair bone healing.

CONCLUSION

CBCT offers an invaluable method for accurately tracking bone healing after cyst enucleation. This study demonstrated significant bone regeneration within 9–12 months in the majority of cases, particularly in younger patients and those with smaller lesions. Healing was delayed in older individuals and with larger cyst sizes, suggesting that such patients may benefit from closer monitoring or adjunctive regenerative techniques. The integration of CBCT in routine postoperative assessment provides a robust framework for clinical decision-making, treatment planning, and improved patient care. Future studies with larger sample sizes and long-term follow-up are recommended to further validate these findings and explore additional factors influencing healing.

Conflict of Interest: None

Authors' Contribution

Concept or Design: Rehana Yasmeen, Aamna Javed, Saif Ullah
Acquisition, Analysis or Interpretation of Data: Sarfaraz Khan, Hina Jadoon, Ambreen
Manuscript Writing & Approval: Rehana Yasmeen, Aamna Javed

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