An irrefutable unambiguous insight into zygomatic air cell defect (ZACD)

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SUMMARY

Zygomatic air cell defect (ZACD) of the temporal bone, has been characterized as the auxiliary air cells in the zygomatic process and articular eminence of the temporal bone. They present as unresectable findings in the zygomatic process of the temporal bone and articular tubercle. They are crucial, as they signify regions of weak resistance and the spread of disease. Comprehension of the decrepit regions in the zygomatic bones with Cone Beam Computed Tomography (CBCT), and the imaging of choice in maxillofacial disorders for its superior 3D anatomical reconstruction and minimal distortion, are indispensable in the diagnosis, treatment planning and placement of endosseous or basal dental implants to elude complications. 154 CBCT images of subjects aged between18 and 70 years with optimal diagnostic quality and area coverage satisfying the selection criteria without the history of maxillofacial fractures, pathologies, anomalies involving the middle one third of the face were analysed. The overall prevalence of ZACD was in 16 (10.4%) subjects, with 9 in females (56.25%) and in 7 males (43.75%). The men-to-women ratio was 1:1.28. It was also revealed that bilateral incidence of ZACD was more common and the prevalence of ZACD the highest 8 (50%) in the age group of 21-30 years. This study highlights the importance of research on the prevalence of the ZACD on CBCT, which was exiguous in the past, and compares with similar studies done using panoramic radiographs. This study paves the way for more studies employing CBCT to justify the findings we have expressed.

Key words: Zygomatic air cell defect – Cone Beam Computed Tomography – Prevalence – TMJ – Endosseous implants

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INTRODUCTION

Growth and development of the skull occurs concomitantly with pneumatization. This process is governed by various vital anatomic factors (Diamant,1954). Zygomatic air cell defect is an addendum of such pneumatization of the temporal bone anteriorly to the articular tubercle. These cells, which imitate the mastoid cells of Lenoir, have been characterized as the auxiliary air cells in the zygomatic process and articular eminence of the temporal bone. It was Tyndall and Matteson that introduced pneumatized articular eminence, later coined as Zygomatic Air Cell Defect (ZACD) in 1987 (Tremble, 1934). There is an array of information which describes air cells that extend up to the Zygomatic process involving the articular eminence. But there is no consensus on the exact classification of Zygomatic Air cell defect, Pneumatized Articular Tubercle (PAT) and Pneumatized Roof of the Glenoid Fossa (PRGF). They present as unresectable, non-protractible, non-disparaging, tangential findings in the zygomatic process of the temporal bone and articular tubercle, which do not project beyond the zygomatic-temporal suture line.

Although ZACD are considered mere anatomical variations without any cortical destruction, knowledge of the same is crucial as they signify regions of weak resistance and the spread of disease into the temporomandibular complex. Common occurrence of otitis and mastoiditis can spread rapidly to the temporomandibular complex leading to joint ankylosis and detrimental effects on the development of mandible. The risk of TMJ surgeries may be increased, as there can be iatrogenic penetrations into the dura and leakage of CSF. Skull fractures can enter into the glenoid fossa, so adequate preoperative identification is necessary to avoid untoward complications. Comprehension of the decrepit regions in the Zygomatic bones is indispensable in the planning and placement of Endosseous or Basal Dental implants to elude complications.

An incidental finding on a panoramic radiograph indicates the presence of ZACD, which originates in the zygomatic arch and displays as an innocuous, radiolucent, non-destructive, non-expansile defect. (Gupta, D et al., 2013). Tyndall and Matteson segregated ZACD into three different types: (a) unilocular type, (b) multilocular type, and (c) trabecular type. The prevalence of ZACD may entail absolute contraindications to complex surgeries pertaining to mandibular dislocations such as eminoplasty or eminectomy.

Cone Beam Computed Tomography (CBCT) is a breakthrough diagnostic tomographic practice of recent times with the ability to appreciate inconspicuous lesions in 3 dimensions whose inherent qualities are the absence of superimposition of the anatomic structures and the absence of obscurity of the resultant images. It is capable of providing millimetric resolution images of superior quality with shorter scanning times. It has greater dimensional accuracy and significantly lesser radiation exposure, compared to conventional CT scans. CBCT has evolved into the imaging of choice in maxillofacial disorders for its superior 3D anatomical reconstruction and minimal distortion.

Until the present date, there are a few studies which bring to the fore the importance of in-depth understanding of the pneumatization and development of ZACD. Existing data about ZACD might be underestimated owing to the limitations of the conventional radiographs. Detailed studies of ZACD with novel and avant-garde imaging techniques like CBCT offer precedence in understanding the disease spread from the mastoid and the mesotympanum to the zygomatic process, and hence the lateral skull base. It provides an insight in the surgical management of the temporomandibular joint disorders. This study helps to spell out the supremacy of accurately estimating the prevalence of ZACD in CBCT, as well as and precise understanding of the entity in comparison with conventional panoramic radiographs.

MATERIAL AND METHODS

This is an invitro survey orchestrated in the Oral Medicine and Radiology department, JSS Dental College and Hospital, JSS Academy of Higher Education and Research, Mysuru, India. The study was envisaged to consider the various presentation of pneumatization like ZACD, PAT and PRGF as ZACD to avoid perplexity in the study.

Purposive sampling was used to collect the sample, and the study sample size was computed using the formula: N = (Z2) P(1-P)/d2, where n = study sample size, and z = level of confidence, P = Prevalence, and d = allowable error. This formula assumes that P and d are decimal values, but it would also be correct if they are percentages, with the exception that the term (1-P) in the numerator would become (100-P).

Prior to the investigation, an ethical clearance was obtained by the university's IEC (IEC No 26/2021). The source of data collection was done in two parts, retrospectively from the archive of CBCT images, which were satisfying the eligibility criteria and prospectively following CBCT examination of the patients for their own dental treatment purpose at the Department of Oral Medicine and Radiology. 154 patients were selected between 18 to 70 years of age satisfying the selection criteria. All the images were taken with PLANMECA Promax 3D mid and analysed using ROMEXIS VIEWER software.

Selected images were considered in sagittal, axial and coronal planes; the attributes of ZACD were examined by an experienced Oral and Maxillofacial radiologist twice with an interval of 4 weeks, and average was considered to avoid intra examiner variability. Mean and standard deviation were used for continuous data, and Chi square test with $p<0.05$ was used for categorical data. SPSS 22 software was used for statistical analysis.

Inclusion criteria:

- CBCT images taken for the purpose of evaluation of third molar, extensive restorative dental procedures, mixed dentition analysis, implant planning in orthodontic and orthognathic procedures.
- Ideal CBCT images with optimal diagnostic quality.
- CBCT images exhibiting structures like zygomatic arch, zygomatic process of maxilla and encompassing TMJ.

Exclusion criteria:

- CBCT images of Subjects with history of maxillofacial fractures, pathologies, anomalies involving the middle one-third of the face involving temporal and the zygomatic bones.
- Images with poor diagnostic quality and with image artefacts.
- Images in which zygomatic arch is not clearly or partially visualised.
- CBCT images with evidence of previous surgeries of TMJ and zygomatic arch and process.
- Images obtained by erratum in the CBCT exposure of Maxillofacial region.
- Images of subjects below 18 years of age, as the pneumatization occurs in adulthood.

RESULTS

Out of 154 patients who were part of the study, 91(59%) were women and 63(41%) were men. (Fig. 1 showing the Sex distribution of ZACD study sample). The 154 subjects were divided into 6 age groups: i.e., up to 20 years, 21 to 30, 31 to 40, 41 to 50, 51 to 60, 61 to 70 years, with sample size distribution of 5 (Male 2 + Female 3) in up to 20 age group, 64 (Males 23 + Females 41) in 21 to 30, 38 (Males 15 + Females 23) in 31 to 40, 25(Males 10 + Females 15) in 41 to 50, 16 (Males 10 + Females 6) in 51 to 60 and 6 (Males 3 + Females 3) in 61 to 70. The average age of the sample size was 33.69 +/- 13.43yrs.

The overall prevalence of ZACD was in 16 (10.4%) subjects, with 7 in males and 9 in females, with 0 up to 20 years of age, 8(50%) in 21-30 years, 3 (18.75%) in 31- 40 years of age, 3 (18.75%) in 41- 50 years, 2(12.5%) in 51-60 years, 0 in 61-70 years of age. The highest incidence was noted in the group of 21-30 years. (Table 1: Age wise distribution of ZACD) (Fig. 2: Age-wise distribution of ZACD).

ZACD was noted bilaterally in 8(5.20%) of the subjects, unilaterally on the right side in 6 (3.90%) and on left side in 2 (1.30%) of the patients. (Table 2: ZACD cell distribution).

In the detailed radiological examination, the distribution of ZACD was as follow:

- Bilateral Multilocular type of ZACD was seen in 6 (25%) subjects on Right side and in 6(25%) on Left side.

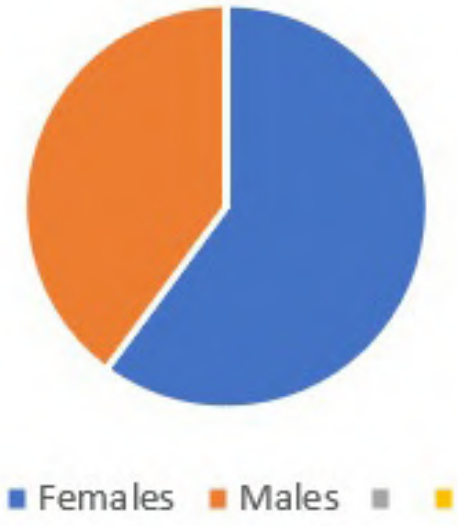

Fig. 1.- Sex Distribution of ZACD study sample.

Table 1. Age wise distribution of ZACD.

Age_Wise_Distribution

Years	Males	Females	Prevalence
11-20	0	0	0
21-30	3	5	8-50%
31-40	1	2	3-18.75%
41-50	2	1	3-18.75%
51-60	1	1	2-12.50%
61-70	0	0	0

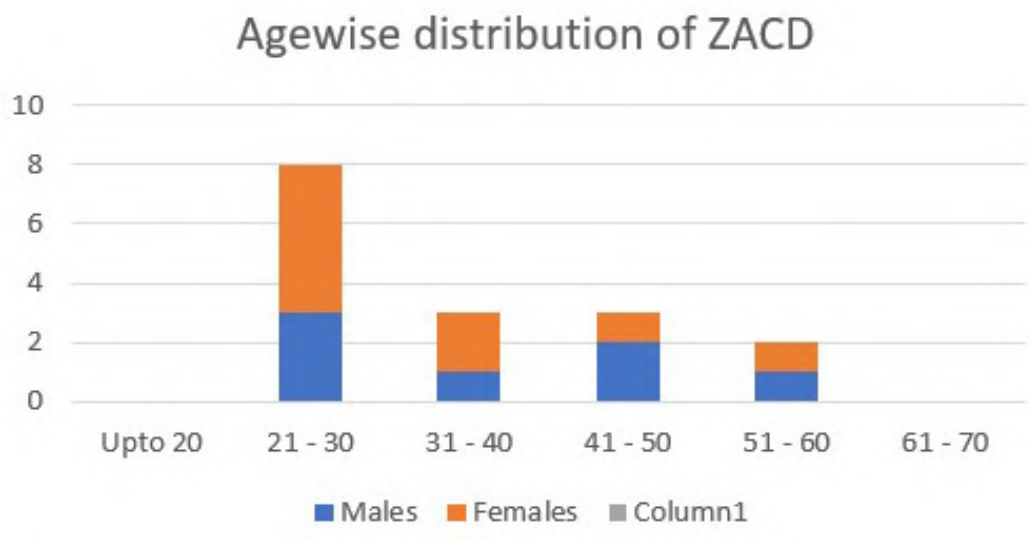

Fig. 2.- Age wise distribution of ZACD.

Table 2. ZACD distribution.

Zacd_distribution

ZACD_cell_distribution	Number	Percentage
Not present	138	89.60%
Bilateral	8	5.20%
Unilateral Right	6	3.90%
Unilateral Left	2	1.30%

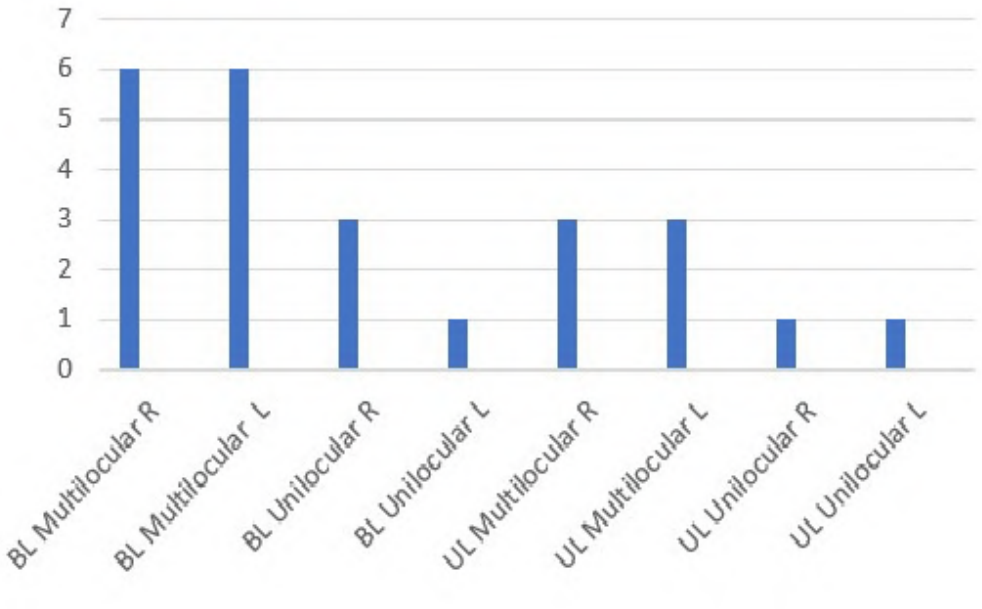

Fig. 3.- ZACD pattern of prevalence. (BL = Bilateral, UL = Unilateral, R = Right, L = Left).

- Bilateral Unilocular type of ZACD was seen in 3 (12.5%) on Right side and in 1 (4.2%) on Left side.
- Unilateral Multilocular type of ZACD was seen in 3 (12.5%) on Right side and in 3 (12.5%) on Left side.
- Unilateral Unilocular type of ZACD was seen in 1 (4.2%) on Right side and in 1 (4.2%) on Left side. (Table 3. ZACD pattern of prevalence) (Fig. 3 ZACD pattern of prevalence).

The Bilateral multilocular type of ZACD was the most common pattern noticed.

DISCUSSION

Tremble organized 10 regions of Air Cells (AC) in the temporal bone with particular quotation to emphasize alleyway of mastoid infection (Tremble, 1934). The root of the zygomatic process, which creates the glenoid fossa, is one of the temporal bone's AC sites. Often the AC of the zygomatic process can even approach the arch (Tremble, 1934). Tyndall and Matteson (1985) re-inscribed the circumstance of the pneumatized articular eminence from a radiological point of view. On panoramic radiographs with an appearance similar to the mastoid AC, they characterized it as an asymptomatic radiolucent "defect" in the zygo-

Table 3. ZACD pattern of prevalence. BL= Bilateral, UL= Unilateral, R= Right, L= Left.

ZACD_pattern

ZACD	Number	Percentage
BL Multilocular R	6	25%
BL Multilocular L	6	25%
BL Unilocular R	3	12.5%
BL Unilocular L	1	4.2%
UL Multilocular R	3	12.5%
UL Multilocular L	3	12.5%
UL Unilocular R	1	4.2%
UL Unilocular L	1	4.2%

matic process of the temporal bone. They assert that the 'defect' optionally approximates up to the temporo-zygomatic suture but never crosses it. Furthermore, they established that the zygoma was in normal shape with no deformation or altered outline.

Tyndall and Matteson (1987) proposed a categorization of ZACD into three types: unilocular, multilocular, and trabecular type. A well-defined oval radiolucency is alluded to as unilocular; multiple small cavities resembling mastoid air cells are considered multilocular; and the trabecular variant is a multilocular defect with internal bony striations.

CBCT has evolved into the prime design of choice in imaging complex structures of maxillofacial regions owing to its superior 3D anatomical reconstruction and minimal distortion. Previously, multitudinous studies of ZACD with Panoramic radiographs were executed. In the analysis designed by Patil et al. (2012), the pervasiveness of ZACD was noted to be 1.82% in a series of panoramic radiographs. On the other hand, the studies conducted by Gupta et al. (2013), Tyndall and Matteson (1987), and Arora et al. (2016) divulged the prevalence rate of ZACD as 5.7%, 1.5%, and 1.94% respectively on panoramic radiographs. A study by De Rezende et al. (2014) revealed a prevalence of 7.57% in the study population based on digitalized skull CT images. These researchers state that, because of its three-dimensional imaging and enhanced spatial resolution of the region of interest, CBCT scans would be a more viable approach. Overall, they demonstrate in their study that ZACD incidence was much lower in panoramic radiographs (1-3.5%) compared to those by CBCT (8%). This finding with CBCT is comparable with the present study, where the prevalence of ZACD was found to be 10.4% (in 16 subjects), which is proportionally higher owing to the superior imaging by CBCT when compared to conventional radiographs. Principally, CBCT is superior to conventional radiographs in visualization of anatomic structure in thin slices, and in meticulous perception of the exact anatomic details.

In this study, ZACD was found in 9 women (56.25%) and in 7 men (43.75%). The men to women ratio was 1:1.28 although there was negative statistical significance difference between the genders. In the scrutiny conducted by Miloglu et al. (2011), the prevalence was found to be 1:1.6; an independent study done by Carter et al. (1999) (M:F= 1:1.2) showed no such predilection, suggesting a panoramic insight in this aspect, whereas in the study by Patil et al. (2012) the prevalence was 0.8:1. The predominant female population attending the dental department for cosmetic purposes and the willingness for volunteering for the research attributable to the heightened perception about the oral health in the developing countries could be a reason for the higher number of females in the sample size.

According to this study, the prevalence of ZACD was zero (0) during the first decade of life, and the highest was 8 (50%) in the age group of 21-30 years. As the age increases, we noticed that the prevalence decreased. The completion of pneumatization by second decade of life could be a major factor in the occurrence. This study was in conformity with the analysis of ZACD by Carter et al.

(1999), who demonstrated that 16.3 % prevalence was seen in the age group of 20-29 years, followed by 30-39 (13.1%), and the least being 0.3% in the age group of 80-89 years.

This is in conformity with the inquiry done by Park et al. (2002) and Patil et al. (2012). The prevalence rate is lesser in older age groups, maybe owing to the remodelling process of the matured bone. Further scientific research is imperative in this respect.

On further evaluation, it was revealed that bilateral incidence of ZACD was more common in 8 (5.20%) than unilateral on right, in 6 (3.9%), and left, in 2 (1.3%). This is in accordance with the survey done by Yavuz et al. (2009). It is contradictory to the review done by Arora et al. (2016) and Patil et al. (2012), where unilateral occurrence was more commonly noticed. This discrepancy may be due to the underestimation of the ZACD prevalence by the conventional technique.

After researching in detail, it was found that bilateral multilocular (Fig. 4: multilocular ZACD in CBCT images) was the most common type of ZACD noted. The unilateral multilocular type of ZACD was more prevalent in the scrutinies done by Patil et al. (2012) and Yavuz et al. (2009). This contradicts the surveys done by Gupta et al. (2013) and Arora et al. (2016), where the unilateral, unilocular (Fig. 5, unilocular ZACD in CBCT images) type was more prevalent, whereas the study by Tyndall and Matteson (1987) gave an equal number of variations. This imbalance in the demonstration of the ZACD in various studies calls for more standardized scientific exploration with CBCT.

Occurrence of pneumatization might be an incidental finding as a routine anatomic variant, but is critical in the planning of surgeries of the temporomandibular joint. Recurrent temporomandibular joint disease could be the result of extensive pneumatization and spread of infection.

An extensive knowledge of pneumatization of Zygomatic air cells is important in understanding the inflammatory process in the lateral skull base.

In-depth comprehension of the anatomy and development of the zygomatic process of the temporal bone is a prerequisite in understanding the pathology of lateral skull base diseases. In addition, there are lot of studies about ZACD, PAT, and PGRF, but not a comprehensive inquiry. In some studies, the terms are interchangeable, but a precise demarcation is the need of the hour. Additionally, it is a quintessential guide for surgery on temporomandibular joint disorders. CBCT is an identifiable implement in scrutinizing

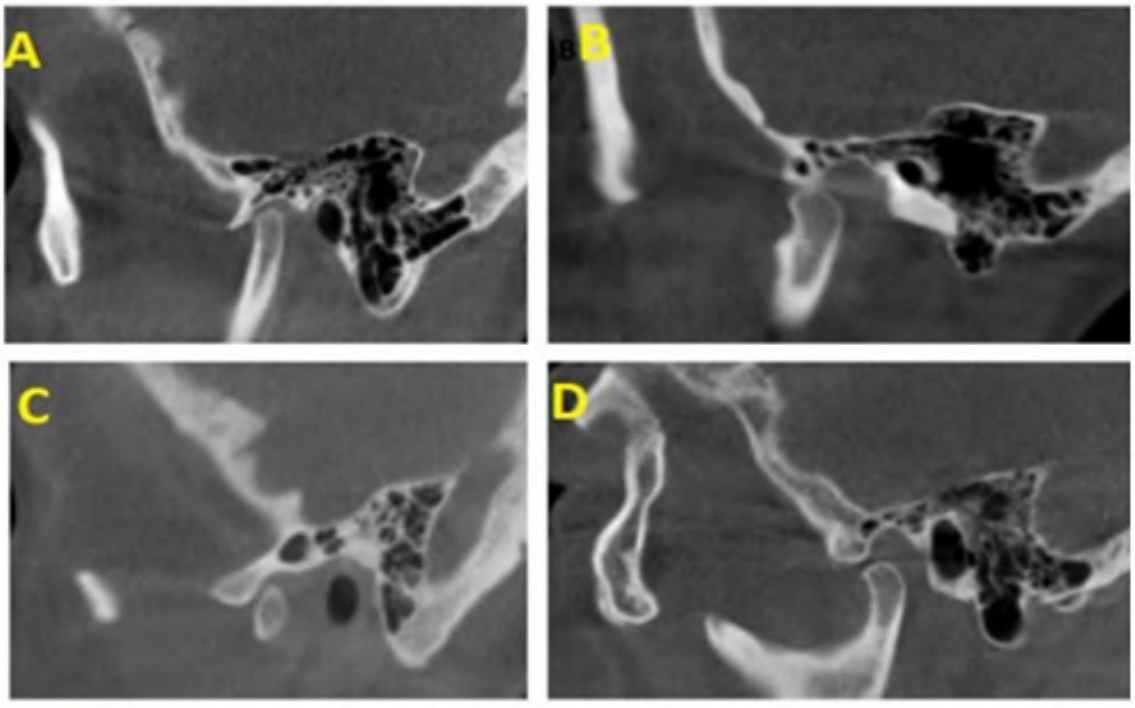

Fig. 4.- Multilocular ZACD in CBCT images.

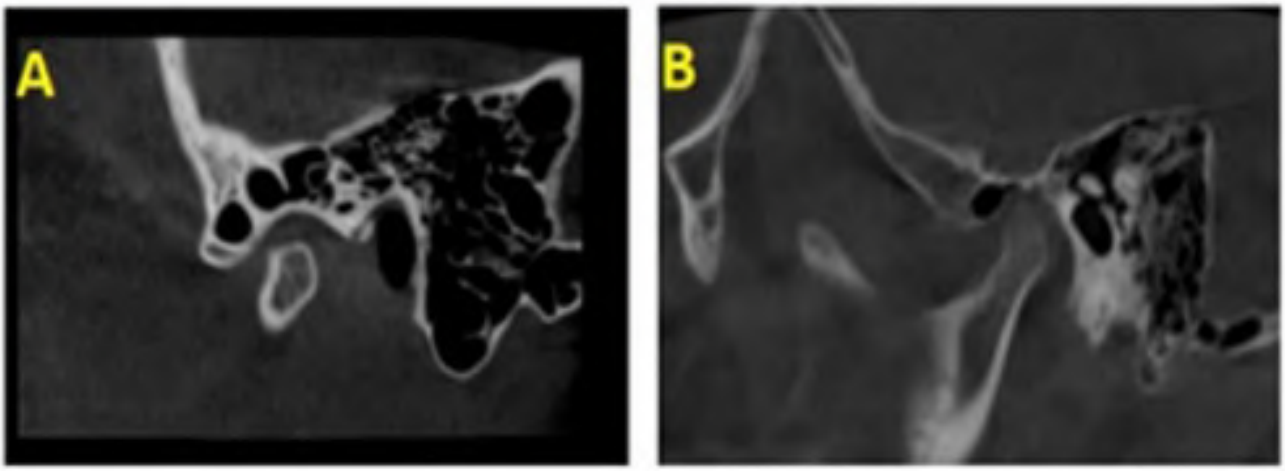

Fig. 5.- Unilocular ZACD in CBCT images.

the anatomical structures of the maxillofacial region by virtue of its inherent qualities. This study highlights the importance of further research on the prevalence of the ZACD on CBCT, which was exiguous in the past, and compares with similar studies done using panoramic radiographs; it also paves the way for more studies employing CBCT to justify the findings we have expressed.

DECLARATIONS

Ethical Approval: Ethics are upheld in conformity with the 1964 Helsinki Declaration and its following revisions Prior to the investigation, an ethical clearance was obtained by the university's IEC (IEC No 26/2021). (JSS DENTAL COLLEGE AND HOSPITAL INSTITUTIONAL ETHICAL COMMITTEE). Informed consent taken from all the participants involved in the study.

Availability of Data and Materials: The complete data base pertaining to the study is preserved as electronic database with the corresponding author and can be retrieved at any point of time.

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