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Assessing incidental findings of maxillary sinus pathologies using cone beam computed tomography -An observational study

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ABSTRACT

Cone beam computed tomography, or CBCT, is used extensively in dentistry these days. It provides thorough, precise, and accurate three-dimensional information on oral and maxillofacial structures in contrast to conventional two-dimensional approaches. An unintentional finding occurs when a hidden object is unexpectedly discovered during an imaging test that is unrelated to the test's indication. Understanding the incidence of these inadvertent maxillary sinus illnesses helps to improve diagnostic criteria and treatment planning, especially in the context of maxillofacial and dental healthcare.

Aim: The purpose of the study was to use cone beam computed tomography to discover incidental findings of maxillary sinus pathologies.

Material and Method: This retrospective study employed 150 Cone Beam Computed Tomography images to assess incidental findings within the maxillary sinus. Digital imaging and transmission in a medical format were used to create the CBCT images. Every coronal, sagittal and axial examination was performed. Anatomical position and clinical relevance were used to record and classify incidental observations.

Results: It is essential to assess the scans outside of the region of interest, and noteworthy accidental results ought to be reported. The most frequent incidental finding among the 150 CBCT scans was sinus septation (55.7%), which was followed by mucosal thickening (25.3%), mucous retention cyst (7.4%), complete or partial sinus opacification (4.1%), cystic lesion (2%), maxillary wall discontinuation (1.3%), fibro-osseous lesion, and benign orthodontic tumour (0.7%).

Conclusion: A thorough assessment of the scans outside of the region of interest is required, and important accidental results to be shared. In order to take precautions and avoid difficulties after surgery, CBCT is advised for a thorough assessment of the toothless area in three plans before sinus surgeries, particularly sinus lifts.

KEYWORDS

Condyle; Mandible; Morphology; Orthopantomographs; CBCT

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Introduction

Cone beam computed tomography (CBCT) has revolutionized dental and maxillofacial imaging by providing high-resolution, three-dimensional (3D) visualization of anatomical structures with minimal distortion [1]. Compared to conventional two-dimensional (2D) imaging techniques such as panoramic radiography and periapical radiographs, CBCT offers superior spatial resolution, allowing for a more accurate assessment of the maxillofacial region [2]. It is extensively used in various dental and maxillofacial procedures, including implant site evaluation, management of impacted teeth, maxillofacial trauma assessment, and orthognathic surgery [3]. CBCT's ability to provide multiplanar views in axial, sagittal, and coronal planes facilitate a detailed evaluation of complex anatomical structures, making it an essential tool for treatment planning and improving patient outcomes. Its widespread adoption has contributed significantly to enhancing diagnostic accuracy and guiding precise surgical interventions [4].

The maxillary sinus, the largest of the paranasal sinuses, plays a critical role in dental and maxillofacial healthcare. Anatomically, it is closely associated with the posterior maxillary teeth, making it susceptible to pathologies that may be detected incidentally during routine CBCT examinations. These incidental findings, defined as unexpected discoveries unrelated to the primary indication for imaging, include a wide range of abnormalities such as mucosal thickening, sinus septa, retention cysts, partial or complete sinus opacification, cystic lesions, and maxillary sinus wall discontinuities [5]. Although many of these findings are asymptomatic, they can have significant clinical implications, particularly in dental implantology and sinus augmentation procedures. Identifying these pathologies is essential for modifying treatment plans, preventing postoperative complications, and optimizing patient care. Studies have demonstrated that overlooking incidental findings can lead to adverse outcomes, such as chronic sinusitis, oroantral fistula formation, and implant failure [6].

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CBCT has demonstrated superior sensitivity and specificity in detecting incidental maxillary sinus pathologies compared to panoramic radiography. Several studies have reported varying prevalence rates of incidental findings, with mucosal thickening, sinus septa, and retention cysts being the most commonly identified abnormalities [7]. A retrospective study by Shanbhag et al. (2021) reported that 35% of CBCT scans performed for dental implant planning revealed incidental maxillary sinus findings, with mucosal thickening and sinus septa being the predominant findings [8]. Similarly, Abesi et al. (2020) found that 37.9% of patients undergoing CBCT scans had incidental maxillary sinus abnormalities, highlighting the importance of thorough radiographic evaluation before initiating treatment [2]. Munde et al. (2020) analyzed 150 CBCT scans and reported a 55.7% prevalence of incidental findings, with sinus septa (55.7%), mucosal thickening (25.3%), mucous retention cysts (7.4%), and cystic lesions (2%) being the most common. Kamble et al. (2020) conducted a similar study and reported that 58% of CBCT scans revealed incidental findings, emphasizing the importance of evaluating CBCT scans beyond the region of interest to detect clinically relevant pathologies [5,9].

Studies comparing CBCT with panoramic radiography have consistently demonstrated that CBCT detects a significantly higher prevalence of incidental sinus findings. Katiyar et al. (2022) reported that CBCT identified incidental sinus findings in 35% of cases, while panoramic radiography missed nearly 20% of these findings [6,10]. The ability of CBCT to eliminate overlapping anatomical structures and provide detailed multiplanar images accounts for its superior diagnostic capability. These findings underscore the clinical value of CBCT in evaluating maxillary sinus pathologies and refining treatment protocols in dental and maxillofacial procedures. Given the growing use of dental implants and sinus lift procedures, preoperative evaluation using CBCT has become essential to minimize complications and improve long-term outcomes [11].

Despite the advantages of CBCT, several limitations must be acknowledged. One of the primary concerns is the increased radiation exposure associated with CBCT compared to panoramic radiography, which makes it less suitable for routine screening, particularly in younger patients or those requiring repeated imaging. Although CBCT delivers a lower radiation dose than conventional computed tomography (CT), clinicians must carefully consider the balance between radiation risk and diagnostic benefit [12]. Additionally, CBCT systems are costly and may not be readily available in all dental and maxillofacial practices, limiting their widespread use, particularly in resource-limited settings. Another notable limitation is the complexity of CBCT interpretation, which requires specialized training and expertise to accurately identify and classify incidental findings [13]. Misinterpretation of CBCT data can lead to missed diagnoses or unnecessary interventions, highlighting the need for standardized training protocols to ensure consistency and accuracy. Furthermore, incidental findings detected on CBCT may result in overdiagnosis, leading to unnecessary investigations or treatments, increasing healthcare costs, and causing patient anxiety. Clinicians should carefully assess the clinical relevance of incidental findings and make evidence-based decisions regarding further management [14].

Given the increasing reliance on CBCT for dental and maxillofacial assessments and the high prevalence of incidental findings in the maxillary sinus, this study aims to address the gaps in understanding the distribution and clinical relevance of these findings. The primary objective of this study is to assess the prevalence, types, and clinical significance of incidental findings in the maxillary sinus using CBCT scans obtained from a tertiary care centre. The study seeks to provide a comprehensive understanding of the distribution of these findings across different age and gender groups, enabling clinicians to anticipate potential complications and refine their treatment approaches. Additionally, the study aims to evaluate the impact of incidental findings on treatment planning and outcomes in dental and maxillofacial procedures. By identifying common incidental findings and their clinical implications, this study will contribute to enhancing diagnostic accuracy, optimizing treatment planning, and improving patient care in dental and maxillofacial healthcare.

Materials and Methods

For one month, from February to March 2024, 150 cone beam computed tomography (CBCT) scans were retrospectively examined from the archives of a tertiary care centre. This study follows a retrospective cross-sectional observational design to assess incidental findings in the maxillary sinus. The study protocol was reviewed and approved by the Institutional Ethics Committee (IEC), ensuring compliance with ethical standards and maintaining patient confidentiality. Informed consent was waived due to the retrospective nature of the study, and patient anonymity was preserved by de-identifying all CBCT scans.

The sample size was calculated using G*Power version 3.0.1 (Franz Faul, Universität Kiel, Germany), employing a point-biserial model for correlation analysis. A total of 150 CBCT scans were selected to achieve a power of 95% ($1-\beta = 0.95$) with a significance level (α) of 0.05 and an effect size (ρ) of 0.26, as referenced from the study by Ahmed J et al. (2023). The power analysis parameters were as follows:

- Tail(s): One
- α error probability: 0.05
- Power ($1-\beta$ error probability): 0.95
- Total sample size: 150
- Noncentrality parameter δ: 3.3048710
- Critical t: 1.6552145
- Degrees of freedom (df): 148

Inclusion criteria

- Patients of any gender aged 15 years or older.
- Patients who had CBCT imaging performed for maxillofacial or dental examinations, including but not limited to implant planning, impacted teeth evaluation, and maxillofacial trauma assessment.

Exclusion criteria

- Individuals who had previously undergone maxillofacial surgeries or treatments affecting the maxillary sinus region.

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- Low-quality CBCT scans with visible artifacts or poor maxillary sinus visualization, which could compromise diagnostic accuracy.

Procedure

A total of 150 CBCT scans that met the inclusion criteria were obtained and analyzed. All images were acquired using a Carestream Select 9300 CBCT machine (Carestream Dental LLC, Atlanta, GA, USA). Standardized imaging parameters included:

- Tube Voltage: 90 kVp
- Tube Current: 8 mA
- Exposure Time: 11–12 seconds
- Field of View (FOV): 8 × 8 cm
- Voxel Size: 0.2 mm

Kodak Dental CS 3D Imaging Software V3.5.7.0 (Madison, NY, USA: Carestream Health Inc.) was used for image acquisition and reconstruction. CBCT scans were obtained using protocols appropriate for maxillofacial evaluation, ensuring consistent imaging quality.

CBCT evaluation

The CBCT images were evaluated in Digital Imaging and Communications in Medicine (DICOM) format. Images were transferred to a standardized computer and analysed using CS 3D Imaging Software. Multiplanar reconstructions were performed to visualize axial, sagittal, and coronal sections for a comprehensive assessment of the maxillary sinus.

Classification of incidental findings

Incidental findings were classified into the following categories based on established radiological criteria from published literature [1,2]:

- Inflammatory Disorders: Mucosal thickening, sinusitis, and polyps.
- Cystic Lesions: Mucous retention cysts and odontogenic cysts.
- Developmental Abnormalities: Sinus hypoplasia and septa variations.
- Tumours/Neoplasms: Benign and malignant lesions.
- Structural Abnormalities: Sinus septa, wall discontinuities, and opacifications.

Each scan was evaluated independently by two experienced maxillofacial radiologists with over 10 years of experience in CBCT interpretation. To ensure inter-rater reliability, disagreements were resolved through consensus, and Cohen's kappa coefficient was calculated to assess agreement between radiologists, with a kappa value > 0.80 indicating excellent agreement.

Statistical analysis

All data were recorded in Microsoft Excel and analysed using the Statistical Package for Social Sciences (SPSS) version 16.0 (Windows version 17.0, SPSS Inc., Chicago, IL, USA). Descriptive statistics were used to present the prevalence and distribution of incidental findings.

Chi-square tests were employed to evaluate the association between incidental findings and demographic variables such as age and gender. The chi-square test was selected due to its appropriateness for categorical data and to assess differences between observed and expected frequencies. For multiple comparisons, a Bonferroni correction was applied to adjust the significance threshold and reduce the risk of Type I errors. A p-value < 0.05 was considered statistically significant.

Quality control measures

To ensure consistency and accuracy in CBCT interpretation, inter-rater reliability was assessed using Cohen's kappa coefficient. Agreement between the two radiologists was calculated for the classification of incidental findings, and discrepancies were resolved by a third senior radiologist when necessary. A kappa value of 0.80 or higher was considered indicative of strong agreement, thereby ensuring the reliability of the findings.

To minimize errors and maintain data integrity, the following quality control measures were implemented:

- Standardized imaging protocols to ensure consistent scan quality.
- Independent validation of classified findings by a third reviewer in case of discrepancies.
- Randomized re-evaluation of 10% of the scans to confirm the accuracy and reproducibility of the data.

Results and Discussion

CBCT has become an essential diagnostic tool in maxillofacial imaging due to its ability to provide high-resolution, three-dimensional (3D) visualization of the maxillofacial region, including the maxillary sinus. This study evaluated incidental findings in the maxillary sinus from 150 CBCT scans, revealing a high prevalence of anomalies that can impact clinical decision-making. The most frequent incidental finding was sinus septation, observed in 55.8% of the scans, followed by mucosal thickening (25.3%), mucous retention cysts (7.4%), and complete or partial sinus opacification (4.1%). Less frequent findings included cystic lesions (2%), maxillary wall discontinuation (1.3%), fibro-osseous lesions, and benign odontogenic tumours (0.7%) (Figure 1). These findings are consistent with those reported by Munde et al. (2020), who identified similar incidental findings with comparable prevalence rates [1].

Sinus septa, the most common finding, are thin bony partitions within the maxillary sinus that can significantly impact surgical procedures such as sinus augmentation and implant placement. Abesi et al. (2020) reported that sinus septa were observed in 37.9% of 809 CBCT scans, with partial septa being more prevalent than complete septa (77.5% vs. 22.5%). The middle region of the sinus was the most common site for septa formation, and the mean septum height was 6.0 ± 3.1 mm on the left and 5.7 ± 3.9 mm on the right [2]. Katiyar et al. (2022) identified mucosal thickening in 25% of CBCT scans, aligning closely with the findings of the current study. Mucous retention cysts, although often asymptomatic, were reported in 7.4% of the scans, consistent with studies that highlight their role in potentially complicating sinus augmentation procedures if undetected [6,15].

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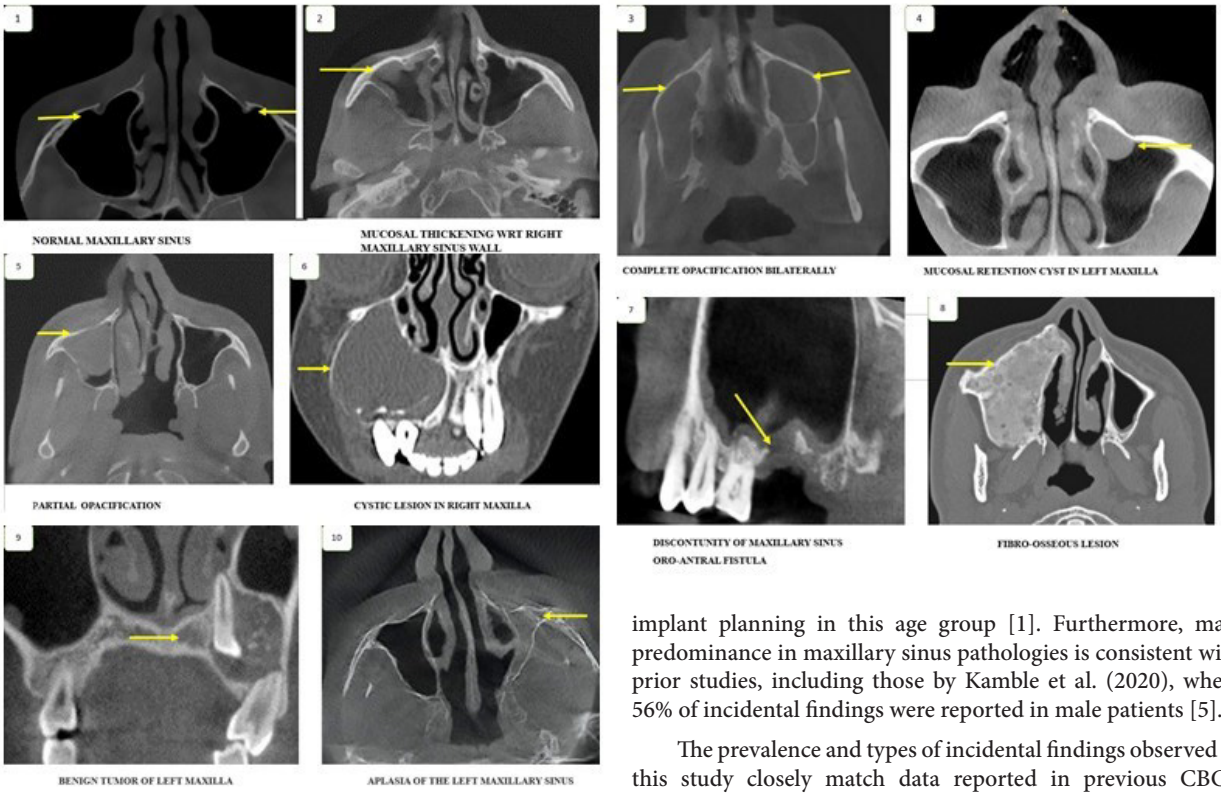

Figure 1(1-10). (1) Normal Maxillary Sinus; (2): Mucosal thickening; (3): Complete opacification; (4): Mucosal retention cyst in left maxilla; (5): Partial opacification; (6): Cystic lesion in right maxilla; (7): Discontinuity of Maxillary sinus, (8): Fibro-osseous lesion; (9): Benign tumor of left maxilla; (10): Aplasia of the left maxillary sinus.

The distribution of incidental findings varied across different age groups, with the highest prevalence observed in the 15–30 years age group (45.3%), followed by 31–45 years (26.0%), 46–60 years (19.3%), and 61–75 years (9.3%). Gender-based analysis showed that males accounted for 54.7% of the cases with incidental findings, while females accounted for 45.3% (Figure 2).

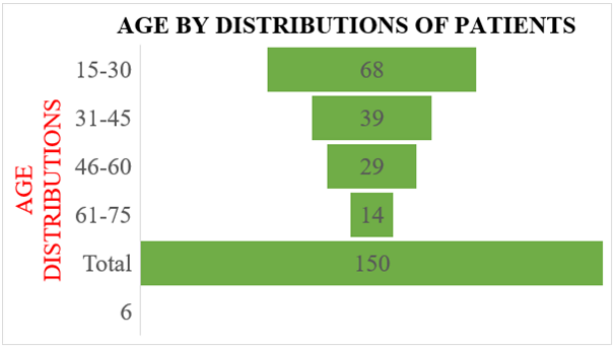

Figure 2. Age distribution of 150 patients.

These results align with findings reported by Munde et al. (2020), where similar age and gender-based distributions of incidental findings were noted. The higher prevalence of incidental findings in younger individuals may be attributed to the increased use of CBCT for orthodontic assessments and implant planning in this age group [1]. Furthermore, male predominance in maxillary sinus pathologies is consistent with prior studies, including those by Kamble et al. (2020), where 56% of incidental findings were reported in male patients [5].

The prevalence and types of incidental findings observed in this study closely match data reported in previous CBCT studies. Munde et al. (2020) analysed 150 CBCT scans and reported that sinus septa were present in 55.7% of cases, while mucosal thickening and mucous retention cysts were observed in 25.3% and 7.4% of cases, respectively. Similarly, Katiyar et al. (2022) reported incidental maxillary sinus abnormalities in 20% of 152 CBCT scans, with developmental abnormalities, cysts, and inflammatory diseases being the most frequently observed [6]. In a large-scale study by Abesi et al. (2020) involving 809 CBCT scans, sinus septa were detected in 37.9% of individuals, with partial septa being significantly more common than complete septa [2]. Furthermore, Kamble et al. (2020) analysed 300 CBCT scans and reported a 100% prevalence of incidental findings, with the nasal cavity region accounting for 83.33% of the findings and the temporomandibular joint (TMJ) region contributing 23.33% of incidental results [5].

Incidental findings in the maxillary sinus can have significant implications for dental implant planning and sinus augmentation procedures. For instance, mucosal thickening may indicate chronic sinusitis, increasing the risk of post-operative infections and implant failure. Shanbhag et al. (2021) emphasized the importance of identifying mucosal thickening before sinus lift procedures to minimize complications. Similarly, sinus septa can complicate sinus lift procedures by increasing the likelihood of sinus membrane perforation during the elevation process. Bornstein et al. (2012) reported that sinus septa were present in 28.4% of CBCT scans and emphasized the need for meticulous preoperative planning to reduce complications.

Cystic lesions such as mucous retention cysts can complicate sinus augmentation or implant placement if not

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identified and managed appropriately. Although these cysts are often asymptomatic, they may enlarge over time and affect the integrity of the sinus membrane. Katiyar et al. (2022) recommended periodic monitoring of mucous retention cysts to prevent potential complications. Maxillary wall discontinuities and fibro-osseous lesions may predispose patients to oroantral fistula formation, making their pre-surgical identification essential for optimal outcomes. CBCT facilitates the early identification of these anomalies, allowing for modifications in surgical approaches to minimize complications [6].

CBCT is also invaluable in managing maxillofacial trauma, enabling the early detection of fractures and discontinuities in the maxillary sinus walls. Kamble et al. (2020) highlighted the importance of detecting incidental findings in the TMJ region, where incidental findings accounted for 23.33% of cases. Early identification of such pathologies can prevent complications such as persistent pain, malocclusion, and reduced range of motion [5].

Despite the valuable insights provided by this study, several limitations should be acknowledged. The retrospective nature of this study limits the ability to establish causal relationships between incidental findings and clinical outcomes. Prospective cohort studies with long-term follow-up are needed to validate these findings. Additionally, since the study was conducted at a single tertiary care centre, the results may not be generalizable to other populations with different demographic characteristics. A multi-centre study involving a larger and more diverse population is necessary to improve the external validity of the findings. Moreover, the exclusion of low-quality CBCT scans with artifacts or inadequate visualization introduces a potential selection bias, which may have led to an underestimation of the true prevalence of incidental findings. Future studies should aim to include a more representative sample by considering variations in scan quality and patient demographics [16,17].

To further improve the understanding of incidental findings in the maxillary sinus, future research should focus on conducting multi-centre studies with larger and more diverse populations. Multi-centre studies can help validate the prevalence and distribution of incidental findings across different ethnic and demographic groups. Additionally, prospective cohort studies with long-term follow-ups can provide insights into the progression of incidental findings and their clinical implications. Artificial intelligence (AI) and machine learning algorithms offer promising avenues for improving the accuracy and consistency of CBCT analysis. Mischkowski et al. (2021) demonstrated that AI models achieved high accuracy in detecting sinus pathologies, reducing diagnostic errors and enhancing the reliability of incidental findings detection. Future research should explore the integration of AI-based systems in routine CBCT analysis to facilitate the early detection and management of incidental findings [18].

The standardization of reporting protocols for incidental findings in CBCT scans is another critical area for improvement. The adoption of structured reporting systems based on international guidelines can facilitate uniform classification and documentation of incidental findings, reducing variability between radiologists. Implementing these standardized reporting protocols can ensure consistent interpretation of CBCT scans and improve patient management in clinical settings [19].

Conclusion

The identification of incidental findings through cone beam computed tomography (CBCT) emphasizes the importance of thorough radiographic evaluation in dental and maxillofacial practice. CBCT provides superior visualization of maxillofacial structures and enhances diagnostic accuracy by detecting sinus pathologies and anatomical variations that may be missed on conventional two-dimensional imaging. The high prevalence of incidental findings, such as sinus septa, mucosal thickening, and cystic lesions, underscores the need for incorporating CBCT as part of the diagnostic workflow in cases where a detailed anatomical assessment is required.

Early identification of these incidental findings has significant implications for treatment planning, particularly in procedures such as dental implant placement, sinus augmentation, and maxillofacial surgery. Detecting mucosal thickening or cystic lesions before sinus augmentation can prevent complications such as membrane perforation, implant failure, and postoperative infections. Additionally, identifying sinus septa can guide modifications in surgical techniques to minimize the risk of membrane damage during sinus elevation procedures. CBCT also plays a critical role in the management of maxillofacial trauma by enabling the early detection of fractures, structural abnormalities, and other pathologies that may impact patient outcomes.

Integrating CBCT assessment protocols selectively into routine clinical practice, particularly for complex cases involving implant planning and sinus surgeries, can enhance diagnostic precision and improve patient safety. Standardizing reporting protocols for incidental findings using internationally recognized guidelines can ensure consistent documentation and facilitate accurate diagnosis. Moreover, future multi-centre research involving diverse populations is essential to validate these findings and establish standardized protocols for the management of incidental maxillary sinus pathologies. By incorporating CBCT into routine diagnostic workflows and adopting structured reporting systems, clinicians can improve treatment outcomes and enhance patient-centred care through individualized treatment planning and reduced post-operative risks.

Disclosure Statement

No potential conflict of interest was reported by the author.

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