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**CARRERA PROFESIONAL DE ESTOMATOLOGÍA**

**“HERRAMIENTAS IMAGENOLÓGICAS PARA LA DETECCIÓN  
DE PATOLOGÍAS SINUSALES DE ORIGEN ODONTOGÉNICO.  
UNA REVISIÓN DE LA LITERATURA”**

Tesis para optar el Título de:

**SEGUNDA ESPECIALIDAD EN RADIOLOGÍA BUCAL Y  
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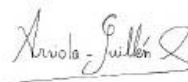
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REVIEW ARTICLE

**IMAGING TECHNOLOGIES FOR THE DETECTION OF SINUS  
PATHOLOGIES OF ODONTOGENIC ORIGIN: A REVIEW**

HERRAMIENTAS IMAGENOLÓGICAS PARA LA DETECCIÓN DE  
PATOLOGÍAS SINUSALES DE ORIGEN ODONTOGÉNICO. UNA REVISIÓN

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## ABSTRACT

Sinus pathologies of odontogenic origin (SPOO) are commonly seen in the clinical setting. However, the detection of these diseases may be difficult and is usually incidental in imaging studies which, in many cases, are of low quality. The objective of this review was to describe the imaging tools that allow the detection of the most frequent SPOOs and also carry out an updated review of the scientific literature published between 2014 and 2020 in order to determine the value of imaging techniques in both the maxillary sinus and the dental organs. This review describes two important results: the first is that cone beam tomography (CBCT) is the imaging modality of choice for the detection of SPOO. The second is that the most frequent SPOO is sinus mucositis, which is related to odontogenic conditions such as periapical lesions and periodontal involvement. While CBCT is the most adequate tool to detect SPOO compared to images obtained by 2D devices, other alternatives such as magnetic resonance imaging and ultrasonography seem to have a promising future.

**Keywords:** Imaging, sinus pathologies of odontogenic origin, cone beam computed tomography, review.

**Declarations of interest:** None

## RESUMEN

Las patologías sinusales de origen odontogénico (PSO) son frecuentes en la consulta clínica; sin embargo, el odontólogo tiene algunas complicaciones para detectarlos porque su descubrimiento suele ser incidental y mediante estudios de imagen que, en la mayoría de los casos, son de baja calidad. El objetivo de esta revisión es describir los recursos de imagen pertinentes que permitan la detección de las PSO más frecuentes y, al mismo tiempo, realizar una revisión actualizada de la literatura científica con el fin de reconocer la imagenología tanto del seno maxilar como de los órganos dentales. Se consultó la literatura científica centrada en este tema, publicada entre 2014

y 2020. La revisión arrojó dos resultados importantes: el primero es que la tomografía de haz cónico (TCHC) representa la modalidad de imagen con mejor desempeño para la detección de PSO por lo que se puede considerar el estándar de oro para este propósito. La segunda es que la PSO más frecuente es la mucositis sinusal, que se relaciona con afecciones odontogénicas como lesiones periapicales y afectaciones periodontales. Si bien la TCHC es la herramienta más adecuada para detectar SPO en comparación con las imágenes obtenidas con dispositivos 2D, también existen otras alternativas como la resonancia magnética y la ecografía, que parecen tener un futuro prometedor.

**Palabras clave:** Imagen, patologías sinulases de origen odontogénico, tomografía computarizada de haz cónico, revisión.

## 1. INTRODUCTION

Sinus pathologies of odontogenic origin (SPOO) are defined as an inflammatory or infectious process that originates in the dental and dent alveolar structures and can directly or indirectly affect the sinus membrane (SM), leading to the development of diseases of the maxillary sinus [1]. SPOO are difficult to diagnose, and their identification is usually incidental [2]. Only between 60 and 70% of cases are analyzed and diagnosed by medical radiologists, and the appearance of SPOO has shown to mainly be unilateral [3-9]. Diseases of the maxillary sinus vary greatly, with only 10 to 12% of these pathologies having an odontogenic origin [3], the most frequent being Schneiderian membrane mucositis, maxillary sinusitis, mucous retention cyst, and antral pseudocysts [4]. The topographic relationship of the teeth and the maxillary sinus is not a determining factor for the appearance of pathologies, but there may be an anatomical relationship [5]. For example, the average distance between the maxillary sinus and the dental apices is only 1.97 mm [3], facilitating the spread of dental infections and iatrogenic events (e. g. foreign body projection) [5,10]. The symptomology related to SPOO is variable [11], and

only 29% of the patient present pain. Establishment of a strictly clinical diagnosis is complicated [12], and there is a risk of subjecting the patient to unnecessary pharmacological regimens and surgical procedures [1]. Periapical and panoramic radiographs are the most widely used imaging tools to diagnose SPOO. However, both have a low predictive value due to their two-dimensional (2D) nature and high distortion [11]. For this reason, cone beam computed tomography (CBCT) has currently shown to be the most adequate tool for the identification and diagnosis of SPOO, due to the high resolution of its images and the considerably lower radiation compared to a medical tomography [1,3,5,13,14]. In addition, CBCT can show the exact size and location of the pathology, its relationship with the anatomical structures, and establish treatment plans. Thus, the purpose of this review was to describe the most effective imaging tools available for the detection of SPOO.

## **2. Article Selection**

The bibliographic search was carried out in databases such as Medline (PubMed), Scopus, LILACS, SCIELO, Google Scholar and Cochrane Library. Studies published between 2014 and 2020 were consulted using the following search terms: "sinusitis of the maxillary sinus and dental organs", "sinusitis of odontogenic origin", "sinus pathologies of odontogenic origin", "periodontitis and maxillary sinusitis", "apical periodontitis and maxillary sinusitis" , "unilateral sinusitis of odontogenic origin" and "odontogenic conditions and pathologies of the maxillary sinus". Both prospective and retrospective reviews and studies were consulted.

## **3. Imaging of the maxillary sinus and its relationship with teeth**



The anatomical structures present between the maxillary sinus and the dental organs are the apices of the dental roots, the periodontium, the alveolar bone, and the vascular canals. Due to the relationship between the airways and the dental organs, the maxillary sinus should be inspected by both an otolaryngologist and a dental surgeon [15,16]. The SM is found inside the maxillary sinus. It has a thickness of 0.3 to 0.8 mm; its nature is similar to the nasal mucosa, and it is composed of the pseudostratified epithelium with ciliary cells. This membrane can undergo morphological alterations due to an infectious process or be perforated during a surgical procedure. Therefore, study of the SM has become clinically important [17,18]. The maxillary sinus is an anatomical structure the size and shape of which vary according to age, height, and pneumatization degree [6,19]. It is closely related to the apices of the posterior maxillary dental organs. It is essential to take this into account because it can sometimes generate a direct communication between the septic environment of an infected dental organ and the sinus cavity, favoring the appearance of an acute or chronic inflammatory process. Concerning the maxillary sinus, the first premolar of the posterior teeth is the farthest away, and the mesiobuccal root of the upper second molar, the closest [20]. Different proposals have been made to classify the proximity between the root apices and the maxillary sinus floor. One of these proposals was developed by Jung in 2009, which proposes four different classifications based on the use of CBCT: type 0: the floor of the maxillary sinus is located on the root apex; type 1: the root apex touches the floor of the maxillary sinus; type 2: the floor of the maxillary sinus is interposed between the roots; and type 3: apical protrusion over the maxillary sinus [7,19]. A relationship between the upper posterior apices of the dental organ roots and the maxillary sinus has been reported in 10.5 to 34.2% of patients. In 46% of incidental cases, a part of the root extends beyond the maxillary sinus, the most frequent roots involved being the palatal root of the upper first molar and the mesiobuccal

root of the upper second molar [21]. The canal for the intraosseous branch of the posterior superior alveolar artery (iobPSAA) is one of the most important anatomical landmarks at the level of the dental organs and the maxillary sinus and extreme caution is necessary to avoid this artery during surgical procedures such as implant placement, maxillary sinus floor elevation, or periapical surgery. CBCT has demonstrated the presence of this artery in 56.2% of patients. In 32% of these cases, the artery presented a diameter greater than 1 mm [22]. In CBCT the iobPSAA is shown to go along an intraosseous canal for an average distance of 6.18 mm from the dental apices and 6.41 mm from the maxillary sinus floor. This information is critical to avoid the risk of laceration during a surgical procedure [20]. Similarly, CBCT has revealed that the volume of the maxillary sinus is totally or partially decreased in edentulous patients. This reduction in volume may be due to the roots of the dental organs acting as a natural support for the anteroposterior architecture of the maxillary bone, and thus, the absence of these roots results in a decreased sinus volume [23]. Other factors that can impact the volume of the maxillary sinus are gender and age, with a significantly higher volume in men compared to women, and a lower sinus volume being observed in patients over the age of 24 years due to full growth of the maxillary sinus being achieved between the second and third decade of life [24]. A recent study carried out with CBCT reported that there are no significant differences regarding the presence of sinus septa in totally or partially edentulous patients. However, it was found that the majority of septa are located in the region posterior to the level of the second upper molar. This information is very relevant and vital to consider in order to avoid operative complications during implant placement, making CBCT a helpful tool for establishing an adequate treatment plan [25]. Finally, CBCT has shown that although pneumatization of the maxillary sinus is often reported following a dental extraction, changes in the maxillary sinus floor position are minimal. Furthermore, most

of the structural alterations occur at the bone crest level, having a direct clinical implication that would indicate the need for a therapeutic option that minimizes this remodeling, such as alveolar preservation [26].

#### **4. Imaging aspects of sinus pathologies of odontogenic origin**

Between 10 and 12% of all cases of maxillary sinusitis are of odontogenic origin (SO) [27]. During long term odontogenic infection, resorption of the alveolar bone may occur as a result of bacterial secretion of collagenase developed through the apical foramen, which can lead to direct communication between the dental organ and the sinus cavity [28,29]. CBCT is able to verify other factors such as frequency, location, and odontogenic conditions related to radio densities which were previously detected incidentally. To detect the presence of periapical lesions in upper maxillary teeth, the SM has been evaluated using CBCT. The results show that the most common type of thickening in the floor of the maxillary sinus is of the “flat” type; related odontogenic conditions are mostly periodontal disease and periapical pathologies; [30] Thickening of SM is usually more frequent in the upper first molar (44% of cases), and in the upper second molars (33%), which is due to the close relationship of these dental organs with the maxillary sinus [31]. Thus, CBCT has demonstrated to be a useful tool to determine the prevalence of SPOO in cases of unilateral sinusitis (US). In one study, 45% of SPOO of the total US was found, which, in addition, were related to pathologies in the ethmoid and frontal sinuses [9]. CBCT allows assessment of the structural changes in SM cases one year after having root canal treatment in infected dental organs, showing a statistically significant 50% reduction in SM in most of the cases analyzed. Authors suggest the selection of an adequate field of view (FOV) in order to achieve correct evaluation of this phenomenon, and in this case, a small FOV would be ideal for evaluating a specific dental organ [32].

Recently, CBCT was used to evaluate the relationship between the position of the maxillary sinus floor and the development of maxillary sinusitis in 152 patients. The horizontal relationship between the maxillary sinus floor and the dental roots was classified into three types: type 1: the maxillary sinus floor is positioned towards the vestibular area in relation to the maxillary buccal roots; type 2: the maxillary sinus is located on the vestibular and the palatal root; and type 3: the floor of the maxillary sinus is positioned in relation to the palatal root. Previous studies have frequently referred to the upper first molar as the tooth most commonly associated with odontogenic sinus infections, and therefore, the authors used this molar as a reference for testing. However, it has been shown that type 2 of the horizontal configuration of the sinus floor is the type most related to inflammatory processes [33]. Odontogenic conditions predisposing SPOO development, such as inadequate endodontic treatment, periapical lesion, and periodontal bone loss, have been analyzed using CBCT and were classified as follows: localized or generalized mucosal thickening, maxillary sinusitis, and mucosal retention cyst. It was concluded that the most prevalent SPOO was generalized mucosal thickening which had an evident relationship with periodontal bone loss and the presence of periapical lesions [5].

### **5. Imaging tools used for the detection of sinus pathologies**

The importance of choosing high-precision imaging tools lies in the need to make an adequate diagnosis and obtain predictable results when proposing a specific therapy. To achieve this, it is essential to detect SPOO early by radiological images. The most commonly used alternative imaging techniques are; panoramic radiography (PR), periapical radiography, CBCT, and magnetic resonance imaging (MRI) [3,4]. Among these options PR is usually the most frequently used in dentistry due to its low cost, easy

access, and the little radiation produced. However, PR has some disadvantages, such as the superposition of anatomical structures, a high degree of distortion [35], and it only records the information obtained within an established focal corridor. Generally, the anteroposterior dimension of the maxillary sinuses exceeds that of the alveolar ridge, and thus, a large amount of information is not accurately detected [36]. Furthermore, it has been reported that it is challenging for this technique to detect maxillary sinuses with a diameter less than 3 mm [37]. Constantine analyzed the efficacy of both PR and CBCT to detect pathologies of the maxillary sinus in 714 patients, obtaining a sensitivity of 36.7% for PR and a specificity of 88.1%, leading the authors to conclude that PR is not a viable alternative for the correct diagnosis of SPOO [36]. These results were supported by other authors [38]. Taking all these results into account, and the research carried out on this topic [12,39], CBCT has shown to be the tool most frequently used for the diagnosis of pathologies related to the maxillary sinuses. CBCT provides high quality, multiplanar image management with different slice thicknesses, which solves the problem generated by the superposition of images present in PR. However, it is also essential to establish appropriate selection criteria for the use of CBCT due to the amount of radiation emitted [34]. CBCT provides detailed analyses of the sinus anatomy, bone patterns and their alterations, the presence of intrasinus calcifications, and the extent of sinus pathology. This method has shown that more than 70% of patients diagnosed with dental infections in the upper jaw have morphological alterations in the maxillary sinus [39]. On the other hand, several authors have proposed the use of MRI as an alternative precision imaging tool for the diagnosis and treatment planning of sinus pathologies, since one of its main virtues is anatomical characterization of soft tissue with a high degree of contrast [41]. The main difference between MRI and CBCT is in the way in which radiological images are obtained: MRI works through signals emitted by water protons within a

magnetic field, and CBCT by X-ray attenuation patterns [40]. One MRI modality is the diffusion weighted magnetic resonance (DWI), which quantifies the values obtained with an apparent diffusion coefficient (ADC). With the ADC, random molecular movement is expressed in detail from water in an intracellular medium to which magnetic energy is applied [41]. In this case, the ADC is recorded using colors that vary from red to blue, in which the first indicates the highest degree of diffusion of the water molecule and the second the lowest. In relation to ultrasound (US), there are no studies on the diagnosis of SPOO with this technique. However, its reliability in the diagnosis of acute and subacute maxillary sinusitis has been verified. On the other hand, another prospective cohort study used US to corroborate the diagnosis of a total of 148 maxillary sinuses in 74 patients and concluded that US is a fast, effective, and easy to use tool to evaluate the maxillary sinus [42].

## 6. Conclusions

SPOO are of multifactorial etiology, which, on occasions, present minimal clinical manifestations. Dental imaging is a fundamental aid for clinicians since it facilitates achieving a correct diagnosis and proposing an adequate therapy.

Several studies have shown that the performance of 2D radiological images is considerably lower compared to CBCT. Nonetheless, other alternative methods for diagnosing SPOO should be investigated, such as MRI and US, which seem to have a promising future.

**Contribution authors:**

All authors have read and approved the final manuscript content, write-up of the manuscript and have significantly contributed to the study.

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The authors declare that they have no competing interest.

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