

Charlotte Choukayrek

Odontogenic sinusitis, from diagnosis to treatment: a narrative revision

Universidade Fernando Pessoa

Faculdade de Ciências da Saúde

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Charlotte Choukayrek

RESUMO

A sinusite maxilar de origem dentária, também conhecida como sinusite odontogênica (OS), é uma doença comum na medicina dentária. Representa aproximadamente 10-12% dos casos de sinusite maxilar.

OS deve ser considerada em indivíduos com sintomas de sinusite maxilar unilateral e história de dor dentária ou mandibular, como infecção dentária, doença periodontal ou endodôntica.

O objetivo deste estudo foi definir as causas da OS e fornecer uma estratégia de diagnóstico e tratamento comparando diferentes métodos.

O método de pesquisa utilizado consistiu na pesquisa nos motores de busca PubMed, B-on e Google Acadêmico utilizando as seguintes palavras-chave: Sinusite Odontogênica, imagem bidimensional, imagem tridimensional, antibioterapia e cirurgia endoscópica nasossinusal.

Um esforço colaborativo próximo entre especialistas médicos e dentistas é essencial para um diagnóstico precoce e preciso e um tratamento ideal.

No entanto, mais estudos prospectivos sobre esse tema são necessários para determinar a melhor direção do cuidado para essa população de pacientes.

Palavras-Chave: “Sinusite Odontogênica”, “Infecção Odontogênica”, “Diagnóstico”, “Tratamento”

ABSTRACT

Maxillary sinusitis of odontogenic origin, also known as odontogenic sinusitis (OS), is a common disease in dentistry. It accounts approximately 10-12% of maxillary sinusitis cases.

OS should be considered in individuals with symptoms of unilateral maxillary sinusitis and a history of dental or jaw pain such as dental infection, periodontal or endodontic disease.

The aim of this study was to underline the causes of OS and to provide a diagnostic and treatment strategy comparing different methods.

The research method used consisted of acquiring data using PubMed, B-on and Google Scholar search using the following keywords: Odontogenic Sinusitis, two-dimensional imaging, three-dimensional imaging, antibiotic therapy and endoscopic sinus surgery.

A close collaborative effort between medical and dentist specialists is essential for an early and accurate diagnosis and optimal treatment.

However, more prospective studies on this topic are needed to determine the best direction of care for this patient population.

Keywords: “Odontogenic Sinusitis”, “Odontogenic infection”, “Diagnosis”, “Treatment”

DEDICATION

*To my older sister, Alexandra, my guardian angel who never stop watching over me, not by
my side but always in my heart ...*

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Foremost, I would like to thank my dear parents. There are no proper words to convey my deep gratitude and respect for their unconditional trust, timely encouragement, and endless love that raised me up again when I got weary. Without them, this day would not have been possible...

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ABBREVIATIONS

3D	Three-Dimensional
CBCT	Cone Beam Computed Tomography
CT	Computed Tomography
OS	Odontogenic Sinusitis
PAL	Periapical Lesions

I. INTRODUCTION

“It’s a common knowledge. I know it, you know it- Why should we tell each other?”.

That was Attila the Hun’s elusive answer when a local savant questioned him on the distance between Earth and the moon (Allevi *et al.*, 2020).

Odontogenic sinusitis (OS), a disease first described in 1943 by William Bauer and defined as sinusitis of dental origin, seems be lighted by the same “common knowledge” syndrome and seems to be suffering of lack of attention compared to other form of sinusitis (Kim, 2019; Allevi *et al.*, 2020; Zhu *et al.*, 2021).

OS represents approximately 10-12% of the total cases of maxillary sinusitis (López *et al.*, 2009; Bouguezzi *et al.*, 2015; Aukštakalnis *et al.*, 2018; Kodur, Kiran & Shivakumar, 2019; Yoo *et al.*, 2020; Psillas *et al.*, 2021).

Despite its high prevalence increasing constantly, OS receives less attention compared to other forms of sinusitis and is often ignored by otolaryngologist and dentist and leads to an unsureness regarding the best diagnostic and treatment strategy to follow (Whyte & Boeddinghaus, 2019a; Yoo *et al.*, 2020; Craig *et al.*, 2021; Zhu *et al.*, 2021).

OS occurs when the Schneidarian membrane is perforated and leads to an inflammatory and/or infectious process in the maxillary sinus (Lee & Lee, 2010; Kim, 2019; Kodur, Kiran & Shivakumar, 2019).

The proximity of maxillary sinus to the root of second molar followed in frequency by the first molar, third molar, second premolar and first premolar teeth makes dental disease a potential source for maxillary sinusitis (Shahbazian & Jacobs, 2012; Psillas *et al.*, 2021).

Early correct diagnosis and treatment of the lesion is an important issue in dentistry and may help prevent unnecessary surgical treatment and deserves special considerations since the management differs depending on the origin of the disease (Akhlaghi *et al.*, 2015; Kim, 2019). The aim of this narrative review is to underline the causes of OS and to provide a diagnostic and treatment strategy comparing different methods.

1. Materials and methods

For this work, a search was carried out between September 2021 and March 2022, using the search engines Pubmed, Medline, Scielo and Academic Google through the access of the Library of the University Fernando Pessoa. The inclusion criteria restricted the search to articles written in English, French, Portuguese, and articles published in the last 18 years. Initially, the selection was based on the reading of the title and abstract, being rejected all of those that substantially diverged from the subject under study or whose availability was impossible. Subsequently, exclusion was determined by analysing the full content of each article, culminating in a total of 39 articles.

The keywords used were: “Odontogenic Sinusitis”, “Odontogenic infection”, “Unilateral maxillary sinusitis” “two-dimensional imaging”, “three-dimensional imaging”, “antibiotic therapy”, “endoscopic sinus surgery”.

II. DEVELOPMENT

1. Etiology

The origin of sinusitis is considered to be primarily rhinogenous. In some cases, a dental infection is a major predisposing factor (Lee & Lee, 2010; Craig *et al.*, 2020).

OS should be considered in individuals with symptoms of maxillary sinusitis and a history of dental or jaw pain such as dental infection, periodontal or endodontic disease (Kodur, Kiran & Shivakumar, 2019).

OS can be acute or chronic (Lacan & Teman, 2017).

Acute OS is uncommon compared to chronic OS. For this reason, maxillary sinusitis of odontogenic is, therefore also known as chronic maxillary sinusitis of dental origin. Hence, acute OS is much more invasive and destructive as it is a rapidly spreading infection (Aukštakalnis *et al.*, 2018; Kim, 2019; Craig *et al.*, 2020; Psillas *et al.*, 2021).

Furthermore, OS may show either fungal (*Aspergillus*) or bacterial (aerobes and anaerobes) etiology (Kodur, Kiran & Shivakumar, 2019; Psillas *et al.*, 2021).

Both aerobes and anaerobes have been related with this disease. As a matter of fact, microbiology studies of OS have proved that anaerobic bacterial flora (*Peptostreptococcus* and *bacilli*) is the most important factor in chronic maxillary sinusitis with a dental origin. Nevertheless, in acute OS patients, the main implicated flora tends to be mixed (Akhlaghi *et al.*, 2015; Psillas *et al.*, 2021). As a matter of fact, after the aerobic flora initiate inflammation and use the oxygen, the ostium is obstructed and inflammation produces changes in the Schneiderian membrane with a reduction of the oxygen providing an optimal environment for growth of anaerobic species. The growth of anaerobes further complicates treatment, because anaerobes develop greater antibiotic resistance than aerobes (Akhlaghi *et al.*, 2015; Mehra & Murad, 2004).

As a reminder, OS starts first in the maxillary sinus floor, progresses to maxillary ostium and finally ends in the surrounding tissues of the maxillary sinus (Psillas *et al.*, 2021; Zhu *et al.*, 2021).

OS refers to either adjacent infectious maxillary dental pathology or iatrogenic injury from

dental procedures (Lee & Lee, 2010; Akhlaghi *et al.*, 2015; Kim, 2019; Craig *et al.*, 2020; Craig *et al.*, 2021).

In this sense some studies have categorized the dental etiology factors of sinusitis according to their type: infectious or iatrogenic (Lee & Lee, 2010; Akhlaghi *et al.*, 2015; Kim, 2019; Craig *et al.*, 2020).

Among these categories, variety of dental pathologies can lead to OS (Tataryn *et al.*, 2018; Kim, 2019; Craig *et al.*, 2020).

The most common are the following: endodontic disease, oro antral fistula (usually after tooth extraction) and periodontitis, root fractures and infection causes by intra-antral foreign bodies in the sinus such as instrumentation beyond the apex via dental canal or dental implant corresponding to a iatrogenic cause (Akhlaghi *et al.*, 2015; Aukštakalnis *et al.*, 2018; Tataryn *et al.*, 2018; Kim, 2019; Craig *et al.*, 2020; Yoo *et al.*, 2020; Psillas *et al.*, 2021).

Among them, endodontic disease includes pulpal necrosis, root fracture, and periapical lesions (PAL) (López *et al.*, 2009; Akhlaghi *et al.*, 2015; Aukštakalnis *et al.*, 2018; Craig *et al.*, 2020).

These latter lesions could progress overtime during either the acute and the chronic phase (Kim, 2019).

PALs include periapical cysts, granulomas, or abscesses (López *et al.*, 2009; Akhlaghi *et al.*, 2015; Craig *et al.*, 2020).

In various studies comparing the incidence of various aetiologies, dental extraction and dental implant, which are both iatrogenic, were considered as the two most common causes of OS. (Lee & Lee, 2010; Akhlaghi *et al.*, 2015; Aukštakalnis *et al.*, 2018; Kim, 2019; Kodur, Kiran & Shivakumar, 2019; Yoo *et al.*, 2020).

As a matter of fact, implants related to OS have a significant incidence in patient who has predisposing factors such as a thin maxillary sinus floor and it is usually caused by a perforated Schneiderian membrane because of the displaced implant material into the maxillary floor. This act as a foreign body and may produce chronic infection (Kodur, Kiran & Shivakumar, 2019; Yoo *et al.*, 2020).

Chronic or marginal periodontitis, caused by inflammation and infection of the gingiva may

also lead to an OS (Lee & Lee, 2010; Aukštakalnis *et al.*, 2018; Kodur, Kiran & Shivakumar, 2019; Craig *et al.*, 2020).

Furthermore, a penetration of dental materials in the maxillary sinus (as a result of endodontic treatment) may lead to a fungal infection causing OS (Lee & Lee, 2010; Aukštakalnis *et al.*, 2018; Kodur, Kiran & Shivakumar, 2019; Craig *et al.*, 2020; Psillas *et al.*, 2021). Indeed, according to a meta-analysis based on articles published between 1986 and 2007, iatrogenic causes for OS include extrusion of endodontic obturation materials into the maxillary sinus floor (Psillas *et al.*, 2021).

Interestingly, it has been reported that dental roots overfilled, following endodontic treatment, in close proximity to maxillary sinus may result in positive cultures for *Aspergillus* which leads to a fungal sinusitis (Kim, 2019; Psillas *et al.*, 2021).

Due to their anatomic location and their complex root canal, maxillary molars are the most common endodontic sources of OS and the American Association of Endodontist recommended that molars endodontic treatment be managed by endodontist rather than general dentist (Craig *et al.*, 2020).

In a study, carried out by Zirk *et al.* (2017) 121 patients were suffering from OS. *Aspergillus* was found in 5 patients in the sinus. In 4 cases of Aspergillosis, a foreign body was detected in the sinus and 1 case of Aspergillosis was detected after tooth extraction.

Since common causes can be iatrogenic (related to dental treatment of a posterior maxillary tooth or implant procedures), a process of consultation between rhinologist and dentists before a dental procedure should take place in order to prevent the development of OS (Lee & Lee, 2010; Aukštakalnis *et al.*, 2018; Kim, 2019; Psillas *et al.*, 2021).

2. Diagnosis

The diagnosis of OS is mainly based on a clinical examination, including an assessment of the patient's symptoms, and on an imaging diagnosis (López *et al.*, 2009; Kodur, Kiran & Shivakumar, 2019; Zhu *et al.*, 2021).

i. Clinical Manifestation

Diagnosing sinus disease of odontogenic origin requires a thorough evaluation of the patient's symptoms, past medical history and the correlation with physical findings (Mehra & Murad, 2004).

It is important to note that clinical manifestation is present in 73% patients (Shahbazian & Jacobs, 2012).

A patient with history of repeated episodes of unilateral sinus disease should always raise the clinical suspicion of the OS. Most studies agree that a distinguishing symptom of OS from other causes of acute or chronic sinusitis is foul smelling rhinorrhoea. As a matter of fact, malodorous secretions are the hallmarks of OS. Other less unique symptoms include fever, facial pain and pressure, and nasal congestion. Only less than half patients report dental pain. Nevertheless, dental symptoms can range from acute pain associated with an exposed tooth nerve to the dull ache of a dental infection that has extended into the bone surrounding the apex of a root (periapical periodontitis) (Mehra & Murad, 2004; Gilain & Laurent, 2005; Whyte & Boeddinghaus, 2019b; Newsome & Poetker, 2020; Craig *et al.*, 2021).

Symptoms can be present from few weeks in acute cases to several years in chronic OS (Newsome & Poetker, 2020; Craig *et al.*, 2021).

Clinical pulp testing is essential when evaluating OS from a possible endodontic etiology (Tataryn *et al.*, 2018; Craig *et al.*, 2021). Electric or thermal pulp testing can be used to assess vitality of the teeth in order to aid in diagnosis. In the suspected quadrant, prior endodontic treatments must also be carefully assessed for leakage, inadequate root canal fillings, or untreated canal anatomy (Mehra & Murad, 2004; Tataryn *et al.*, 2018; Craig *et al.*, 2021).

Cold, hot and electric responses are typically absent in OS because infected teeth are usually non-vital (Craig *et al.*, 2021). As a matter of fact, a healthy vital pulp will not lead to any periradicular or odontogenic sinus inflammation (Tataryn *et al.*, 2018).

While periapical disease may result in positive examination findings (pain on percussion/biting or draining fistula), frequently there will be no examination findings (Mehra & Murad, 2004; Craig *et al.*, 2021).

Therefore, imaging is essential for evaluating periapical disease (periapical radiography and cone beam computed tomography are the most recommended for periapical lesion) (Craig *et al.*, 2021).

Referred pain from symptomatic teeth to adjacent structures is also common. It is sometimes difficult to elicit whether symptoms are of odontogenic, or sinus origin and this difficulty can unfortunately lead to a root canal therapy or extraction of a noninfected tooth (Mehra & Murad, 2004).

Thus, a thorough dental and sinus evaluation with appropriate radiographs will help with the diagnosis (Mehra & Murad, 2004; Newsome & Poetker, 2020).

ii. Imaging Diagnosis

Radiographic imaging has always played a significant role in establishing the odontogenic etiology of maxillary sinusitis and complement the clinical examination (Newsome & Poetker, 2020; Psillas *et al.*, 2021).

As a matter of fact, an accurate and exact classification of sinusitis is based on clinical symptoms and radiological findings (Shahbazian & Jacobs, 2012).

iii. Two-dimensional imaging

Two-dimensional imaging exams that can be used and include panoramic and periapical radiographs (Newsome & Poetker, 2020).

Panoramic and periapical radiography are helpful to determine the size of a periapical lesion, visualization of a displaced roots, teeth or foreign bodies inside the maxillary sinus (Psillas *et al.*, 2021).

The panoramic radiograph is a standard radiograph used in dental offices (Mehra & Murad, 2004).

As a matter of fact, this panoramic radiography produces a flat representation of the curved surfaces of the jaws and gives an extensive overview of the sinus floor and its relationship with

maxillary teeth (Mehra & Murad, 2004; Shahbazian & Jacobs, 2012; Craig *et al.*, 2021; Psillas *et al.*, 2021).

However, it should be noted that panoramic radiography has lower sensitivity compared to periapical radiography for detection of apical periodontitis for example (Mehra & Murad, 2004; Craig *et al.*, 2021; Psillas *et al.*, 2021).

Although periapical radiography has better resolution, the radiolucencies should reach a considerable size or perforate the cortical bone in order to be seen (Mehra & Murad, 2004; Shahbazian & Jacobs, 2012). As periapical radiography only provides two-dimensional imaging of the posterior maxilla, periapical lesion can unfortunately be obscured by superimposition (Mehra & Murad, 2004).

Both of these radiographies belong to two-dimensional imaging and therefore they are not specific enough to clearly evaluate upper maxillary areas compared to 3D (Psillas *et al.*, 2021). As a matter of fact, all two-dimensional imaging studies have the same limitation: they try to portray a three-dimensional space in a flat image that often compromises anatomic relationship because of its superimposition, making difficult to identify OS. This is why three-dimensional imaging is often used as confirmatory diagnostic tool to help finding the exact etiology cause of an OS (Shahbazian & Jacobs, 2012; Newsome & Poetker, 2020; Psillas *et al.*, 2021).

iv. Three-dimensional imaging

Computed tomography (CT) and cone beam computed tomography (CBCT) are regarded better options for diagnosing maxillary sinus disease (Zhu *et al.*, 2021). As a matter of fact, the risk of OS is strongly associated with opacification for more than the half of the maxillary sinus on CT and CBCT (Whyte & Boeddinghaus, 2019a).

CT appears to be an excellent tool for diagnosing OS (Lee & Lee, 2010).

CT imaging allows 3D observation and clear visualisation of the nasal and paranasal sinus. More specifically, axial, sagittal and coronal sinus CT views show the relationship between the periapical abscess and sinus floor and help determining the exact location of a foreign bodies within the maxillary (Shahbazian & Jacobs, 2012; Psillas *et al.*, 2021).

CT has several advantages over conventional radiography (Lee & Lee, 2010; Psillas *et al.*, 2021). First, it eliminates superimposition of anatomical structures and has high contrast resolution which allows to note the differences between tissues differing in physical density by less than 1% compared with 10% for conventional radiography. Yet, due to its high radiation dose and low spatial resolution, this technique remains impractical for dental application. Therefore, their use is limited in OS due to their non-obvious details related to specific pathology on teeth and bone. Another disadvantage of CT is metal artefact. Indeed, the presence of a metallic object near the tooth can impact the images analysis (Mehra & Murad, 2004; Shahbazian & Jacobs, 2012; Psillas *et al.*, 2021).

Nevertheless, until now, the ability to visualize bone and soft tissues and obtain thin sections and multiple views make the CT still considered as gold standard for the diagnosis of maxillary sinusitis (Mehra & Murad, 2004; Lee & Lee, 2010; Shahbazian & Jacobs, 2012; Psillas *et al.*, 2021).

New advances in 3D imaging systems have introduced CBCT in dentistry (Shahbazian & Jacobs, 2012; Vestin Fredriksson *et al.*, 2017; Psillas *et al.*, 2021).

CBCT provides detailed three-dimensional images of the structures scanned. Bones and teeth can be imaged in an extremely detailed manner (Maillet *et al.*, 2011; Brüllmann *et al.*, 2012; Vestin Fredriksson *et al.*, 2017).

Its availability in the dental office may open new possibilities in maxillofacial imaging. As a matter of fact, its higher spatial resolution may help identifying odontogenic cause of maxillary sinusitis (Brüllmann *et al.*, 2012; Shahbazian & Jacobs, 2012).

Thus, the combination of a higher resolution and a lower radiation represent the major advantages of CBCT in sinus diagnosis (Maillet *et al.*, 2011; Brüllmann *et al.*, 2012; Shahbazian & Jacobs, 2012).

This technique shows also a high accuracy in finding apical periodontitis and mucosal thickening (Shahbazian & Jacobs, 2012). Even small apical destructions that may be difficult or impossible to detect using two-dimensional techniques can be detected using CBCT (Vestin Fredriksson *et al.*, 2017).

The use of CBCT shows also the size and location of the lesions in relation to other anatomic structures which could affect a clinician's treatment (Maillet *et al.*, 2011; Brüllmann *et al.*, 2012; Shahbazian & Jacobs, 2012).

CBCT technology has many applications including sinusitis, aspergilloma, impaction of foreign bodies, endodontic lesions and oro-antral fistula (Maillet *et al.*, 2011; Brüllmann *et al.*, 2012).

Yet, patients with very large metallic restorations remains a major disadvantage (Maillet *et al.*, 2011; Brüllmann *et al.*, 2012; Shahbazian & Jacobs, 2012).

3. Treatment

OS treatment is complex and consists mainly in removing the infectious source. As a matter of fact, if the odontogenic etiology is overlooked the treatment will be unsuccessful because the source of infection is left untreated (Bouguezzi *et al.*, 2015; Aukštakalnis *et al.*, 2018; Zhu *et al.*, 2021).

There is still no gold standard in selecting the most suitable treatment method. According to the literature, there are many opinions on the treatment methods for OS and most of them rely on a combination of three global applications: medical management, including antibiotics and saline nasal irrigation, dental treatment including tooth root canal therapy and tooth extraction, and surgical treatment (Mehra & Murad, 2004; Aukštakalnis *et al.*, 2018; Newsome & Poetker, 2020; Yoo *et al.*, 2020).

i. Medical management

The medical treatment is considered as a first-line therapy in OS (Gilain & Laurent, 2005; Psillas *et al.*, 2021).

Indeed, antibiotics are the mainstay of the treatment and play an important role in treating the infectious part of an OS (Gilain & Laurent, 2005; Newsome & Poetker, 2020; Zhu *et al.*, 2021). As a matter of fact, the antibiotic choice is based on a bacteriologic profile and should initially target aerobe and anaerobe bacteria. For this reason, amoxicillin with clavulanate, being part of the β -lactamase family, is preferred (Newsome & Poetker, 2020; Psillas *et al.*, 2021).

For patients with confirmed penicillin allergy, the highest susceptibility rate is found with piperacillin (93.9%), cefotaxime (78.1%), cefuroxime (69.4%) and clindamycin (50%); fluoroquinolones, such as moxifloxacin (86.2%) and ciprofloxacin (62.2%), and tetracyclines (62.9%) (Psillas *et al.*, 2021).

Medical Management often include a 7 to 14 days course of oral antibiotics (Mehra & Murad, 2004). Antibiotic may be combined with use of nasal decongestants in addition to moisturizing nasal drops and saline spray during 2 to 3 days (Mehra & Murad, 2004; Whyte & Boeddinghaus, 2019b).

Nevertheless, antibiotic therapy alone may be inappropriate without definitive dental treatment (Craig *et al.*, 2020).

ii. Dental Treatment

Depending on the situation, dental treatment could range from endodontic treatment of the infected tooth to its extraction, along with medical treatment (Lee & Lee, 2010; Maillet *et al.*, 2011; Bouguezzi *et al.*, 2015; Aukštakalnis *et al.*, 2018; Yoo *et al.*, 2020).

The common aim is to eliminate the source of the infection in order to prevent a recurrence of sinusitis (Lee & Lee, 2010; Psillas *et al.*, 2021).

Root canal therapy treats endodontic infection by removing pathogenic bacteria and necrotic debris from the infected root canal systems. In order to prevent the reinfection, it is subsequently followed by an occlusal restoration. A decrease in the number of intracanal bacteria is going to reverse the balance between bacteria irritants and the body's defences, thus allowing to cure the lesions (Craig *et al.*, 2020).

Root canal therapy can also resolve PALs. However, some PALs will not respond and may require subsequent dental treatment such as apicoectomy or dental extraction (Craig *et al.*, 2020).

Nonetheless, patients who did not respond to initial antibiotic therapy together with dental procedures, should consider a surgical treatment (Mehra & Murad, 2004; Tataryn *et al.*, 2018; Psillas *et al.*, 2021).

iii. Surgical treatment

When the penetration of an odontogenic foreign body occurs, the latter can be surgically removed if it is greater than 3mm. Mechanical irritation results from overfilling the root canal, thereby invading foreign materials on the vital tissues. The material produces an inflammatory reaction. Such inflammation is likely to persist until the foreign object is removed. Removal of foreign bodies through an endonasal endoscopic approach is the treatment of choice. In this technic an endoscope is passed through the nose and inserted into the sinus to provide an internal view of the sinus so that the infected other so small objects blocking the sinus opening can be removed (Mehra & Murad, 2004; López *et al.*, 2009; Akhlaghi *et al.*, 2015; Bouguezzi *et al.*, 2015; Kodur, Kiran & Shivakumar, 2019; Psillas *et al.*, 2021).

When considering surgical approach, a combination with medical therapy is generally required. (López *et al.*, 2009; Kodur, Kiran & Shivakumar, 2019).

Although these procedures are performed with the goal of re-establishing sinus aeration and may provide relief of some symptoms, neglecting the dental etiology by focusing only on medical and surgical therapies will not resolve OS. As a matter of fact, elimination of dental infection before sinus surgery is necessary to achieve an excellent treatment outcome (Mehra & Murad, 2004; Aukštakalnis *et al.*, 2018; Tatarzyn *et al.*, 2018; Psillas *et al.*, 2021).

To conclude, an appropriate combination of medication, dental treatment and endoscopic sinus surgery should be applied to treat patient with an OS. Thus, if sinusitis is fully cured by dental treatment alone, unnecessary surgery could be avoided (Lee & Lee, 2010; Yoo *et al.*, 2020).

Self-evidently, it is important that treated patients consider a frequent follow-up visit until the defect heals completely and no sign of sinusitis develop (Mehra & Murad, 2004; Tatarzyn *et al.*, 2018).

III. DISCUSSION

OS is a common sinus disease that deserves special consideration. In most otorhinolaryngological literature, the incidence of OS is underreported and seems to be very low despite the high frequency of dental infections. With the frequent use of sinus endoscopic surgery, an increased incidence of OS has been recorded over the last decade. More recent studies suggest that nearly 40% of patients actually had an OS (Mehra & Jeong, 2008; Lee & Lee, 2010; Whyte & Boeddinghaus, 2019b; Newsome & Poetker, 2020; Psillas *et al.*, 2021).

In a study of Lee & Lee (2010), dental implant-related complication was the most common cause found in 10 of the 27 patients (27%). Dental extraction related complications were the second most common cause found in 8 of the 27 patients (29.6%). However, other recent literature strongly supports a higher incidence for OS when existing endodontic origin and periodontal infection. As a matter of fact, in the endodontic field the extrusion of any of the materials used may induce inflammation of the surrounding tissues. There not making a correct apical stop has a high risk of producing maxillary sinusitis. For periodontal infection, the direct dissemination of a buccal sepsis to the maxillary sinus may increase the incidence of the OS. This seems to represent a somewhat common scenario (Tataryn *et al.*, 2018; Kodur, Kiran & Shivakumar, 2019). Nevertheless, in a meta-analysis of Arias Irimia *et al.* (2010), iatrogenia is much more frequent than other etiological factors such as periodontal infection which has been considered by many authors as the most common way of spreading oral pathogens to the maxillary sinus. This disagreement may be attributed to a decrease in periodontal infection due to a better hygiene and the preventive technique concerning the periodontal diseases.

Furthermore, most studies agree that a distinguishing symptom of OS is unilateral purulent rhinorrhoea. According to the study of Lee & Lee, this rhinorrhoea was found in 18 over 27 patients (66.7%). This was followed by cheek pain in 9 over 27 patients (33.3%), an offensive odour in 7 over 27 patients (25.9%), unilateral nasal congestion in 5 over 27 patients (18.5%), postnasal dripping in 4 over 27 patients (14.8%), and upper gingiva swelling and discharge in 4 over 27 patients (14.8%). One patient (3.7%) without symptoms was diagnosed incidentally by radiography. Almost all of the patients with odontogenic sinusitis had unilateral symptoms. However, the study of Lee & Lee reported no significant differences between the symptoms of OS and other types of sinusitis. As a matter of fact, these symptoms can also be present in a sinusitis without odontogenic origin. Moreover, there are several other important causes of unilateral sinus disease such as: antrochoanal polyp, inverted papilloma, squamous cell

carcinoma and allergic fungal sinusitis (Newsome & Poetker, 2020). Nonetheless, the possibility of OS should always be considered when a patient has unilateral symptoms. Thus, we cannot diagnose OS based only on symptoms criteria (Lee & Lee, 2010; Newsome & Poetker, 2020).

Radiological imaging is therefore an important tool for establishing the diagnosis. Standard imaging in a dental office includes intra oral and panoramic radiographs. However, this two-dimensional imaging has a limited role in the diagnosis of sinusitis because of its nonspecific sign due to the high superimposition. Hence, they cannot evaluate clearly the upper maxillary aeras compared to the three-dimensional techniques. Moreover, high rates of false negatives have been reported with both intra oral and panoramic radiography demonstrating that periapical radiography missed more than 60% of periodontal pathology when compared to the three-dimensional techniques. Indeed, a CT is an excellent tool for diagnosing odontogenic sinusitis. CT scans produce a three-dimensional rendering of pertinent anatomical structures in axial, sagittal and coronal planes. As a result, this imaging modality is the gold standard for radiographic evaluation of the paranasal sinuses in patients (Lee & Lee, 2010; Longhini & Ferguson, 2010; Allevi *et al.*, 2020; Psillas *et al.*, 2021). Yet, a major disadvantage of CT is its high radiation dose and relatively low spatial resolution.

The CBCT consumes approximately 10% of the radiation dose of conventional thin-slice CT, focusing on image bony details, although soft tissue quality is reduced Nevertheless, this imaging is mostly used to evaluate the involvement of the maxillary sinuses in case of endodontic treatment failure. (Lee & Lee, 2010; Allevi *et al.*, 2020; Psillas *et al.*, 2021).

Regarding endoscopic sinus surgery, it should be performed on patients who failed initial antibiotic treatment and dental treatment, however a common consensus on the treatment plan of OS is not yet established (Psillas *et al.*, 2021). No studies have directly evaluated the efficacy of oral antibiotics alone for OS. As a matter of fact, a combination of medical and surgical approaches is usually necessary for the treatment of OS as long as the source of the infection is eliminated in order to avoid a recurrence of OS. Further studies are necessary to determine whether some type of OS could be cured by oral antibiotics alone. Besides, there is a lack of studies about treatment performing only etiological factor removal. As a matter of fact, it is still unclear the sequence and the timing for endoscopic sinus surgery, if the remotion of the infection source does not ensure the resolution of disease (Lee & Lee, 2010; Aukštakalnis *et al.*, 2018; Craig *et al.*, 2020).

IV. CONCLUSION

OS occurs when the Schneiderian membrane is perforated and leads to an inflammatory and/or infectious process of the paranasal sinuses.

This condition results of dental pathology or iatrogenic injury from dental procedures.

Dental origin is always suspected when a patient has unilateral sinusitis and should make a two-dimensional and three-dimensional imaging to identify the cause of the infection. Patients with OS will generally have a sinus opacification on it.

Infections are often mixed polymicrobial aerobic and anaerobic requiring special consideration for antimicrobial therapy.

Treatment frequently requires a combination of antibiotic therapy, dental procedures and endoscopic sinus surgery to achieve an excellent treatment.

However, more prospective studies on this topic are needed to determine the best direction of care for this patient population.

Finally managing OS may require collaboration between otolaryngologists and dentist always with the aim of giving the best possible care to the patient and to apply the maxim of HIPPOCRATE:

“Primum Non Nocere”

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