

Systematic Review

Microbiology of Maxillary Sinus Infections: Systematic Review on the Relationship of Infectious Sinus Pathology with Oral Pathology

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Abstract: The main objective of this systematic review was to evaluate the microbiology of maxillary sinus infections and to determine whether an odontogenic origin of the infection can be established. The PIE question posed was the following: In patients with sinus and dental symptomatology who come for ENT or dental assessment and who undergo a microbiological study of the maxillary sinus and are found to have infectious sinus pathology, is the infectious sinus pathology related to an odontogenic origin? The literature review was carried out in *PubMed*, *Web of Science*, and the *Cochrane Library*. A total of 2769 articles were identified in the three databases used. Inclusion and exclusion criteria were applied, and after eliminating duplicates, 55 full-text publications were identified as suitable for inclusion. After reading this series of publications, four articles were excluded due to lack of data in the article. Finally, 51 studies were included in the qualitative analysis. In this study, the microorganisms were classified into three groups: group 1 (microorganisms of the oral microbiome related in the literature to oral pathology, namely caries and periodontal disease), group 2 (microorganisms found in the oral microbiome but not related to oral disease), and group 3 (microorganisms not identified in the microbiome). This review included 51 articles and a total of 6415 patients who underwent surgery in 7051 sinuses. Most sinus infections were caused by group 2 (63.51%) or group 1 (24.21%) bacteria. Within group 1, the most frequent bacteriological agents in sinus infections were *Peptostreptococcus* spp. (35.22%) and *St. Viridans* spp. (39.89%). In group 2, the most frequent bacteriological agents in sinus infections were *H. influenzae* (29%) and *Streptococcus* spp. (23.63%). In group 3, the most frequent cause of sinusitis of dental origin was dental caries, followed by foreign bodies (implants) and sinus elevation. Different studies have shown that certain species of bacteria isolated from maxillary sinus cultures are more frequently associated with rhinosinusitis of odontogenic origin. The results of this systemic review show that, among the bacterial species most frequently found, anaerobic species predominate over aerobic species, especially *Peptostreptococcus* and *Staphylococcus aureus*, which are part of the oral microbiome, suggesting an odontogenic origin of maxillary sinus infection. Therefore, bacterial cultures of maxillary sinus aspirate can be of great use to clinicians in the differential diagnosis of odontogenic sinusitis.

Keywords: microbiology; maxillary sinus; infections; sinus pathology; oral pathology

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1. Introduction

The close anatomical relationship of some teeth to the floor of the maxillary sinus is the cause of certain alterations of the sinus mucosa [1]. The roots of posterior maxillary teeth are separated from the sinus by cortical bone of variable thickness, and there are also numerous vascular anastomoses that perforate this space and can serve as channels for the spread of bacteria [2]. The teeth most frequently associated with the sinus are the upper first and second molars, followed by the premolars [3].

Odontogenic rhinosinusitis is an inflammatory/infectious process of the nasal mucosa of dental origin, which can present an acute or chronic course [4]. Epidemiological reports

of chronic rhinosinusitis estimate a prevalence of 7–27% in Europe, with 89% rhinogenic origin and approximately 11% odontogenic origin [4,5].

The dental aetiology brings together several causes, such as acute and chronic periapical disease, periodontal disease, and endodontic treatment. Infection and sinusitis may also result from trauma or surgery in the posterior maxilla, including tooth extraction, alveolectomy, or other invasive surgical procedures that cause communications between the oral cavity and the maxillary sinus, such as implantology or sinus lift [5].

Clinical manifestations include unilateral purulent discharge, dental and centrofacial pain, nasal obstruction, hyposmia, and in more advanced cases anosmia, headache, halitosis, and cough. Bilateral cases are rare (25%). The evolution time between the onset of symptoms and the triggering dental procedure is variable [6].

Diagnosis includes an evaluation of nasal-sinus and oral symptoms as well as a physical examination of the dentition, periodontal tissues, and presence or absence of oroantral fistula in addition to intranasal examination with endoscopy; however, the most sensitive method in the detection of odontogenic sinusitis is CBCT imaging due to its high resolution and its ability to differentiate bone and soft tissue [5,7].

If sinusitis of odontogenic origin is refractory to conventional medical treatment, a precise microbiological diagnosis must be made. Currently, the procedure used to obtain a microbiological culture is sinus puncture with aspiration and culture of the contents. Unfortunately, these are invasive processes that require time and can cause infrequent but possible complications, such as lesions of the external carotid artery, especially the maxillary artery and its branches [7].

The human oral cavity contains a number of different habitats including the teeth, gingival sulcus, tongue, cheeks, hard and soft palate, and tonsils, which are all colonised by bacteria. The oral microbiome is composed of more than 600 taxa prevalent at the species level, with distinct subsets predominating in different habitats [8]. The classification of this study was performed using the *Human Oral Microbiome Extended Database* (HOMD), which provides the scientific community with comprehensive and adequate information on the bacterial species present in the human aerodigestive tract [9].

The microbiology of odontogenic sinusitis differs from other sinusitis [8]. The literature data show that infections of odontogenic origin are polymicrobial with a predominantly anaerobic population. The most common organisms are Gram-negative anaerobic bacilli, *Peptostreptococcus* spp., *Fusobacterium* spp., *Prevotella* spp., *Streptococcus viridans*, *Staphylococcus aureus*, and *viridans* [5,8]. On the other hand, coexisting aerobes include *Streptococcus* spp. (haemolytic, microaerophilic) and *Staphylococcus* spp., found in 75% of cases of odontogenic sinusitis [5].

The most frequent collection of anaerobes in sinusitis associated with an odontogenic origin may be related to poor drainage and increased intranasal pressure [10]. This can reduce oxygen tension in the inflamed sinus, decreasing mucosal blood flow and depressing ciliary action [11]. The reduction of oxygen and the pH of the sinus cavity favours the growth of anaerobes [12]. Since anaerobes are part of the normal oral flora and outnumber aerobic organisms, it is not surprising that they predominate in odontogenic infections [11,12].

Management of maxillary sinus disease of odontogenic origin often requires medical treatment with appropriate antibiotics, surgical drainage, and treatment to eliminate the offending dental aetiology [5]. Therefore, establishing the correct microbiology in all forms of sinusitis is of paramount importance, as it can serve as a guide for choosing the appropriate antimicrobial therapy [13].

Although dental pathology is recognised as a cause of some sinus alterations and infections, there is little literature on its management in the dental field, as 90% of the published works come from the field of otorhinolaryngology (ENT). Due to the increase in dental procedures and related diagnostic tests, this percentage may currently be increasing.

The main objective of this systematic review was to evaluate the microbiology of maxillary sinus infections and to determine whether an odontogenic origin of sinus infection can be established based on the bacteria cultured.

2. Materials and Methods

The following PIE (Patients, Intervention, Evaluation) question was posed: In patients with sinus and dental symptomatology who come for ENT or dental assessment (Patients) and who undergo a microbiological study of the maxillary sinus (Intervention) and are found to have infectious sinus pathology, is the infectious sinus pathology related to an odontogenic origin (Evaluation)?

The relationship between dental treatments and dental pathology and maxillary sinus pathology was evaluated.

2.1. Eligibility Criteria

2.1.1. Inclusion Criteria

Articles in English and Spanish with the abstract available and specifying microbiology by culture of chronically or acutely infected maxillary sinus contents were included. Patients presenting to the ENT department for sinus pathology were included as well as those presenting to the dental department for dental treatment with or without known dental or sinus pathology. Meta-analyses, systematic reviews, clinical trials, and prospective and retrospective studies were reviewed.

2.1.2. Exclusion Criteria

We excluded studies that addressed anatomical variations or other types of pathologies unrelated to infection of the maxillary sinus or other paranasal sinuses as well as systemic pathologies such as lymphoma. Those studies that did not evaluate microbiology by culture were also excluded. Similarly, clinical cases and case series were discarded.

2.2. Information Sources

Three online databases, *PubMed*, *Cochrane Library*, and *Web of Science*, were searched extensively without time constraints. The complete search strategy is shown below and specified in the flow chart following the PRISMA guidelines [14] (Figure 1).

2.3. Search Strategy

The search strategy involved the following combinations of terms: ((“maxillary sinusitis” (MeSH Terms) OR (“maxillary” [All Fields] AND “sinusitis” (All Fields) OR “maxillary sinusitis” (All Fields) AND (“microbiology” (MeSH Subheading) OR “microbiology” (All Fields)) OR “microbiology” (MeSH Terms) OR “microbiology” (All Fields)) in *PubMed* and (Maxillary Sinus AND Microbiology) in *Cochrane* and *Web of Science*. A total of 2769 articles were identified in the three databases used. Inclusion and exclusion criteria were applied, and after removing duplicates, 55 publications were identified as full-text eligible for inclusion. After reading this series of publications, four articles were excluded due to lack of data in the article and impossibility to obtain them by contacting the author [15–18]. Finally, 51 studies were included in the qualitative analysis.

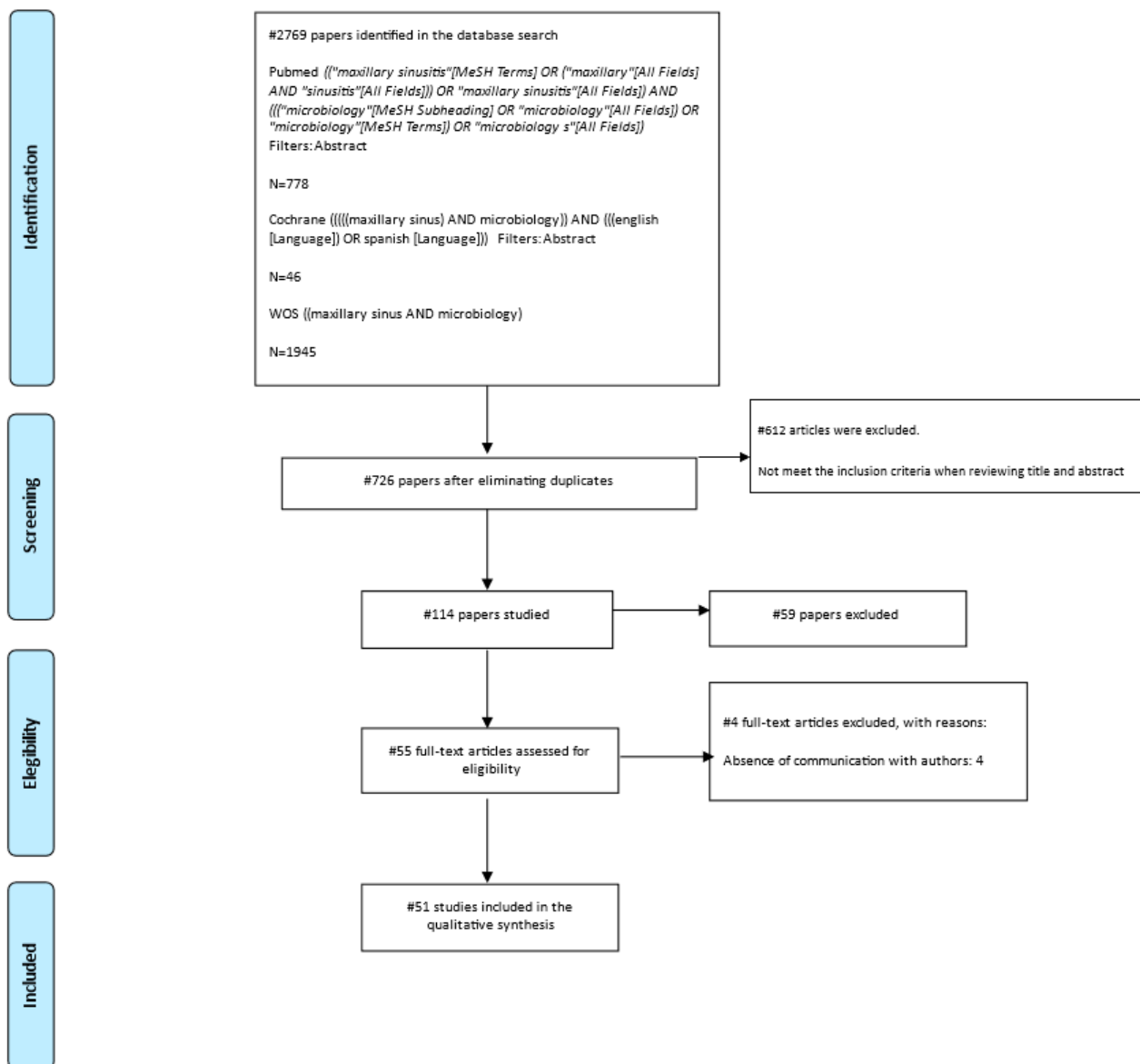


Figure 1. Flow chart of included papers according to PRISMA guidelines [14].

2.4. Isolated Micro-Organisms

As previously mentioned, the oral microbiome is composed of more than 600 taxa prevalent at the species level, with distinct subsets predominating in different habitats [8]. The classification of this study was performed using the *Human Oral Microbiome Extended Database* (HOMD), which provides the scientific community with comprehensive and adequate information on the bacterial species present in the human aerodigestive tract [9].

2.5. Selection of Studies

The following variables were collected for each study: year of publication, country, study period, mean age of patients, sex, dental cause, other non-dental causes, and microorganisms collected in maxillary sinusitis cultures. No restriction was made by date of publication.

2.6. Statistical Analysis

From the 51 articles studied, data were extracted on the microorganisms isolated in maxillary sinus cultures as well as the pathology or dental treatment associated with

maxillary sinusitis. A descriptive analysis of the results obtained was carried out in Excel and SPSS V.20 to determine the distribution of the different species within groups G1, G2, and G3, using the 95% confidence interval or the mean and standard deviation as a measure of dispersion. In addition, the number of underlying articles about the origin of the detected sinusitis was reflected, thus obtaining a quantitative value of the frequency of a certain aetiopathogenic entity. For this purpose, the number of patients from which a certain species was identified according to each study was computed, and the frequency of that species in each group was computed proportionally.

3. Results

3.1. Study Selection and Characteristics

Fifty-one studies were selected, providing 6415 adult patients (3335 females and 3080 males). The mean age of the patients studied was 33.82 years old, all of whom presented symptomatology. Within the origins of sinusitis, two origins were differentiated: dental (4%) and unknown (96%). The most common cause of sinusitis with dental origin was dental caries, followed by foreign bodies (implants) and sinus lift. The bacteria causing sinusitis in the patients studied that were not classified within the oral microbiome were termed of unknown origin.

3.2. Results of Individual Studies

Table 1 presents the counts and general characteristics of the articles as well as the origin of the sinusitis.

Table 1. General characteristics of included studies and origin of the sinusitis.

	N	% (CI 95%)
Total sinuses	7051	
Total patients	6415	
Males	3080	48%
Females	3335	52%
Children	319	
Mean age	33.82	
Origin of sinusitis		
Dental	259	4%
1. Caries	17	7%
2. Sinus lift	9	3%
3. 3rd molar extraction	3	1%
4. Cyst	3	1%
5. Foreign body	35	14%
6. Improper placement of dental implants	6	2%
7. Pulpitis	16	6%
8. Maxillofacial surgery	1	0%
9. Abscesses	14	5%
10. Fistulas	8	3%
11. Periodontitis	20	8%
12. Endodontics	12	5%
13. Other dental pathologies	4	2%
Not specific *	6156	96%

* Not specific: The dental pathology that gives rise to the sinus infection has not been specified in the study or has not been found.

Overall, 78.4% of the studies reported no causal relationship of sinus pathology (unknown causality). Only five studies adequately described the possible causes of sinus pathology [19–23].

Table 2 summarizes the average percentage of the different causes reported. As shown, the most common cause of sinusitis was dental caries ($74.4 \pm 25.1\%$), followed by implant-related problems ($23.9 \pm 13.4\%$).

Table 2. Distribution of the main causes of sinus pathology of oral origin based on data extracted from the 51 selected articles.

	Mean Percentage (%)	Dispersion Percentage (SD)	Number of Underlying Articles
Dental caries	74.4	25.1	9
Implant-related *	23.9	13.4	2
Sinus lift	8.2	11.0	3
Periodontitis	6.7	3.6	2

* The implant-related category includes implant migration, implant malpositioning, and sinus lift procedures.

Isolated Micro-Organisms

In this study, microorganisms were classified into three groups: group 1 (microorganisms from the oral microbiome related in the literature to oral pathology—caries, periodontal disease), group 2 (microorganisms found in the oral microbiome but not related to oral disease), and group 3 (microorganisms not identified in the microbiome). Results where the genus of the microorganisms was not mentioned were included in the miscellaneous group [24–28].

As for the bacterial families involved in sinus infection, Table 3 describes the main prevalent agents belonging to group 1, group 2, and group 3.

Most sinus infections were caused by group 2 bacteria (63.51%) or group 1 bacteria (24.21%). Within group 1, the most frequent bacteriological agents in sinus infections were *Peptostreptococcus* spp. (35.22%) and *St. viridans* spp. (39.89%). These bacteriological agents were found in 26 and 18 studies, respectively. Likewise, within group 2, the most frequent bacteriological agents in sinus infections were *H. influenzae* (29%) and *Streptococcus* spp. (23.63%). These bacteriological agents were found in 43 and 40 studies, respectively.

Table 3. Distribution of the main bacteriological agents of group 1, group 2, and group 3 involved in sinus infections, based on the 51 selected papers.

	Mean Percentage (%) Relative Prevalence (CI 95%)	Studies Supporting the Finding
Proportion of G1 infections out of total sinus infections	24.21% (17.8–30.6)	51
<i>Fusobacterium</i>	14.60% (10.7–18.5)	17
<i>Prevotellas</i>	27.03% (20.6–33.5)	19
<i>Porphyromonas</i>	7.37% (4.4–10.4)	10
<i>Veillonellas</i>	14.06% (8.0–20.2)	19
<i>Actinomyces</i>	21.16% (8.8–51.1)	8
<i>Eubacterium</i>	9.06% (0.5–17.6)	13
<i>Peptostreptococcus</i>	35.22% (27.4–43.0)	26
<i>Propionibacterium</i>	17.09% (9.8–29.4)	23
<i>St. Viridans</i>	39.89% (24.4–55.4)	18
<i>Enterococcus</i>	16.88% (4.0–29.8)	8

Table 3. Cont.

	Mean Percentage (%) Relative Prevalence (CI 95%)	Studies Supporting the Finding
Proportion of G2 infections out of total sinus infections	63.51% (57.9–69.2)	51
<i>Bacteroides</i>	15.65% (9.1–22.2)	25
<i>Clostridium</i>	4.55% (2.5–6.6)	10
<i>Staphylococcus aureus</i>	20.10% (2.6–37.6)	43
<i>Klebsiella</i>	4.74% (3.2–6.3)	26
<i>Streptococcus</i>	23.63% (18.2–29.0)	40
<i>St. pyogenes</i>	8.62% (4.1–13.1)	18
<i>Proteus</i>	5.84% (3.1–8.6)	18
<i>Pseudomonas</i>	6.54% (3.9–9.2)	26
<i>E. coli</i>	3.99% (2.5–5.5)	27
<i>H. influenzae</i>	29% (21.0–37.1)	43
<i>Neisserias</i>	6.40% (3.4–9.4)	22
<i>Enterobacter</i>	6.18% (2.6–9.8)	12
<i>Moraxellas</i>	6.82% (3.7–10.0)	15
Proportion of G3 infections out of total sinus infections	12.27% (8.1–16.5)	51
<i>St. pneumoniae</i>	20.02% (10.0–30.02)	45
<i>Citrobacter spp.</i>	2.71% (1.4–4.2)	7

In group 3, *St. pneumoniae* (20.02%) stands out, as it was found in 45 studies.

Finally, mixed infections (miscellaneous) were reported by 37 papers, with a mean proportion of 15.65% of all sinus infections reported in these articles.

4. Discussion

Often overlooked as a cause of sinus disease by otolaryngologists, dentists, and radiologists, odontogenic rhinosinusitis deserves special consideration, as it differs from sinus disease of nasal origin in terms of its microbiology and pathophysiology and, consequently, its treatment management [29–31]. The close anatomical relationship of the maxillary sinus to the dental region means that dental infections or other odontogenic diseases can affect the maxillary sinus. Odontogenic infections that manage to affect the maxillary sinus include mainly acute and chronic periapical diseases, periodontal diseases, and poorly performed endodontic treatments. Infection and sinusitis can also result from dental trauma or surgery to the posterior maxilla or other invasive surgical procedures that result in communication between the oral cavity and the maxillary sinus [32,33].

Sinusitis of dental origin has been described as polymicrobial and caused by bacteria from the oral cavity and upper respiratory tract. Multiple studies have shown that anaerobic bacteria and polymicrobial growth are common in odontogenic rhinosinusitis [32,34–40], but very few studies have directly compared culture results between patients with rhinosinusitis of dental origin and patients with other sinusitis. Therefore, the aim of our study was to evaluate the microbiology of maxillary sinus infections and to determine whether an odontogenic origin of sinus infection can be established based on bacterial culture. A total of 51 studies were reviewed, providing 6415 patients (7051 sinuses) in whom a culture of the bacterial contents of the infected maxillary sinus was performed.

In relation to the dental origin of rhinosinusitis, Arias-Irimia et al. (2010) evaluated through a meta-analysis the frequency of different odontogenic pathologies that can lead to maxillary sinusitis, which most frequently manifests as chronic maxillary sinusitis. According to their findings, iatrogenic pathologies, in particular dental extractions, are more frequent than other aetiological factors such as chronic periodontitis [41], although other authors [42–45] have considered periodontal disease to be the most common form of spread of oral pathogens to the maxillary sinus. Consistent with these results, in the present

study, the most common cause of sinusitis of odontogenic origin was found to be dental caries in more than half (74.4%) of all cases reviewed, followed by dental implant-related problems (23.9%). Dental caries is one of the most prevalent diseases of infectious origin in humans and one of the main public health problems worldwide with a multifactorial aetiology, while the placement of implants, being a costly treatment, is only found in 2 out of 10 patients. Therefore, the most common origin of dental pathology related to sinus pathology is dental caries.

Although investigated by some authors, the microbiology of maxillary sinusitis associated with odontogenic infection is still poorly understood [46–48]. Data from the literature indicate that the most common organisms are Gram-negative anaerobic bacilli (Brook, 2005). The results of this review show that most sinus infections are from bacteria of the oral microbiome unrelated to oral disease in 63.5% of cases, followed by those that the literature has linked to oral pathology in 24.2% of studies. Within the latter, the most frequently isolated species were *Peptostreptococcus* spp. (35.2%) and *Streptococcus viridans* spp. (39.9%); and among the species not usually associated with dental infections, the most frequent were *Haemophilus influenzae* (29%) and *Streptococcus* spp. (23.6%). Among the microorganisms that are not part of the oral microbiome, *Streptococcus pneumoniae* (20%) was found in 45 of the 51 studies reviewed. Finally, 37 studies reported the presence of mixed infections of the maxillary sinuses analysed. These results suggest that sinus infections may have an odontogenic origin due to the presence of bacteria that are usually part of the oral microbiome [46,49–55].

Other authors have found similar results regarding the bacterial species most frequently isolated from cultures of patients with chronic maxillary sinusitis. According to Brook (2006), anaerobic Gram-negative species of *Peptostreptococcus*, *Staphylococcus aureus*, and members of the *Enterobacteriaceae* family were the most common bacteria isolated from 62 patients with chronic sinusitis, while *Haemophilus influenzae* and *Moraxella catarrhalis*, which have historically played an important role in the aetiology of acute sinusitis, were isolated less frequently [13]. In the same vein, Puglisi et al. (2011), in aspirations performed on 59 patients with chronic maxillary sinusitis (47 non-odontogenic and 12 odontogenic) collected over a 3-year period, found mixed aerobic-anaerobic infections in 75% of patients with chronic odontogenic sinusitis. The main aerobic species isolated were *Staphylococcus aureus* and *Streptococcus pneumoniae*, and the main anaerobes were *Prevotella* spp. and *Peptostreptococcus* spp. In contrast, they did not find bacteria frequently associated with chronic rhinosinusitis, such as *Haemophilus influenzae* and *Moraxella catarrhalis*. Furthermore, when comparing culture results between patients with odontogenic and non-odontogenic sinusitis, they observed a higher number of anaerobes in odontogenic maxillary sinusitis (43% vs. 32%) [19].

In a recent case-control study, Yassin-Kassab et al. (2021) compared bacterial cultures from the maxillary sinus between patients with chronic odontogenic and non-odontogenic rhinosinusitis. The authors found that the following bacteria were significantly more frequent in rhinosinusitis of dental origin: mixed anaerobes, *Fusobacterium* spp., *Eikenella corrodens*, *Streptococcus intermedius*, *Streptococcus anginosus*, and *Streptococcus constellatus*, species that are part of the oral microbiome as a cause of oral pathology. In contrast, *Staphylococcus aureus* and *Pseudomonas aeruginosa* species were inversely related to odontogenic rhinosinusitis. However, no significant differences were observed in maxillary sinus cultures between the different dental pathologies [56].

Craig et al. (2021) reviewed studies that analysed bacterial cultures from patients with odontogenic sinusitis and reported the relative frequencies of specific bacteria. According to their results, both aerobic and anaerobic bacteria were isolated, with a slight predominance of anaerobes. Aerobes were cultured 199 times with α -haemolytic streptococcus species (belonging to viridans group streptococci), and *Staphylococcus aureus* isolated most frequently in 42% and 16% of all cases, respectively. Anaerobes were cultured 243 times, with *Prevotella*, *Fusobacterium*, and *Peptostreptococcus* species being the most commonly isolated [57].

All these previous findings suggest, similarly to those of the present study, that certain bacterial species are more frequently isolated from maxillary sinus aspirates when there is rhinosinusitis associated with odontogenic infections. Among them, anaerobes predominate over aerobes and species that form part of the oral microbiome except for *Streptococcus pneumoniae*, which is found to be more prevalent in most studies. Within the microbiome, *Peptostreptococcus* and *Staphylococcus aureus* species are the most frequently isolated by most authors.

Moreover, Tashieri et al. (2017) demonstrated that apical lesions are mainly caused by *Actinomyces* spp., an anaerobic bacterium related to the formation of biofilms on the root surface or the presence of other endo-antral foreign bodies [58]. It has also been described that dental roots after endodontic treatment in regions close to the maxillary sinus can result in *Aspergillus*-positive cultures [59]. In the study by Zirk et al. (2017), which included 121 patients with odontogenic rhinosinusitis who underwent surgery, *Aspergillus* was found in the sinuses of five patients, and in four cases of aspergillosis, a foreign body was detected in the sinus; furthermore, in one case, aspergillosis was detected after dental extractions were performed [22].

There are several clinical scenarios in which sinus cultures could be beneficial in detecting a possible odontogenic cause of sinusitis, after which the diagnosis could be confirmed by appropriate dental evaluation. Firstly, according to Pokorny and Tataryn (2013), some patients with odontogenic sinusitis have subtle dental pathology or pathology that does not show up on computed tomography (CT) images [60]. It is also possible that clinicians may overlook overt dental pathology on CT scan, as suggested by the study of Longhini and Ferguson (2011), in which 21 patients with sinusitis failed endoscopic sinus surgery due to unrecognised odontogenic causes. In these scenarios, identification of bacteria associated with sinusitis of odontogenic origin from maxillary sinus cultures could provide the necessary diagnostic information to direct further dental evaluation [61].

4.1. Limitations

However, the study has several limitations, as only four studies directly related an odontogenic origin of sinus infections. In the remaining studies, the aetiology of sinus pathology was unknown or not reported. The search was conducted in two languages, so there could potentially be more data in other languages.

4.2. Clinical Implications

In relation to the clinical implications of this study, the authors emphasize the importance of microbiological analysis of the content of the infected maxillary sinuses in order to determine the bacteriology and therefore the origin of the infection.

It is important to note that on many occasions, the dental origin of the infection is established due to the presence of infected teeth (molars and premolars), intrasinus foreign bodies (dental implants or root remnants), or previous surgeries (sinus lift). The authors consider that it is important to carry out an exhaustive analysis of the origin of chronic sinusitis since it is possible that their dental origin is higher than that reported in the literature. It would be interesting to have more and higher-quality studies on this topic.

5. Conclusions

Different studies have shown that certain species of bacteria isolated from maxillary sinus cultures are more frequently associated with rhinosinusitis of odontogenic origin than with other aetiologies. Thus, among the bacterial species most frequently found, anaerobic species predominate over aerobic ones, particularly *Peptostreptococcus* and *Staphylococcus aureus* species, which are part of the oral microbiome, suggesting an odontogenic origin of maxillary sinus infection.

Identification of the species causing maxillary sinus infections is essential when specific treatment is required in patients with rhinosinusitis resistant to standard antimicrobial

therapy. Furthermore, in this type of case, bacterial cultures of aspirates can be useful for clinicians in the differential diagnosis of sinusitis.

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