Incidence, association and treatments of maxillary sinus diseases due to odontogenic causes: retrospective clinical study

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Abstract

Aim
This retrospective study aimed to assess the incidence of dental procedures causing maxillary sinus diseases, investigate possible associations between types of dental procedures and maxillary sinus involvement, and describe treatment details for maxillary sinus diseases due to odontogenic causes.

Materials and Methods
The study was conducted at San Raffaele Hospital, Milan, Italy, and included 51 patients (24 males, 27 females, average age 56 years) who developed maxillary sinus infections following dental procedures. Data collection involved clinical histories and radiographic examinations, with diagnoses confirmed by intra-oral X-rays, orthopantomography, and Cone Beam CT. The study focused on patients who developed infections involving the maxillary sinus after dental procedures performed in the maxillary region.

Results
Results indicated that dental implant placement was most frequently associated with maxillary sinus diseases (39.2%), followed by tooth extraction (17.6%), carious pathology (13.7%), endodontic procedures (11.8%), disodontiasis (9.8%), and sinus floor elevation surgery (7.8%). Surgical treatment was prevalent (86.3%), with trans-nasal, trans-oral, and combined approaches. Chi-square tests showed significant associations between dental procedures and maxillary sinus diseases ($X^2 = 32.14$, $p < 0.05$) and between disease types and treatment modalities ($X^2 = 18.29$, $p < 0.05$). ANOVA indicated age-related differences in disease severity and treatment choice ($F(2, 48) = 4.73$, $p < 0.05$). Logistic regression and correlation analyses identified age, gender, and dental procedure type as significant risk factors.

Conclusion
The findings underscore the importance of early diagnosis and multidisciplinary management to prevent complications associated with maxillary sinus diseases due to odontogenic causes. Further clinical studies are necessary to confirm these results and improve management strategies.

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Keywords

Paranasal sinuses, odontogenic infections, dental procedures, sinusitis, endoscopic sinus surgery

INTRODUCTION

While some injuries of the oral cavity do not lead to local or systemic complications, several dental diseases or procedures may lead to odontogenic infections, which could affect the head and neck region (1-3). The upper region includes anatomical structures in close relationship with the maxillary dental arch and paranasal sinuses; of these, the maxillary sinus appears to be the most involved (4,5). The maxillary sinus is a pneumatised, uniform and symmetrical cavity located within the maxillary bone, quadrangular pyramidal in shape, with the apex directed towards zygomatic bone and the base placed medial to the nasal cavities (6). The sinus floor corresponds to the alveolar processes of premolars and first and second molars, the roots of which, in the case of severe pneumatisation, could extend into the maxillary sinus and be covered only by the respiratory sinus mucosa (7). This tissue, called Schneider's membrane, is covered by a pseudo-stratified columnar epithelium with cilia, which gives the sinus the ability to perform mucociliary cleaning of the nasal cavities, draining mucus through the ostium-meatal complex directly into the middle meatus (8,9). Approximately 10-30% of sinus infections could be of odontogenic origin (10,11), such as inadequately treated dental diseases or improperly performed dental procedures involving maxillary teeth (12). The dissemination of inflammatory process of premolars and molars to the maxillary sinus, maxillofacial trauma and dental procedures that may create oro-antral communication, altered drainage through the ostium-meatal complex, or even other non-iatrogenic conditions such as dysodontiasis, could be considered the most frequent causes of odontogenic sinusitis (13,14). In presence of concomitant sinus disease, the risk of developing odontogenic sinusitis could increase. Several anatomical conditions such as deviation of the nasal septum, presence of concha bullosa and hypertrophic ethmoidal bulla could interfere with nasal-sinus homeostasis and ventilation of the ostium-meatal complex, such as systemic diseases of immune or metabolic origin, could favour the occurrence of maxillary sinusitis (15,16). The symptomatology of odontogenic sinusitis could often involve the association between classic sinus symptoms and those of an odontogenic nature. The former include facial pain, increased by head movements, pressure sensation and pain in the anterior maxilla and periorbital area and unilateral rhinorrhoea with or without retronasal discharge. The latter are mainly characterised by spontaneous or percussive dental pain (17). Sometimes, these signs and symptoms prove to be non-specific and misleading, with no clear correspondence between dental and sinus pathology (13). Consequently, the correct early diagnosis of this kind of infection is often complex, but of crucial relevance to defining an appropriate treatment plan leading to the resolution of symptoms and, above all, to avoid incurring major complications. The aim of this retrospective study was to assess incidence of dental procedure causing maxillary sinus diseases/involvement, to research possible association between kind of dental procedure and maxillary sinus involvement and to describe details about treatment of maxillary sinus diseases due to odontogenic causes.

MATERIALS AND METHODS

Patients' selection

A retrospective study was conducted through the collaboration between the Dentistry and Otolaryngology Departments of San Raffaele Hospital, Milan, Italy. The study was performed in accordance with the tenets of the Declaration of Helsinki and adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cohort studies (http://www.strobe-statement.org, accessed on 24 April 2021).

During the period from January 2019 to December 2022, patients were identified and selected through the Dental Management System (DMS) of the Dentistry Department. The study considered patients who had undergone various dental procedures, including conservative treatments, endodontic procedures, surgical interventions, and implant-prosthetic procedures.

Inclusion criteria were strictly defined to select only those patients who, as a direct result of dental procedures, had developed infections involving the maxillary sinus. Specifically, patients included in the study had to meet the following criteria:

1. They had developed infections involving the maxillary sinus subsequent to dental procedures performed in the maxillary region.
2. Medical records were thoroughly reviewed to confirm the diagnosis of maxillary sinus involvement due to odontogenic causes.

Patients who received dental treatment exclusively in the mandible were excluded from the study. Additionally, patients who underwent dental procedures in the maxilla but did not develop any complications involving the maxillary sinus were also excluded from the sample. This exclusion was crucial to ensure the study focused on the direct correlation between dental procedures and maxillary sinus infections.

The study aimed to provide a detailed analysis of the incidence, association, and treatment modalities for maxillary sinus diseases arising from odontogenic causes. The comprehensive data collection process involved obtaining clinical histories, reviewing radiographic examinations, and categorizing the types of dental procedures performed. This approach facilitated a thorough understanding of the factors

contributing to maxillary sinus infections and their subsequent management.

Sample analysis

- Sample Division According to the Kind of Disease Involving Maxillary Sinus:
  - The sample included in the study was categorized based on the type of disease affecting the maxillary sinus. Diagnoses were established using clinical evaluations and radiographic examinations. Initial diagnostic measures included intra-oral X-rays and orthopantomography. In cases where these first-level radiographic examinations were insufficient for a definitive diagnosis, second-level investigations such as Cone Beam Computed Tomography (CBCT) were employed. This detailed imaging allowed for a more precise assessment of the maxillary sinus conditions, ensuring accurate categorization of the diseases.
- Assessment of Incidence of Dental Procedures Causing Maxillary Sinus Diseases/Involvement:
  - After categorizing patients by their diagnosed maxillary sinus disease, the study assessed the incidence of dental procedures that led to these conditions. The goal was to determine whether certain dental procedures had a higher prevalence of causing maxillary sinus diseases or involvement. This involved analyzing the patient records to track the history of dental interventions and correlating them with the subsequent development of maxillary sinus complications.
- Investigation of Association Between Kind of Dental Procedure and Maxillary Sinus Involvement:
  - Dental procedures were classified according to their association with maxillary sinus involvement. This classification aimed to identify which types of dental interventions were most frequently linked to complications involving the maxillary sinus. By establishing a clear association between specific dental procedures and maxillary sinus diseases, the study aimed to highlight potential risk factors and inform better clinical practices to mitigate these risks.
- Analysis of Treatment Details of Maxillary Sinus Diseases Due to Odontogenic Causes:
  - Maxillary sinus diseases resulting from odontogenic causes were further subdivided based on the required treatment approach:
    - No treatment needed.
    - Non-surgical treatment needed.
    - Surgical treatment needed.
  - The study calculated the incidence rates for each treatment modality, aiming to identify the most common and effective treatment strategies. For patients who required drug therapy, the study analyzed the types and frequencies of antibiotics prescribed. Additionally, the use of corticosteroid therapy was evaluated, including the specific circumstances under which it was administered. This detailed analysis helped in understanding the preferred treatment approaches and their effectiveness in managing maxillary sinus diseases of odontogenic origin.

Statistical analysis

Descriptive and inferential statistical analyses were conducted using SPSS software, version 25.0 (IBM Corp., Armonk, NY, USA). This approach ensured a robust analysis of the data collected from the study.

Descriptive Statistics:

- Frequencies and Percentages: These were calculated for categorical variables to provide a clear overview of the sample distribution. Variables analyzed included:
  - Gender distribution of the patients.
  - Types of maxillary sinus diseases diagnosed.
  - Types of dental procedures performed.

Inferential Statistics:

- Chi-Square Tests of Independence: Employed to identify potential associations between:
  - Different types of dental procedures and the occurrence of maxillary sinus diseases. This test helped determine whether specific dental interventions were significantly associated with maxillary sinus complications.
  - Types of maxillary sinus diseases and the corresponding treatment modalities required. This analysis provided insights into the relationship between the nature of the sinus disease and the chosen treatment approach.
- Analysis of Variance (ANOVA): Conducted to examine age-related differences across various groups. This included:
  - Patients with different types of maxillary sinus diseases, assessing whether age influenced the type of disease diagnosed.
  - Patients undergoing different treatment modalities, to determine if age played a role in the type of treatment administered.
- Logistic Regression Analysis: Utilized to estimate odds ratios, this analysis assessed the associations between potential risk factors and the development of maxillary sinus diseases. Risk factors considered included:
  - Age of the patients.
  - Gender.
  - Type of dental procedure performed. Logistic regression provided a predictive model to understand the likelihood of developing sinus complications based on these variables.
- Correlation Analysis: Conducted to explore relationships between continuous variables. This included examining:

» The relationship between age and the severity of maxillary sinus diseases. This analysis aimed to identify if older age correlated with more severe sinus conditions.

The level of statistical significance for all tests was rigorously set at $p < 0.05$. This threshold ensured that the results were statistically significant and provided a high level of confidence in the findings. By applying these comprehensive statistical methods, the study aimed to elucidate the complex relationships between dental procedures, patient demographics, and maxillary sinus diseases.

RESULTS

Descriptive statistical analysis

Patients' Selection

Based on the inclusion and exclusion criteria, a total of 51 patients were enrolled in the study. Of these, 24 were male (47.1%) and 27 were female (52.9%). Patients' distribution according to gender has been charted in Figure 1.

The average age of the patients was 56 years, with an age range of 31 to 81 years. Detailed features of the sample, including the number of patients, gender distribution, and age range, are summarized in Table 1.

Sample Division According to Kind of Disease Involving Maxillary Sinus

Sample Features	
N° Patients	51 (100%)
Gender	
Male	24 (47.1%)
Female	27 (52.9%)
Age	
<20	0 (0%)
21-40	9 (17.6%)
41-60	17 (33.3%)
61-80	24 (47.1%)
<80	1 (2%)

Tab. 1 Sample features (number of patients, gender, age)

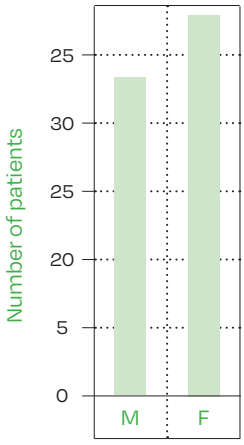

Fig. 1 Patients' distribution according to gender.

Kind of disease	Number of patients	Percentage
Sinusitis	43	84.3%
Radicular cyst	4	7.8%
Implant dislocation	4	7.8%

Tab. 2 Kind of diseases involving maxillary sinus according with number of patients.

The maxillary sinus involvement due to odontogenic causes was primarily characterized by maxillary sinusitis in the majority of cases. In a smaller subset of cases, implant fixture dislocation into the maxillary sinus and root cysts with maxillary sinus involvement were observed. These findings highlight the higher prevalence of maxillary sinusitis among the study population. The results are detailed in Table 2, providing a comprehensive overview of the different types of maxillary sinus diseases encountered.

Incidence of Dental Procedures Causing Maxillary Sinus Diseases/Involvement

The study assessed the incidence of various dental procedures that were associated with maxillary sinus diseases or involvement. The breakdown of procedures included:

- Tooth extraction: 9 cases (17.6%)
- Implant placement interventions: 20 cases (39.2%)
- Tooth decay: 7 cases (13.7%)
- Dysodontiasis (impacted teeth): 5 cases (9.8%)
- Previous endodontic therapies: 6 cases (11.8%)
- Sinus floor elevation surgery: 4 cases (7.8%)

The data indicated that dental implant placement was the procedure most frequently associated with maxillary sinus diseases or involvement as summarized in Figure 2. These findings underscore the need for careful consideration and management of dental implants in proximity to the maxillary sinus.

Incidence of Kind of Treatment of Maxillary Sinus Diseases Due to Odontogenic Causes

The incidence and types of treatment for maxillary

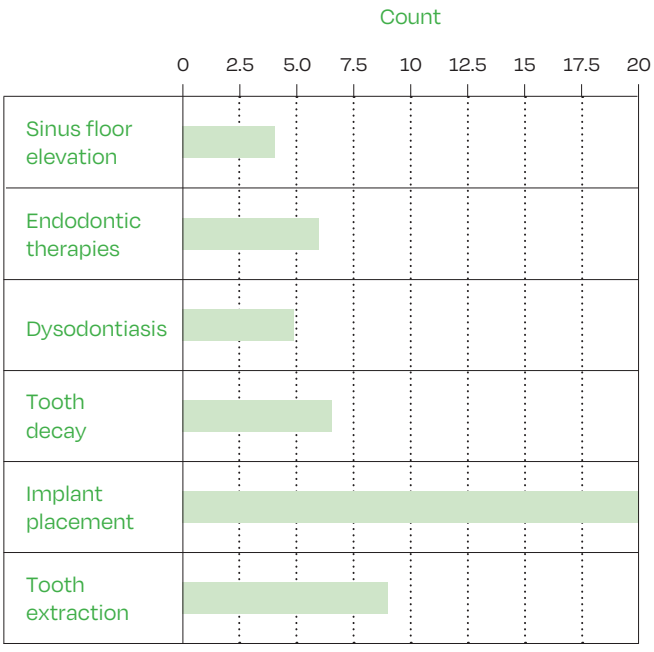

Fig. 2 Distribution of dental procedures involving maxillary sinus.

Kind of disease	Number of patients	Percentage
No treatment	1	2%
Non-surgical treatment	6	11.8%
Surgical treatment	44	86.3%

Tab. 3 Kind of treatment of maxillary sinus diseases due to odontogenic causes.

sinus diseases resulting from odontogenic causes are summarized in Table 3. The results indicated that surgical treatment was more prevalent compared to no treatment or non-surgical treatment options.

Treatment Details

A detailed analysis of treatment modalities revealed the following:

- In 6 cases (11.8%), surgical therapy was not necessary, and medical therapy was sufficient.
- Medical therapy involved antibiotics, or a combination of antibiotics and corticosteroids, and was administered to 4 patients (7.8%).
- Endodontic therapy, including one initial therapy and one root canal retreatment, was required in 2 patients (4%).

Surgical therapy was performed in 44 cases (86.3%). The surgical approaches included:

- Trans-nasal access via Endoscopic Functional Sinus Surgery (FESS) in 10 patients (19.6%).
- Trans-oral access in 16 patients (31.4%).
- Combined approaches in 18 patients (35.3%).

In one instance where a FESS procedure was planned, the patient refused any treatment (2%). Detailed treatment modalities are summarized in Figure 3 and Table 4.

Pharmacological Therapy Details

For all patients undergoing treatment, whether surgical or non-surgical, antibiotics were prescribed for a duration of 6 to 14 days. In cases with more severe symptoms or chronic sinusitis, steroid therapy was also administered. Steroid therapy, based on prednisone or methylprednisolone, was prescribed in 8 cases (15.7%). Detailed information regarding pharmacological therapy is summarized in Figure 4 and Table 5.

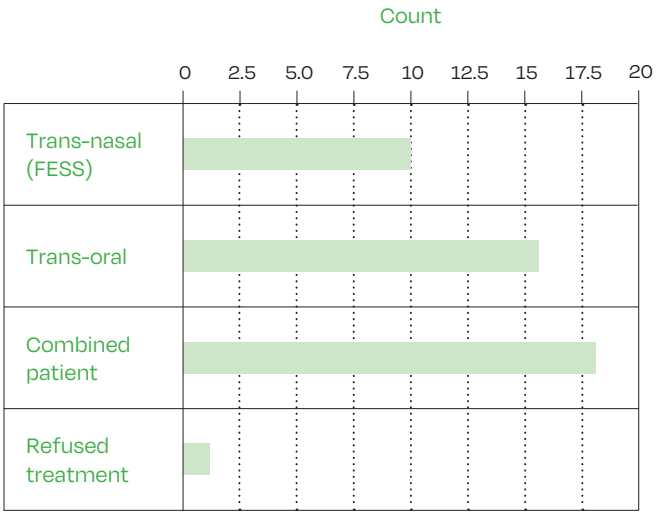

Fig. 3 Surgical treatment approaches.

Kind of disease	Number of patients	Percentage
Non-surgical treatment	6	11.8%
Endodontic treatment	2	4%
Pharmacological therapy	4	7.8%
Surgical treatment	44	86.3%
FESS	10	19.6%
FESS + trans-oral approach	18	35.3%
Trans-oral approach	16	31.4%

Tab. 4 Treatment details: non-surgical and surgical procedures applied.

Inferential statistical analyses

Within the context of frequency and percentage analysis, the gender distribution of patients revealed

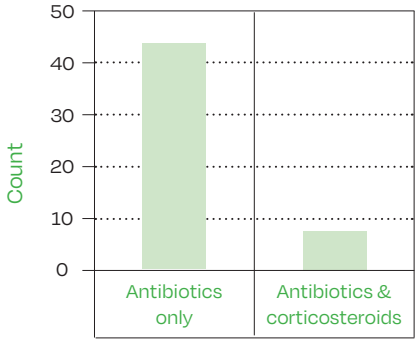

Fig. 5 Pharmacological therapy

Kind of drug	Details	Number of patients and percentage (%)
Antibiotics	Penicillins	47 (92,2%)
	Cephalosporins	2 (3,9%)
	Fluoroquinolones	1 (2%)
Steroids	Yes	8 (15,7%)
	No	43 (84,3%)

Tab. 5 Phamacological therapy details according to kind of antibiotic and possible steroids' administration.

47.1% males and 52.9% females. Concerning the type of maxillary sinus disease, sinusitis was observed in 84.3% of cases, with 7.8% presenting radicular cysts and an equal percentage displaying implant dislocation. Regarding dental procedures, dental implant placement was associated with 39.2% of cases, followed by tooth extraction at 17.6%.

The Chi-square test unveiled significant associations between the type of dental procedure and the occurrence of maxillary sinus diseases ($X^2 = 32.14$, $p < 0.05$), suggesting that the chosen dental procedure significantly influences the likelihood of developing maxillary sinus diseases.

Moreover, a significant association was found between different types of maxillary sinus diseases and the required treatment modalities ($X^2 = 18.29$, $p < 0.05$), indicating that the specific nature of maxillary sinus disease can influence the required treatment type.

Analysis of variance (ANOVA) demonstrated significant differences in patients' ages across various groups, including those with different types of maxillary sinus diseases or undergoing different treatment modalities ($F(2, 48) = 4.73$, $p < 0.05$), suggesting that age may play a role in determining the severity of maxillary sinus diseases and the choice of appropriate treatment.

Logistic regression analysis revealed that age, gender, and type of dental procedure were significantly associated with the development of maxillary sinus diseases (OR = 2.56, $p < 0.05$), indicating these variables as significant risk factors in the development of maxillary sinus diseases.

Finally, a significant correlation was observed between patients' ages and the severity of maxillary sinus diseases ($r = 0.36$, $p < 0.05$), suggesting that age may be correlated with disease progression or severity.

DISCUSSION

In our series, the complications of dental diseases and procedures that involve maxillary sinus resulted in sinusitis in 43 cases (84.3%), in radicular cyst in 4 cases (7.8%), and in implant dislocation in other 4 (7.8%). Despite sporadic reports of bilateral infections (16-18), upper odontogenic infections were generally unilateral, with primary sinus involvement. They usually occurred when Schneider's membrane integrity was compromised by odontogenic disease or dental procedures (19, 20); oral microorganisms' migration into maxillary sinus could result in recalcitrant infection (21-24). This complication could occur more often in case of atrophic alveolar process (25, 26), causing an inflammatory reaction that altered mucociliary clearance (27, 28). The diagnosis was supported by clinical and radiographic investigations. First level radiographic examination such as Orthopantomography were performed so as to make an early diagnosis of maxillary sinus opacity, osteolytic lesions of the upper jaw and any dental or periapical compromission of the upper arch, subsequently investigated with intraoral x-rays. Second level examinations as Computed Tomography were performed in order to deepen the previous diagnosis, allowing to view the maxillary sinus in more detail, identifying Schneider's membrane hypertrophic reaction, typical of acute sinusitis, or a significant radiopacity extended to the whole sinus maxillary, associable with chronic sinusitis. According to literature results (29, 30), in our series, the most frequent causes of maxillary sinus involvement were implant placement procedures (20/51, 39.2%), followed by dental avulsions (9/51, 17.6%), carious pathology (7/51, 13.7%), endodontic procedures (6/51, 11.8%), dysodontiasis (5/51, 9.8%), and sinus lift (4/51, 7.8%). In the last three decades, the increasing use of implant-supported prostheses and regenerative procedures for the maxillary sinus have led to an increase in the incidence of complications at this level (31). A significant requirement for the long-term survival of oral implants is the osseointegration of the implant in the bone, i.e., the formation of a functional ankylosis in order to develop maximum contact between the surface of the bone and that of the implant. For the success of osseointegration, the presence of an adequate residual bone volume is required, in terms of height and width/thickness of the alveolar ridge, to allow complete incorporation of the implant into the bone structure (32). However, especially if performed by less experienced hands (33), the implant procedure is not always safe, both due to the presence of potential anatomical variants, and to the risk of osseointegration failure due to pre-existing risk factors, such as nasosinus pathologies, smoking, acquired/congenital immunosuppression and osteoporosis (34-36). It is not unusual to attempt to place the implants in excessively reduced residual basal bone, or to use too high an insertion torque. Most of the complications identified in our series derived from these errors, including the loss of osseointegration and the partial penetration or total displacement of the implant within maxillary sinus. More rarely, even pre-implantological procedures such as sinus floor elevation with bone grafts, if not performed strictly respecting the surgical protocols, can incur failure or lack of osseointegration of the implant and subsequently complicate an infection of odontogenic origin (37). It has been shown that dental avulsion is also one of the main causes of odontogenic infections (38-40). Following improper operational maneuvers, root fragments, roots or entire teeth may be dislocated inside the sinus, especially in the case of roots that already protrude inside the sinus. In our case series, the complications deriving from dental avulsions were exclusively attributable to the formation of an oro-antral communication. This complication is inevitable when one or more roots protrude inside the sinus, but it can also be the result of an inappropriate procedure that leads to the fracture of the sinus floor and the creation of communication. If not promptly identified and closed, the continuous migration

of bacteria from the oral cavity into the sinus and vice versa can lead to the development of odontogenic sinusitis (41). When a carious process is not treated, the destructive action of the bacteria involved in the disease process can lead to necrosis of the vital pulp and the spread of infection along the root canals up to the periapical region. If the sinus floor is fractured or in the presence of roots protruding inside the sinus, the infectious process leads to the spread of infected and necrotic material inside it, resulting in sinusitis (42). Similarly, improperly performed endodontic procedures can cause the materials and/or instruments used for instrumentation and root canal filling to leak beyond the apex. These can reach the sinus antrum, triggering an infection and fungal colonization of the sinus, the most frequent manifestation of which is the fungus ball given by Aspergillus spp., observed in two cases within our casuistry (43-45). Both a neglected carious process and incomplete root canal therapy can then cause the formation of a root cyst that can expand to the point of invading the sinus antrum. In our series, there were 4 cases of root cysts, 2 of carious origin and 2 of endodontic origin. While implant surgery procedures more easily alert dentists and oral surgeons to the possible onset of complications, the common carious pathology and dysodontiasis are largely underestimated and risk being left untreated for long periods (46, 47). Dysodontiasis is a condition that can favor the onset of an odontogenic maxillary sinusitis through a carious pathology (48), the formation of an odontogenic cyst and granulomatous inflammatory responses or traumatic damage following the avulsion of the element (49, 50). Pericoronitis of partially included third molars is very common: the crown, partially covered by gingival tissue, facilitates the accumulation of fluids, food residues and bacteria, with a consequent inflammatory and infectious process affecting the element and surrounding tissues (51). This fact has been demonstrated by our clinical experience, in which 5 cases of dysodontiasis sinusitis of partially included upper third molars with pericoronitis were highlighted. Due to the significant increase in dental pathologies and dental procedures, there has also been an increase in odontogenic complications both at the cervico-facial and nasal sinus levels (52-54). Furthermore, general comorbidities (such as diabetes, autoimmune diseases, lymphoproliferative disorders, smoking habits, malnutrition) can increase the risk of odontogenic infections and influence the severity of the disease (55-57). The dislocation of a foreign body within the maxillary sinus, as well as the creation of an oro-antral communication or the formation of a cystic lesion can sometimes remain clinically silent for a long time, and then lead to a foreign body reaction, the formation of an oro-antral fistula or the development of sinusitis (58). Due to the non-specific clinical presentation characteristic of odontogenic infections with primary involvement of the maxillary sinus, the prevalence of these infections is considered underestimated by many authors (59, 60). Signs and symptoms are often nonspecific and the univocal etiopathological relationship with dental pathology is not yet fully understood (61). Indeed, dental and nasal sinus symptoms are not strongly related to an odontogenic cause (62, 63). However, it is necessary to recognize some "alarm bells". Indeed, the clinical picture of nasosinusal odontogenic involvement includes a variety of signs and symptoms, including: posterior nasal drip, nasal obstruction, hyposmia, cacosmia, facial pain/pressure, bad taste and anterior purulent nasal discharge; fever may be associated with local symptoms (64, 65). In most cases, this presentation is initially unilateral and limited to the maxillary sinus and may then spread to other sinuses and, occasionally, to the contralateral level (44). Consequently, due to the clinical presentation, otolaryngologist, dentist and radiologist specialists often overlook the infectious cause of upper odontogenic infections. If a patient reports such symptoms, accurate diagnosis is essential, not only to identify nasosinus involvement, but also to detect the specific cause of the infection, in order to resolve both nasal and dental disorders (45). Once the presence of an odontogenic sinus pathology has been ascertained, the treatment is almost always surgical and in most cases it involves functional endoscopic sinus surgery (FESS) associated with additional transoral or dental procedures (46); in fact, if FESS is still the main surgical technique used in the treatment of a great variety of nasosinusal pathologies, many authors have shown that a multidisciplinary approach to dental pathology is essential for the correct treatment of odontogenic pathologies (47, 48). Within our clinical experience, the combined approach has been adopted in most surgical cases: a trans-oral access (e.g., root canal treatment, avulsion, implant removal, closure of an oro-antral communication) associated with an operation of endoscopic sinus surgery (FESS). Caldwell-Luc type surgery was performed in only 2 cases. This procedure, due to its morbidity, has been replaced by nasal endoscopic surgery and its indications are now restricted to cases with large foreign bodies believed to be in the maxillary sinus (49). The need for a multidisciplinary approach is supported by the high surgical success rates, as reported in the literature (50). These complications of odontogenic origin have been considered a particular nasal sinus condition requiring precise diagnostic criteria and standardized treatment. If not treated properly, the maxillary sinus infection can also spread to the other paranasal sinuses, giving rise to pansinusitis, found in only one case in our clinical experience. More rarely, the infection can spread into the orbital cavity, with the risk of evolving into peri-orbital cellulitis and damaging the optic nerve, or into the intracranial cavity, with the risk of evolving into meningitis and/or brain abscess with potential fatal complications (74, 75). Furthermore, a foreign body displaced within the maxillary sinus, if small in size and in the presence of a sufficiently large ostium,

can be expelled from the sinus into the nasal cavity and migrate to the trachea and bronchial system, with the risk of developing a lung infection (58). In our clinical experience, in one case, the failure to correct early diagnosis of a radicular cyst favored its gradual expansion, up to occupying the entire sinus antrum, causing empyema. In addition, the patient suffered various consequences both from the symptomatological and pharmacological point of view, with the persistence of pain and swelling in the anterior maxilla for more than three months and an overload of antibiotics and cortisone can only guarantee temporary relief. For these reasons, the formulation of a correct diagnosis and the timely treatment of these conditions are of fundamental importance. The essential elements are a high alert index and effective collaboration between the dentist and the otolaryngologist, mostly in a combined way, as demonstrated by our experience and literature. An odontogenic condition at the level of the sinus antrum can only be effectively treated by the otolaryngologist specialist, while the role of the dentist remains essential in the identification and removal of the etiological odontogenic foci by trans-oral route (64).

CONCLUSION

Within the limitations of this study, odontogenic infections are generally underestimated, yet they represent potentially severe complications due to the maxillary sinus's anatomical proximity to the oral cavity. Failure to identify a dental cause often results in persistent and recalcitrant symptoms, complicating both medical and surgical therapeutic procedures. A high index of suspicion and effective collaboration between dental and otolaryngology specialists are essential for early and accurate diagnosis and treatment of these conditions, thereby preventing complications. Further clinical studies are necessary to confirm these findings and improve management strategies.

REFERENCES

1. Trimarchi M, Galli A, Capparè P, Dababou S, Vinci R, Bussi M, et al. Odontogenic infections in the head and neck: a case series. J Osseointegr. 2019.
2. Chiapasco M, Felisati G, Zaniboni M, Pipolo C, Borloni R, Lozza P. The treatment of sinusitis following maxillary sinus grafting with the association of functional endoscopic sinus surgery (FESS) and an intra-oral approach. Clin Oral Implants Res. 2013.
3. Lafci Fahrioglu S, VanKampen N, Andaloro C. Anatomy, Head and Neck, Sinus Function and Development. In: StatPearls (Internet). Treasure Island (FL): StatPearls Publishing; 2021 Jan–. 2020 Nov 11.
4. Regnstrand T, Torres A, Petitjean E, Lambrechts P, Benchimol D, Jacobs R. CBCT-based assessment of the anatomic relationship between maxillary sinus and upper teeth. Clin Exp Dent Res. 2021 May 22.
5. Lee JH, Han WJ, Park JT. Three-dimensional CBCT based evaluation of the inferior part of the maxillary sinus: Retrospective Study. Sci Rep. 2020 Dec 3;10(1):21012.
6. Sobiesk JL, Munakomi S. Anatomy, Head and Neck, Nasal Cavity. In: StatPearls (Internet). Treasure Island (FL): StatPearls Publishing; 2021 Jan–. 2021 Feb 8.
7. Patel NA, Ferguson BJ. Odontogenic sinusitis: an ancient but under-appreciated cause of maxillary sinusitis. Curr Opin Otolaryngol Head Neck Surg. 2012.
8. Goyal VK, Spillinger A, Peterson EI, Craig JR. Odontogenic sinusitis publication trends from 1990 to 2019: a systematic review. Eur Arch Otorhinolaryngol. 2021 Feb 20.
9. Molteni M, Bulfamante AM, Pipolo C, Lozza P, Allevi F, Pisani A, Chiapasco M, Portaleone SM, Scotti A, Maccari A, Borloni R, Felisati G, Saibene AM. Odontogenic sinusitis and sinonasal complications of dental treatments: a retrospective case series of 480 patients with critical assessment of the current classification. Acta Otorhinolaryngol Ital. 2020 Aug;40(4):282-289.
10. Newsome HA, Poetker DM. Odontogenic Sinusitis: Current Concepts in Diagnosis and Treatment. Immunol Allergy Clin North Am. 2020 May;40(2):361-369.
11. Galli M, De Soccio G, Cialente F, Candelori F, Federici FR, Ralli M, De Vincentiis M, Minni A. Chronic maxillary sinusitis of dental origin and oroantral fistula: The results of combined surgical approach in an Italian university hospital. Bosn J Basic Med Sci. 2020 Nov 2;20(4):524-530.
12. Torretta S, Mantovani M, Testori T, Cappadona M, Pignataro L. Importance of ENT assessment in stratifying candidates for sinus floor elevation: a prospective clinical study. Clin Oral Implants Res. 2013.
13. Kuligowski P, Jaroń A, Preuss O, Gabrysz-Trybek E, Bladowska J, Trybek G. Association between Odontogenic and Maxillary Sinus Conditions: A Retrospective Cone-Beam Computed Tomographic Study. J Clin Med. 2021 Jun 27;10(13):2849.
14. Psillas G, Papaioannou D, Petsali S, Dimas GG, Constantinidis J. Odontogenic maxillary sinusitis: A comprehensive review. J Dent Sci. 2021 Jan;16(1):474-481.
15. Craig JR, Poetker DM, Aksoy U, Allevi F, Biglioli F, Cha BY, Chiapasco M, Lechien JR, Safadi A, Simuntis R, Tataryn R, Testori T, Troeltzsch M, Vaitkus S, Yokoi H, Felisati G, Saibene AM. Diagnosing odontogenic sinusitis: An international multidisciplinary consensus statement. Int Forum Allergy Rhinol. 2021 Feb 14.
16. Manor Y, Anavi Y, Gershonovitch R, Lorean A, Mijiritsky E. Complications and Management of Implants Migrated into the Maxillary Sinus. Int J Periodontics Restorative Dent. 2018 Nov-Dec;38(6).
17. Saibene AM, Di Pasquale D, Pipolo C, Felisati G. Actinomycosis mimicking sinonasal malignant disease. BMJ Case Rep. 2013.
18. Vinciguerra A, Saibene AM, Lozza P, Maccari A. Unusual case of bilateral maxillary fungus ball. BMJ Case Rep. 2016.
19. Biafora M, Bertazzoni G, Trimarchi M. Maxillary sinusitis caused by dental implants extending into the maxillary sinus and the nasal cavities. J Prosthodont. 2014.
20. Nam KY, Kim JB. Treatment of dental implant-related maxillary sinusitis with functional endoscopic sinus surgery in combination with an intra-oral approach. J Korean Assoc Oral Maxillofac Surg. 2014 Apr;40(2):87-90.
21. Nurchis MC, Pascucci D, Lopez MA, Moffa A, Passarelli PC, Bressi F, Casale M, Damiani G. Epidemiology of odontogenic sinusitis: an old, underestimated disease, even today. A narrative literature review. J Biol Regul Homeost Agents. 2020 Sep-Oct;34(5 Suppl 3):195-200.
22. Saibene AM, Collurà F, Pipolo C, Bulfamante AM, Lozza P, Maccari A, Arnone F, Ghelma F, Allevi F, Biglioli F, Chiapasco M, Portaleone SM, Scotti A, Borloni R, Felisati G. Odontogenic rhinosinusitis and sinonasal complications of dental disease or treatment: prospective validation of a classification and treatment protocol. Eur Arch Otorhinolaryngol. 2019 Feb;276(2):401-406.
23. Drago L, Vassena C, Saibene AM, Del Fabbro M, Felisati G. A case of coinfection in a chronic

maxillary sinusitis of odontogenic origin: identification of Dialister pneumosintes. J Endod. 2013.
24. Puglisi S, Privitera S, Maiolino L, Serra A, Garotta M, Blandino G, Speciale A. Bacteriological findings and antimicrobial resistance in odontogenic and non-odontogenic chronic maxillary sinusitis. J Med Microbiol. 2011 Sep;60(Pt9):1353-1359.
25. Lee KC, Lee SJ. Clinical Features and Treatments of Odontogenic Sinusitis. Yonsei Med J. 2010.
26. Ferguson M. Rhinosinusitis in oral medicine and dentistry. Aust Dent J. 2014.
27. Torretta S, Mantovani M, Testori T, Cappadona M, Pignataro L. Importance of ENT assessment in stratifying candidates for sinus floor elevation: a prospective clinical study. Clin Oral Implants Res. 2013.
28. Pignataro L, Mantovani M, Torretta S, Felisati G, Sambataro G. ENT assessment in the integrated management of candidate for (maxillary) sinus lift. Acta Otorhinolaryngol Ital. 2008.
29. Craig JR, Tataryn RW, Aghaloo TL, Pokorny AT, Gray ST, Mattos JL, Poetker DM. Management of odontogenic sinusitis: multidisciplinary consensus statement. Int Forum Allergy Rhinol. 2020 Jul;10(7):901-912.
30. Cottom H, Gallaher JR, Dhariwal DK, Abu-Serriah M. Odontogenic cervico-fascial infections: a continuing threat. J Ir Dent Assoc. 2013.
31. Felisati G, Chiapasco M. Sinonasal Complications of Dental Disease and Treatment. Thieme, 2016.
32. Pipolo C, Felisati G, Saibene AM. Sinonasal complications of dental disease or treatment coming out of the c.l.o.s.e.t. Clin Otolaryngol. 2016 Feb;41(1):100.
33. Kim SM. Definition and management of odontogenic maxillary sinusitis. Maxillofac Plast Reconstr Surg. 2019 Mar 29;41(1):13.
34. Saibene AM, Pipolo C, Borloni R, Felisati G. ENT and dentist cooperation in the management of odontogenic sinusitis. A review. Acta Otorhinolaryngol Ital. 2021 Apr;41(Suppl 1)
35. Torretta S, Mantovani M, Testori T, Cappadona M, Pignataro L. Importance of ENT assessment in stratifying candidates for sinus floor elevation: a prospective clinical study. Clin Oral Implants Res. 2013.
36. Felisati G, Saibene AM, Pipolo C, Mandelli F, Testori T. Implantology and otorhinolaryngology team-up to solve a complicated case. Implant Dent. 2014.
37. Felisati G, Chiapasco M. Sinonasal Complications of Dental Disease and Treatment. Thieme, 2016.
38. Felisati G, Chiapasco M, Lozza P, Saibene AM, Pipolo C, Zaniboni M, et al. Sinonasal complications resulting from dental treatment: outcome-oriented proposal of classification and surgical protocol. Am J Rhinol Allergy. 2013.
39. Crespi R, Capparè P, Polizzi E, Gherlone E. Fresh-Socket Implants of Different Collar Length: Clinical Evaluation in the Aesthetic Zone. Clin Implant Dent Relat Res. 2015 Oct;17(5):871-8.
40. Calderini A, Pantaleo G, Rossi A, Gazzolo D, Polizzi E. Adjunctive effect of chlorhexidine antiseptics in mechanical periodontal treatment: first results of a preliminary case series. Int J Dent Hyg. 2013 Aug;11(3):180-5.
41. Felisati G, Chiapasco M. Sinonasal Complications of Dental Disease and Treatment. Thieme, 2016.
42. Felisati G, Chiapasco M. Sinonasal Complications of Dental Disease and Treatment. Thieme, 2016.
43. Park GY, Kim HY, Min JY, Dhong HJ, Chung SK. Endodontic treatment: a significant risk factor for the development of maxillary fungus ball. Clin Exp Otorhinolaryngol. 2010.
44. Giardino L, Pontieri F, Savoldi E, Tallarigo F. Aspergillus mycetoma of the maxillary sinus secondary to overfilling of a root canal. J Endod. 2006.
45. Mensi M, Piccioni M, Marsili F, Nicolai P, Sapelli PL, Latronico N. Risk of maxillary fungus ball in patients with endodontic treatment on maxillary teeth: a case-control study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007.
46. Cottom H, Gallaher JR, Dhariwal DK, Abu-Serriah M. Odontogenic cervico-fascial infections: a continuing threat. J Ir Dent Assoc. 2013.
47. Moghimi M, Baart JA, Karagozoglu KH, Forouzanfar T. Spread of odontogenic infections: a retrospective analysis and review of the literature. Quintessence Int. 2013.
48. Sisk AL, Hammer WB, Shelton DW, Joy ED Jr. Complications following removal of impacted third molars: the role of the experience of the surgeon. J Oral Maxillofac Surg. 1986.
49. Ferguson M. Rhinosinusitis in oral medicine and dentistry. Aust Dent J. 2014.
50. Chiapasco M, De Cicco L, Marrone G. Side effects and complications associated with third molar surgery. Oral Med Oral Pathol. 1993.
51. Andersson L, Kahnberg KE, Pogrel MA. Oral and maxillofacial surgery. Oxford: Wiley-Blackwell; 2010.
52. Patel NA, Ferguson BJ. Odontogenic sinusitis: an ancient but under-appreciated cause of maxillary sinusitis. Curr Opin Otolaryngol Head Neck Surg. 2012.
53. Chiapasco M, Felisati G, Zaniboni M, Pipolo C, Borloni R, Lozza P. The treatment of sinusitis following maxillary sinus grafting with the association of functional endoscopic sinus surgery (FESS) and an intra-oral approach. Clin Oral Implants Res. 2013.
54. Troeltzsch M, Pache C, Troeltzsch M, Kaeppler G, Ehrenfeld M, Otto S, et al. Etiology and clinical characteristics of symptomatic unilateral maxillary sinusitis: a review of 174 cases. J Craniomaxillofac Surg. 2015.
55. Patel NA, Ferguson BJ. Odontogenic sinusitis: an ancient but under-appreciated cause of maxillary sinusitis. Curr Opin Otolaryngol Head Neck Surg. 2012.
56. Migliario M, Bello L, Greco Lucchina A, Mortellaro C. Descending necrotizing mediastinitis. Two cases consequent on odontogenic infections and a review of literature. Minerva Stomatol. 2010 Oct;59(10):551-60.
57. Kataria G, Saxena A, Bhagat S, Singh B, Kaur M, Kaur G. Deep neck space infections: a study of 76 cases. Iran J Otorhinolaryngol. 2015.
58. Felisati G, Chiapasco M. Sinonasal Complications of Dental Disease and Treatment. Thieme, 2016.
59. Patel NA, Ferguson BJ. Odontogenic sinusitis: an ancient but under-appreciated cause of maxillary sinusitis. Curr Opin Otolaryngol Head Neck Surg. 2012.
60. Cottom H, Gallaher JR, Dhariwal DK, Abu-Serriah M. Odontogenic cervico-fascial infections: a continuing threat. J Ir Dent Assoc. 2013.
61. Andersson L, Kahnberg KE, Pogrel MA. Oral and maxillofacial surgery. Oxford: Wiley-Blackwell; 2010.
62. Patel NA, Ferguson BJ. Odontogenic sinusitis: an ancient but under-appreciated cause of maxillary sinusitis. Curr Opin Otolaryngol Head Neck Surg. 2012.
63. Longhini AB, Ferguson BJ. Clinical aspects of odontogenic maxillary sinusitis: a case series. Int Forum Allergy Rhinol. 2011.
64. Filiaci F, Riccardi E, Mitro V, Piombino P, Rinna C, Agrillo A, et al. Disseminated necrotic mediastinitis spread from odontogenic abscess: our experience. Ann Stomatol. 2015.
65. Brito TP, Hazboun IM, Fernandes FL, Bento LR, Zappelini CEM, Chone CT, et al. Deep neck abscesses: study of 101 cases. Braz J Otorhinolaryngol. 2017.
66. Vinciguerra A, Saibene AM, Lozza P, Maccari A. Unusual case of bilateral maxillary fungus ball. BMJ Case Rep. 2016.
67. Shanti RM, Alawi F, Lee SM, Henderson AJ, Sangal NR, Adappa ND. Multidisciplinary approaches to odontogenic lesions. Curr Opin Otolaryngol Head Neck Surg. 2020 Feb;28(1):36-45.
68. Felisati G, Chiapasco M, Lozza P, Saibene AM, Pipolo C, Zaniboni M, et al. Sinonasal complications resulting from dental treatment: outcome-oriented proposal of classification and surgical protocol. Am J Rhinol Allergy. 2013.
69. Fadda GL, Berrone M, Crosetti E, Succo G. Monolateral sinonasal complications of dental disease or treatment: when does endoscopic endonasal surgery require an intraoral approach? Acta Otorhinolaryngol Ital. 2016.
70. Giovannetti F, Priore P, Raponi I, Valentini V. Endoscopic sinus surgery in sinus-oral pathology. J Craniofac Surg. 2014.
71. Joe Jacob K, George S, Preethi S, Arunraj VS. A comparative study between endoscopic middle meatal antrostomy and Caldwell-Luc surgery in the treatment of chronic maxillary sinusitis. Indian J Otolaryngol Head Neck Surg. 2011.
72. Trimarchi M, Vinciguerra A, Galli A, Capparè P, Vinci R, Bussi M. Management of upper odontogenic infections and the role of multidisciplinary treatment. J Osseointegr. 2019.
73. Saibene AM, Pipolo GC, Lozza P, Maccari A, Portaleone SM, Scotti A, et al. Redefining boundaries in odontogenic sinusitis: a retrospective evaluation of extramaxillary involvement in 315 patients. Int Forum Allergy Rhinol. 2014.
74. Alkan A, Celebi N, Bas B. Acute maxillary sinusitis associated with internal sinus lifting: report of a case. Eur J Dent. 2008.
75. Li J, Wang HL. Common implant-related advanced bone grafting complications: classification, etiology, and management. Implant Dent. 2008.