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Odontogenic Sinusitis is a Common Cause of Operative Extra-Sinus Infectious Complications

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Abstract

Background: Orbital, intracranial, and osseous extra-sinus complications can arise from bacterial or fungal sinusitis. Odontogenic sinusitis (ODS) can cause extra-sinus complications, but its prevalence remains poorly characterized.

Objective: To determine the frequency of ODS as a cause of operative extra-sinus infectious complications and describe clinical features of all complicated sinusitis cases.

Methods: A multi-institutional retrospective review was performed on all operative sinusitis-related extra-sinus complications from 2011 to 2020. ODS was diagnosed by sinus computed tomography (CT) and dental evaluations when available. Demographics, complication types, sinusitis etiologies, and various clinical features were analyzed.

Results: Forty-five patients were included (mean age 55.5 years, 56% male). Of the extra-sinus complications, 40% were orbital only, 22% intracranial only, 13% osseous only, and 25% involved combined complications. The 2 most common causes of extra-sinus complications were ODS (40%) and mucopyocele (27%). When invasive fungal etiologies were excluded, and only unilateral maxillary opacification on CT was considered, nearly 60% of extra-sinus complications were due to ODS. Unilateral maxillary sinus opacification on CT was present in 100% of complicated ODS compared to 44% of nonodontogenic cases, and oral anaerobes were only identified in ODS cases. No complicated ODS patients underwent dental interventions during hospitalization.

Conclusion: ODS was the most common cause of operative extra-sinus infectious complications. Clinicians should consider ODS high on the differential diagnosis of all patients presenting with complicated sinusitis, especially when sinusitis is unilateral and invasive fungal infection is not suspected.

Keywords

apical periodontitis, brain abscess, orbital abscess, orbital cellulitis, rhinosinusitis, odontogenic sinusitis, oroantral fistula, Pott's puffy tumor, cavernous sinus thrombosis, meningitis

Introduction

Orbital, intracranial, and osseous extra-sinus infectious complications represent only 3% to 20% of rhinosinusitis cases but can cause significant morbidity and even death.[1,2] Odontogenic sinusitis (ODS) is one potential cause of extra-sinus infectious complications,[3] but notably, sinusitis guidelines and position statements have not discussed ODS as a form of complicated sinusitis.[4,5]

ODS refers to bacterial maxillary sinusitis, with or without extension to other paranasal sinuses, secondary to either adjacent infectious maxillary dental pathology, or following complications from dental procedures.[6] Potential dental pathologies causing ODS include apical periodontitis (AP, endodontic infection), marginal periodontitis (periodontal infection), oroantral communication or fistula, and dental

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treatment-related maxillary sinus foreign bodies.[6–10] ODS most commonly presents unilaterally and represents 45% to 75% of all unilateral maxillary sinus opacification on computed tomography.[11–14]

ODS has been significantly underrepresented in the sinusitis literature compared to other forms of sinus disease,[15] and while ODS has been reported to cause extra-sinus complications, this has largely been described in case reports. A recent systematic review reported clinical features of all published complicated ODS cases,[3] but the prevalence of ODS among other causes of complicated sinusitis has not been studied. The purpose of this study was to determine the frequency of ODS as a cause of extra-sinus infectious complications requiring surgical intervention and to describe the clinical features of these complicated sinusitis cases.

Materials and Methods

This study was approved by the University of Pennsylvania and Henry Ford Health System Institutional Review Boards. A retrospective review was performed of all adult patients undergoing surgery for orbital, intracranial, or osseous complications of sinusitis between 2011 and 2020. Medical records were reviewed for demographic information, presence of immunodeficiency (primary or acquired immunodeficiencies, tobacco use, and diabetes mellitus), underlying sinusitis etiology, complication types, sinus opacification patterns on computed tomography (CT), dental pathologies in ODS patients, and bacterial cultures. Whether patients were initiated on antimicrobial therapy was recorded, but type and duration of antimicrobials were not. Additionally, whether dental, sinus, orbital, or intracranial interventions were performed was noted.

Orbital complications included pre and postseptal orbital cellulitis, preseptal orbital abscess, subperiosteal phlegmon or abscess, orbital abscess, cavernous sinus thrombosis, or intraoptic nerve abscess (Figure 1A and B). Intracranial complications included meningitis, epidural abscess, subdural abscess, intraparenchymal abscess, and cerebral sinus thrombosis. Osseous complications included frontal subperiosteal abscess (Pott's puffy tumor) with or without sinocutaneous fistula (Figure 1C and D).

Electronic medical records were reviewed from dental, otolaryngologic, ophthalmologic, and neurosurgical services. Sinusitis types were categorized by CT and histopathology. ODS was diagnosed based on confirmed infectious sinusitis on nasal endoscopy and CT, and confirmed dental pathology by dental examination when available. Additionally,

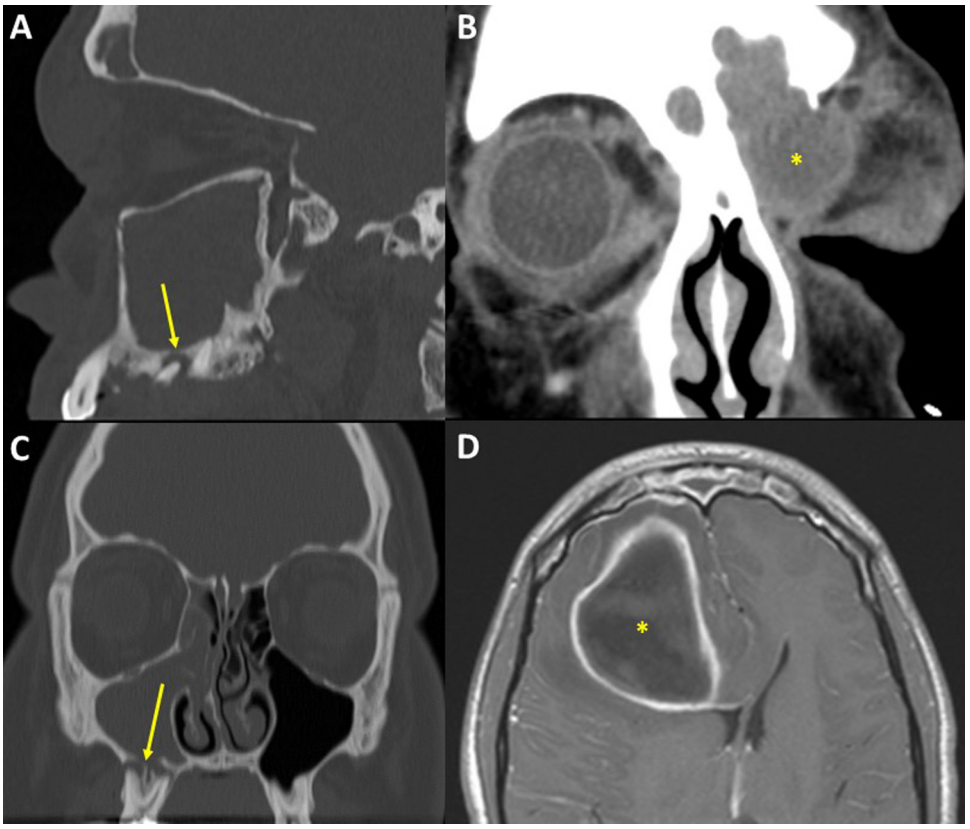

Figure 1. Computed tomography scans of 2 representative case examples. (A, B) Example of (A) odontogenic sinusitis due to apical periodontitis with a periapical lesion (yellow arrow) causing (B) frontal sinusitis with a subperiosteal orbital abscess (yellow asterisk). (C, D) Example of (C) odontogenic sinusitis due to apical periodontitis with a periapical lesion (yellow arrow) causing (D) frontal sinusitis and a large right intraparenchymal brain abscess (yellow asterisk).

maxillary sinuses ipsilateral to causative maxillary dental pathologies were required to be opacified on CT. In the absence of dental examinations, dental pathologies were tentatively confirmed if CT demonstrated overt maxillary dental pathology.[6] Overt dental pathologies included periapical lesions indicative of AP, and possible oroantral communication or fistula signified by absent alveolar bone between oral and sinus mucosa. Note that oroantral communication and fistula were only formally diagnosed by physical examination.

Bacterial cultures were obtained from purulent secretions in sinus, orbital, or intracranial spaces, and were submitted to microbiology laboratories for aerobic and anaerobic cultures and identification. Lengths of hospital stays were recorded, but subsequent outpatient follow-ups were too inconsistent to be analyzed. Records were also assessed for any returns to hospitals for recurrent complicated sinusitis. Descriptive statistics were analyzed using Stata/IC 16.1 (StataCorp, College Station, TX, USA). A student's *t*-test was used to compare ages between ODS and non-ODS groups. All other variables were assessed using a Chi-squared test.

Results

Of the 45 patients who underwent surgery for complicated sinusitis, mean age was 55.5 ± 19.9 years, and 56% were male. Table 1 demonstrates patient demographics, comorbidities, and extra-sinus complication types. Gender proportions and mean ages were similar between ODS and non-ODS patients. Of the extra-sinus complications, 40% were orbital only, 22% intracranial only, 13% osseous only, and 25% involved more than one complication type. Extra-sinus complications were unilateral in 82% of cases (37/45), with 64% having only unilateral sinus opacification on CT (29/45). Of those with unilateral sinus opacification on CT, complications were ipsilateral to the sinusitis in 93% of cases (27/29) and contralateral in 7% (2/29).

Figure 2 shows the frequencies of sinusitis types causing extra-sinus complications. Overall, complicated sinusitis occurred most commonly from ODS (40%), followed by mucopyocele (27%), chronic rhinosinusitis without nasal polyposis (9%), acute invasive fungal sinusitis (9%), chronic rhinosinusitis with nasal polyposis (7%), acute rhinosinusitis (7%), and chronic invasive fungal sinusitis (2%). When invasive fungal infections were excluded, and only cases with unilateral maxillary sinus opacification on CT were considered, ODS accounted for 58% of cases (11/19).

Table 2 demonstrates the frequencies of each extra-sinus complication. Among all orbital complications, postseptal orbital cellulitis and subperiosteal orbital abscesses were most common. Intracranial and osseous complications occurred with similar frequencies in both complicated ODS and nonodontogenic sinus disease. Extra-sinus complications occurred ipsilateral to the ODS side in 94% of cases (17/18), with one epidural abscess occurring contralateral to the ODS side due to sphenoid sinus roof erosion.

Of the 18 ODS patients, all were due to unilateral dental pathology. Eight had ODS confirmed through dental evaluations and 10 had ODS tentatively confirmed by CT; 89% had AP (16/18), 6% had a temporary oroantral communication (1/18), and 6% had an oroantral fistula (1/18) after dental extraction. Of the dental pathologies seen on CT, only 61% were identified by radiologists. Also of note, of the 19 patients who had at least unilateral maxillary sinus

Table 1. Demographics, Medical Comorbidities, and Frequencies of Extra-Sinus Complications.

Variables		All (n = 45)	ODS (n = 18)	Non-ODS (n = 27)	*P*-value
Demographics					
Age (years)	Mean (SD)	55.5 (19.9)	50.8 (19.9)	58.7 (19.7)	.196
Female	% (n)	56 (25)	44 (8)	44 (12)	1.00
Male	% (n)	44 (20)	56 (10)	56 (15)	
Comorbidities					
Current smoker	% (n)	11 (5)	22 (4)	4 (1)	.063
Former smoker	% (n)	24 (11)	11 (2)	33 (9)	1.000
Diabetes mellitus	% (n)	22 (10)	22 (4)	22 (6)	.073
Immunodeficiency (primary or acquired)	% (n)	11 (5)	0 (0)	19 (5)	.073
Extra-sinus complications					
Any orbital	% (n)	62 (28)	56 (10)	67 (18)	.451
Any intracranial	% (n)	31 (14)	33 (6)	30 (8)	.793
Any osseous	% (n)	36 (16)	50 (9)	26 (7)	.098
Orbital only	% (n)	40 (18)	28 (5)	48 (13)	.172
Intracranial only	% (n)	22 (10)	17 (3)	26 (7)	.716
Osseous only	% (n)	13 (6)	22 (4)	7 (2)	.199
Osseous and orbital	% (n)	16 (7)	17 (3)	15 (4)	1.000
Orbital and intracranial	% (n)	2 (1)	6 (1)	0 (0)	.400
Osseous and intracranial	% (n)	2 (1)	6 (1)	0 (0)	.400
Osseous, orbital, and intracranial	% (n)	4 (2)	6 (1)	4 (1)	1.000

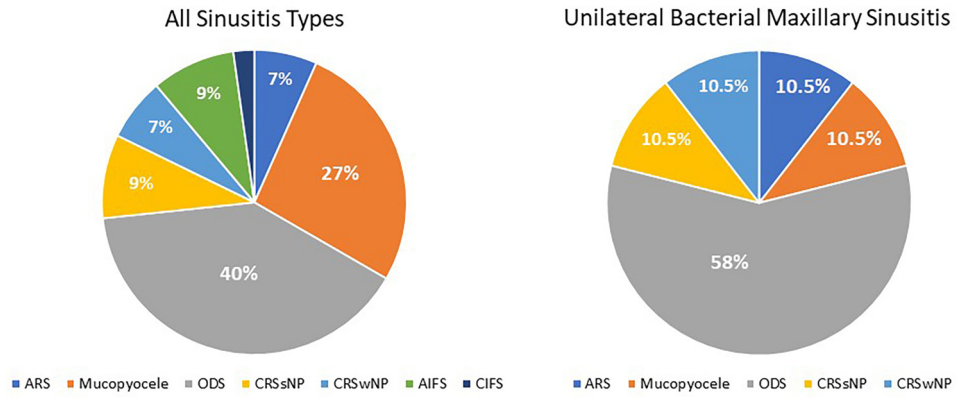

Figure 2. Frequencies of sinusitis types causing complicated sinusitis (left), and frequencies of conditions presenting as unilateral bacterial maxillary sinusitis types (excluding invasive fungal sinusitis cases) (right). Odontogenic sinusitis (ODS) caused 58% of all complicated bacterial maxillary sinusitis cases when invasive fungal sinusitis cases were excluded.
Abbreviations: ODS, odontogenic sinusitis; CRSsNP, chronic rhinosinusitis without nasal polyposis; AIFS/CIFS, acute/chronic invasive fungal sinusitis; CRSwNP, chronic rhinosinusitis with nasal polyposis; ARS, acute rhinosinusitis.

Table 2. Extra-Sinus Infectious Complication Types.

Extra-sinus complications	All % (n/45)	ODS % (n/18)	Non-ODS % (n/27)	*P*-value
Orbital (n = 33)	73 (33)	56 (10)	85 (23)	.451[a]
Preseptal orbital cellulitis	9 (4)	6 (1)	11 (3)	.640
Preseptal orbital abscess	9 (4)	6 (1)	11 (3)	.640
Subperiosteal phlegmon	2 (1)	0 (0)	4 (1)	1.000
Subperiosteal abscess	16 (7)	28 (5)	7 (2)	.098
Postseptal orbital cellulitis	20 (9)	11 (2)	26 (7)	.279
Orbital abscess	7 (3)	0 (0)	11 (3)	.264
Cavernous sinus thrombosis	11 (5)	6 (1)	15 (4)	.634
Intracranial (n = 15)	33 (15)	33 (6)	33 (9)	.793[a]
Meningitis	4 (2)	0 (0)	7 (2)	.509
Epidural abscess	20 (9)	17 (3)	22 (6)	.721
Subdural abscess	2 (1)	0 (0)	4 (1)	1.000
Intraparenchymal abscess	2 (1)	11 (2)	0 (0)	.155
Cerebral sinus thrombosis	2 (1)	6 (1)	0 (0)	.400
Osseous (n = 17)	38 (17)	50 (9)	30 (8)	.098[a]
Frontal subperiosteal abscess	31 (14)	18 (8)	22 (6)	.115
Sinocutaneous fistula	7 (3)	6 (1)	7 (2)	1.000

[a]*P*-values tested the number of individuals with one or more complications and not the number of complications per individual.

opacification on CT, only 32% underwent formal dental evaluations (6/19).

Also of interest, of the 27 non-ODS patients, 8 had unilateral sinus opacification on CT, but no clear causative etiology. They had no overt dental pathology on CT but did not have dental evaluations. Six of these patients had culture data: 2 grew *Streptococcus intermedius*, 2 coagulase-negative staphylococcus, one methicillin-sensitive *Staphylococcus aureus*, and one *Klebsiella* species.

Table 3 shows the sinus opacification patterns on CT. With regard to ODS-related extra-sinus complications, while all patients had unilateral ODS with sinuses opacified ipsilateral to their dental pathology, some also had contralateral nonodontogenic sinus opacification on CT. Overall, 61% of ODS patients had solely unilateral sinus opacification (11/18), with 39% of cases having contralateral sinus opacification to varying degrees (7/18). None of the ODS patients had overt maxillary dental pathology on sides contralateral to their ODS. Among the 27 complicated non-ODS cases, 67% had only unilateral sinus opacification (18/27). Nonodontogenic cases demonstrated a wide variety of opacification patterns, but notably, only 44% of unilateral cases demonstrated maxillary sinus opacification (8/18), as opposed to 100% of ODS cases ($P = .004$).

Table 4 shows the culture results for 37/45 patients (95% from sinuses). Some cultures were from brain abscesses (n =

Table 3. Sinus Opacification Patterns on Computed Tomography (CT).

Sinuses opacified on CT	All patients % (n/45)	ODS % (n/18)	Non-ODS % (n/27)	*P*-value
Unilateral	64 (29)	61 (11)	67 (18)	.703
Maxillary only	4 (2)	6 (1)	4 (1)	1.000
Maxillary, ethmoid	7 (3)	17 (3)	0 (0)	.058
Maxillary, ethmoid, frontal	20 (9)	28 (5)	15 (4)	.449
Maxillary, ethmoid, sphenoid	4 (2)	0 (0)	7 (2)	.509
Ethmoid, frontal	4 (2)	0 (0)	7 (2)	1.000
Ethmoid, sphenoid	2 (1)	0 (0)	4 (1)	.509
Sphenoid only	4 (2)	0 (0)	7 (2)	.073
Frontal only	11 (5)	0 (0)	19 (5)	.555
Pan-sinus	7 (3)	11 (2)	4 (1)	.703
Bilateral	36 (16)	39 (7)	33 (9)	.703
Maxillary, ethmoid	2 (1)	6 (1)	0 (0)	.400
Maxillary, ethmoid, frontal	16 (7)	22 (4)	11 (3)	.412
Ethmoid, sphenoid, frontal	2 (1)	0 (0)	4 (1)	1.000
Sphenoid, frontal	0 (0)	0 (0)	0 (0)	–
Frontal only	4 (2)	0 (0)	7 (2)	.509
Pan-sinus	11 (5)	11 (2)	11 (3)	1.000
Unilateral, any maxillary	66 (19/29)	100 (11/11)	44 (8/18)	**.004**
Bilateral, any maxillary	81 (13/16)	100 (7/7)	67 (6/9)	.213

2, 5%), orbit (n = 1, 3%), or unknown location (n = 2, 5%). Oral anaerobes were present only in ODS ($P = .001$), with all anaerobes cultured in non-ODS cases being *Propionibacterium acnes* (skin flora). Alpha-hemolytic streptococcal species were also more common in ODS ($P = .016$). No growth occurred in 18% of patients (8/45), with 7 of these being non-ODS cases.

Of the 28 patients with orbital complications, either isolated or in combination with osseous or intracranial complications, 24 (86%) underwent formal ophthalmologic evaluation. A total of 14 of these patients had ophthalmoplegia (50%), and 6 had visual acuity loss (21%). Among the 10 ODS patients with orbital complications, 6 had ophthalmoplegia (60%) and one had visual acuity loss (10%). Among the 18 non-ODS patients with orbital complications, 8 had ophthalmoplegia (44%), and 5 had visual acuity loss (28%). There were no significant differences between ODS and non-ODS cohorts with regard to ophthalmoplegia ($P = .695$) and visual acuity loss ($P = .375$). Of the 14 intracranial complications, neurological exam findings were too variably recorded to be reported.

All patients were initiated on intravenous antimicrobial therapies upon admission, according to suspicion for bacterial or fungal disease. Among all orbital complications, only 7/28 underwent orbital surgery: incision and drainage (n = 5) or orbital decompression (n = 2). Only 21% of intracranial complications required craniotomy (3/14).

None of the complicated ODS patients underwent dental intervention during hospitalizations. Following discharge, only 2/16 patients had confirmed dental interventions (one dental extraction, one root canal), each at 3 to 4 weeks after discharge. The remainder of patients was lost to follow-up. Other than 2 acute invasive fungal sinusitis patients who died due to sepsis and multiorgan involvement, all other complicated sinusitis patients were discharged in stable conditions, with mean length of stay of 7.6 days. No patients returned to the authors' institutions for recurrent complicated sinusitis.

Discussion

Extra-sinus infectious complications from rhinosinusitis are rare but can cause significant ophthalmologic and neurologic morbidity, and even death. Extra-sinus spread can occur via septic thrombophlebitis through veins traversing bony foramina and canals, or via direct extension through bony sinus wall defects into the intraorbital, intracranial, or subcutaneous spaces.[4] Bony wall defects that could put patients at risk for extra-sinus spread include prior surgery or trauma, neoplasia, or idiopathic intracranial hypertension with meningoencephaloceles.[4,16–18]

Studies have described extra-sinus infectious complications in the setting of both acute and chronic rhinosinusitis, but have not reported the frequency with which these complications stem from ODS. Recent sinusitis guidelines and position statements have not discussed complicated ODS, and also have not specifically discussed how to diagnose and manage ODS in general.[4,5] This could be due to multiple reasons. First, there has been an overall lack of published literature on ODS.[15] Second, among published complicated ODS cases, over 90% have been case reports, and only 23% have been published in the otolaryngology literature.[3] Lastly, only recently was a consensus statement published on diagnosing ODS,[6] so it is possible that ODS was overlooked in prior complicated rhinosinusitis studies.

There have been some trends in the complicated rhinosinusitis literature to support a hypothesis that ODS is a

Table 4. Culture Data from Patients With Extra-Sinus Infectious Complications From Odontogenic Sinusitis (ODS) and Nonodontogenic Sinus Disease (Non-ODS).

Cultured bacteria or fungi	Total % (n/45)	ODS % (n/18)	Non-ODS % (n/27)	*P*-value
Anaerobic	36 (16)	50 (9)	26 (7)	.098
Propionibacterium acnes	16 (7)	0 (0)	26 (7)	**.031**
Anaerobic (excluding *P. acnes*)	36 (16)	50 (9)	0 (0)	**.001**
Mixed anaerobes	7 (3)	17 (3)	0 (0)	.097
Fusobacterium species	4 (2)	11 (2)	0 (0)	.218
Actinomyces	2 (1)	6 (1)	0 (0)	.474
Dialister pneumosintes	2 (1)	6 (1)	0 (0)	.474
Peptostreptococcus species	2 (1)	6 (1)	0 (0)	.474
Prevotella species	2 (1)	6 (1)	0 (0)	.474
Alpha-hemolytic *Streptococcus*	24 (11)	44 (8)	11 (3)	**.016**
Streptococcus anginosus	7 (3)	17 (3)	0 (0)	.058
Streptococcus constellatus	7 (3)	11 (2)	4 (1)	.555
Streptococcus intermedius	7 (3)	6 (1)	7 (2)	1.000
Alpha-hemolytic strep (non-typed)	4 (2)	11 (2)	0 (0)	.155
Aerobic gram-negative	16 (7)	11 (2)	16 (5)	.684
Acinetobacter species	4 (2)	0 (0)	7 (2)	.509
Chryseobacterium species	2 (1)	0 (0)	4 (1)	1.000
Eikenella corrodens	2 (1)	6 (1)	0 (0)	.400
Klebsiella species	2 (1)	0 (0)	4 (1)	1.000
Pseudomonas aeruginosa	2 (1)	6 (1)	0 (0)	.400
Stenotrophomonas maltophilia	2 (1)	0 (0)	4 (1)	1.000
Aerobic gram-positive	51 (23)	61 (11)	44 (12)	.273
Coagulase-negative staphylococcus	31 (14)	39 (7)	26 (7)	.358
Staphylococcus aureus (Methicillin-sensitive)	11 (5)	11 (2)	11 (3)	1.000
Staphylococcus lugdunensis	4 (2)	6 (1)	4 (1)	1.000
Corynebacterium species	2 (1)	6 (1)	0 (0)	.400
Enterococcus faecalis	2 (1)	0 (0)	4 (1)	1.000
Fungal	16 (7)	0 (0)	26 (7)	**.031**
Aspergillus	9 (4)	0 (0)	15 (4)	.138
Rhizopus	4 (2)	0 (0)	7 (2)	.509
Mucor	2 (1)	0 (0)	4 (1)	1.000
No growth	18 (8)	6 (1)	26 (7)	.119

relatively common cause of extra-sinus infectious complications. First, rhinosinusitis complications are usually unilateral,[19–22] and studies on rhinosinusitis-related orbital[20,23–28] and intracranial[29–31] complications have reported significant rates of odontogenic bacteria in sinus cultures. As ODS is a very common cause of unilateral sinus disease,[11] and odontogenic organisms are more common in ODS than rhinosinusitis,[32,33] it is possible that prior sinusitis complications studies inadvertently included ODS patients in their study populations. Supporting this notion, the current multicenter study showed that ODS was the most common cause of complicated sinusitis, especially in the setting of unilateral nonfungal sinus disease.

Findings from the current study demonstrated some similarities and differences from a recent systematic review on complicated ODS.[3] Specifically, ODS always occurred unilaterally, most commonly caused ipsilateral orbital complications, and was most commonly due to AP. Additionally, oral anaerobes and alpha-hemolytic streptococcal species were more common in complicated ODS compared to non-ODS. In contrast to the prior systematic review, the current study demonstrated roughly equal proportions of males and females in the complicated ODS group and a mean age of 54.2 years. In contrast, the systematic review reported that 74% of cases were male with a mean age of 31.7 years. Larger studies are necessary to understand these demographic differences. Lastly, ODS-related orbital complications in the current study presented with ophthalmoplegia and visual acuity loss in 60% and 10% of cases, respectively, compared to 85% and 69%, respectively, in the complicated ODS review. This difference could possibly be explained by publication bias since 91% of cases in the ODS review study were case reports of severe disease. This represents an important area for future study to determine whether complicated ODS portends worse visual outcomes.

Also interesting in this study was that only 32% of all patients with unilateral maxillary sinus opacification received formal dental evaluations, and no patients underwent dental

interventions during hospitalizations. This highlights a few interesting points. First, complicated ODS patients present like other forms of complicated rhinosinusitis, and therefore are likely to be evaluated initially by otolaryngologists and the other clinicians necessary to manage extra-sinus complications. However, since radiologists frequently miss the dental pathology on CT,[11,34,35] and patients often have no dental complaints,[5] ODS can be overlooked if it is not considered in the differential diagnosis. Additionally, some hospitals may not have dental provider coverage for inpatient consultations and treatment. Regarding dental intervention, while published case reports have recommended immediate dental intervention to manage complicated ODS,[3] the current study suggests that this may not always be necessary since no ODS patients underwent dental interventions during hospitalizations, and all were discharged in stable conditions. While 2 patients with AP underwent dental treatment within a month of their hospital stay, the remainder of complicated ODS patients were lost to follow-up. As none of the complicated ODS patients returned to the authors' institutions for recurrent complicated sinusitis during the study period, they may have undergone dental treatment at a later date, but this is not known with certainty. It is imperative that future studies explore the optimal type and timing of dental interventions for complicated ODS.

One last point warranting further study is whether immunodeficiency contributes to extra-sinus infectious complications. While it is intuitive that a dysfunctional immune system could predispose patients to extra-sinus infectious spread, this has not been demonstrated in the literature.[3,4] In the current study, the small sample size limited the ability to make meaningful conclusions, but none of the complicated ODS patients had primary or acquired immunodeficiency, and the non-ODS patients with primary or acquired immunodeficiency all had acute invasive fungal sinusitis.

Limitations should also be discussed. First, the small sample size limited the study's statistical analyses and generalizability. Second, the retrospective design prevented the acquisition of reliable long-term follow-up data, which would be valuable in determining clinical outcomes such as symptom recurrence and visual acuity, as well as dental interventions and outcomes. Additionally, as formal dental evaluations were not completed in many of the patients with extra-sinus complications, the incidence of ODS cannot be determined with certainty. For example, 2 studies have shown that nearly one-third of ODS cases due to AP have no detectable periapical lesions on CT.[15,34] Therefore, some non-ODS patients in this study with no overt dental pathology on CT could have had ODS. As an example, 2 patients in this study had unilateral bacterial sinusitis with no clear etiology, but grew *Streptococcus intermedius*, a common odontogenic organism. It is possible these cases represented ODS, but this could not be confirmed. Lastly, the current study only included operative cases, but some cases of sinusitis-related extra-sinus complications resolve with antimicrobial therapy alone. This could have affected the overall frequencies of etiologies, and future studies should include all medically and surgically treated complicated sinusitis cases.

Conclusion

ODS was the most common cause of operative extra-sinus infectious complications, particularly when excluding invasive fungal disease. Clinicians should always consider ODS as a possible cause of complicated sinusitis, but especially if CT scans demonstrate unilateral maxillary sinus opacification and overt dental pathology, and if sinus cultures reveal odontogenic bacteria. Multidisciplinary collaboration between otolaryngologists, ophthalmologists, and neurosurgeons is essential for the optimal evaluation and management of complicated sinusitis. In the setting of suspected ODS, formal dental consultations to confirm infectious dental pathology is ideal, but the type and timing of dental intervention requires further study.

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