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# Odontogenic sinusitis publication trends from 1990 to 2019: a systematic review

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## Abstract

**Purpose** Odontogenic sinusitis (ODS) is underrepresented in the literature compared to other forms of rhinosinusitis, specifically in sinusitis guidelines and position statements. ODS publication characteristics could help explain why ODS has received less attention in sinusitis guidelines and position statements. The purpose of this study was to explore trends in the quantity and quality of ODS studies over 3 decades from 1990 to 2019.

**Methods** A systematic review was performed to identify all ODS studies from 1990 to 2019. The following variables from all ODS studies were compared between and across the 3 decades: authors' specialties, journal specialties, authors' geographic origins (continents), study topics, study designs, and evidence levels.

**Results** From 1990 to 2019, there were 254 ODS studies that met inclusion criteria. Numbers of publications increased each decade, with 161 being published from 2010 to 2019. Otolaryngologists and dental authors published over 75% of ODS studies each decade, with 60–75% of ODS articles being published in otolaryngology or dental journals. European and Asian authors published the most ODS studies each decade. Overall, 92–100% of ODS publications per decade were level 4 and 5 evidence, with no significant changes between or across decades.

**Conclusion** While numbers of ODS publications increased each decade from 1990 to 2019, evidence levels remained low without significant changes over time. Otolaryngologists and dental authors published the majority of ODS studies each decade, with a minority of these studies being multidisciplinary. More ODS studies are needed across all aspects of the condition, and future projects would benefit from improved study designs and multidisciplinary collaboration.

**Keywords** Odontogenic sinusitis · Unilateral sinus disease · Maxillary sinusitis · Chronic rhinosinusitis · Endoscopic sinus surgery

## Introduction

Odontogenic sinusitis (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 [1]. Potential dental pathologies that cause ODS include apical periodontitis (endodontic disease),

periodontitis, oroantral fistula, or dental-treatment related to foreign bodies within the maxillary sinus [2–9]. Some studies have suggested ODS represents 25–40% of all causes of chronic maxillary sinusitis [10, 11]. Other studies have specifically assessed the prevalence of ODS amongst causes of unilateral maxillary sinus opacification on computed tomography, and shown it to represent 45–75% of cases [9, 12–14].

ODS is diagnosed through a combination of dental exam, nasal endoscopy, and imaging of both the maxillary dentition and paranasal sinuses. Therefore, diagnosing and managing ODS most commonly involves otolaryngologists, dental providers, and radiologists. Other medical or surgical providers may also be involved in the management of ODS when pediatric patients are affected or when the infection spreads intraorbitally, intracranially, or systemically. Depending on the dental pathology, dental treatment may be performed by general dentists, endodontists, periodontists,

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or oral maxillofacial surgeons. ODS is, therefore, a multidisciplinary condition that requires collaboration between various medical, dental, and surgical providers.

Despite ODS being a well-recognized condition, clinicians can miss the diagnosis for several reasons. First, ODS patients commonly present with nonspecific sinonasal symptoms and minimal dental complaints [15–17]. Second, both radiologists and dentists often miss the diagnosis [11, 14, 15, 17–20]. Otolaryngologists are, therefore, often responsible for suspecting ODS and referring patients to the appropriate dental providers to confirm the dental pathology. However, ODS is underrepresented in sinusitis guidelines and position statements [15, 20–22], and the unilateral sinus disease literature [23–26], so awareness amongst otolaryngologists could also be suboptimal. One possible explanation for the underrepresentation of ODS in sinusitis guidelines, and challenges faced when diagnosing and managing the condition, could be the relative paucity of ODS publications in the medical and dental fields responsible for managing the condition. The purpose of this study was to explore trends in the quantity and quality of ODS research publications over the last 3 decades from 1990 to 2019.

## Materials and methods

### Search strategy

A systematic review of the literature was performed using keyword searches through PubMed, Embase, and the Cochrane Central Register of Control Trials databases to search for all ODS studies between January 1990 and December 2019. The following search terms were used to generate the initial list of ODS-related articles: “odontogenic sinusitis,” “odontogenic rhinosinusitis,” and “odontogenic maxillary sinusitis.” Search results were then screened for eligibility criteria to determine if they would be included for review.

### Eligibility criteria

Only studies on ODS were included for review. If included articles provided any of the variables of interest detailed in the data abstraction section below, they were included for review and analysis. If some study variables could not be determined for any reason, those variables were recorded as unknown. If no study variables could be determined due to non-English language articles or unobtainable abstracts or full-text, those studies were excluded from review.

### Study selection

Two authors (VG and AS) screened abstracts and then evaluated the remaining articles for eligibility. Discrepancies were resolved by the senior author (JRC).

### Data abstraction

Data were obtained from full-text articles when available, but if full text was not available, then abstracts were reviewed for pertinent data. The following variables were recorded for each reviewed study: decade of publication (1990–1999, 2000–2010, 2010–2019), authors’ specialties, journal specialties, authors’ geographic origins (continents), study topics, study designs, levels of evidence according to the Oxford Centre for Evidence-based Medicine [27]. Note that for some variables, there could be multiple data entries (e.g., authors’ specialties, study topics, continents). With regard to authors’ specialties, it was also determined how often dental authors and otolaryngologists published together in a multidisciplinary fashion.

Study topics were grouped into the following categories: epidemiology, pathophysiology, microbiology, diagnosis, treatment, and literature reviews. Studies were considered epidemiology if they assessed the incidence or prevalence of ODS amongst other causes of sinonasal disease. Studies were considered pathophysiology if they assessed different dental pathologies causing ODS, or if they analyzed sinus or dental histopathology. Publications were considered studies on diagnosis if they assessed diagnostic modalities for either sinus or dental pathologies, or both. Studies were considered microbiology only if they reported frequencies of bacterial or fungal culture results for all ODS patients in those studies. Studies were classified as treatment-based if they assessed outcomes of any ODS management options. Lastly, studies were considered literature reviews if they were summary review articles, systematic reviews, or meta-analyses.

### Statistical analysis

Study variable frequencies were calculated for each decade based on their known totals in each decade. Unknown variables were excluded from these calculations. Frequencies of the study variables were compared between and across the 3 decades (i.e., between 1990–1999 and 2000–2009, 2000–2009 and 2010–2019, and 1990–1999 and 2010–2019). Separately, numbers of ODS publications per decade were compared between otolaryngologists and dental authors.

Statistical analyses were performed using SAS version 9.2 (SAS Institute, Inc., Cary, NC). Most of the

decade-by-decade analyses were carried out using chi-squared tests. When sample sizes were too low, a Fisher's exact test was used. When comparing numbers of publications between otolaryngologists and dental authors, a McNemar's test for paired proportions was utilized.  $P$  values  $< 0.05$  were considered statistically significant.

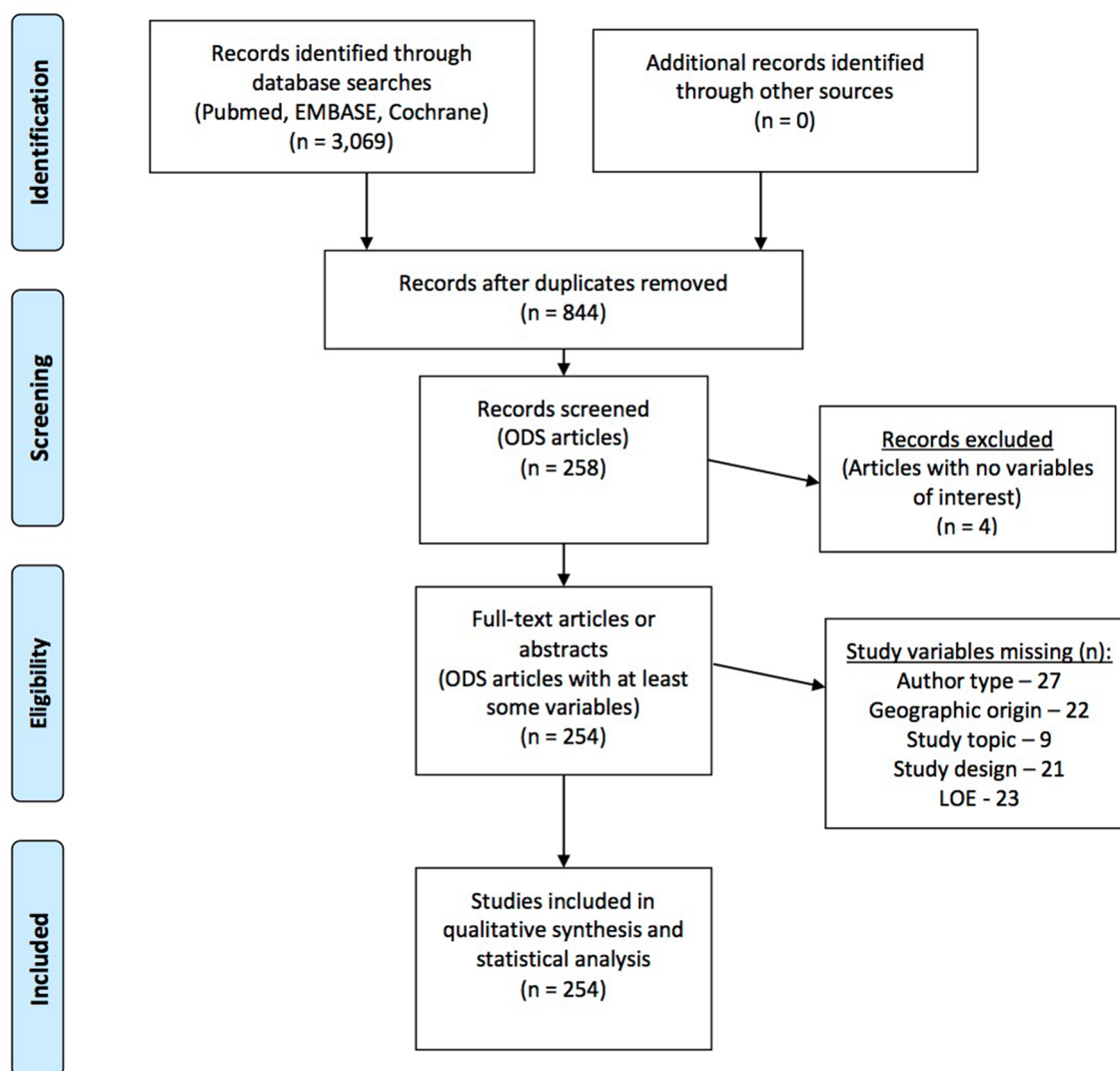
## Results

Of the initial 844 studies identified from the keyword searches, 258 studies were specifically about ODS. Of the 258 ODS studies screened, only 4 studies were excluded due to there being no study variables of interest to analyze. Due to either inability to translate or obtain adequate article text, the following percentages of studies' variables

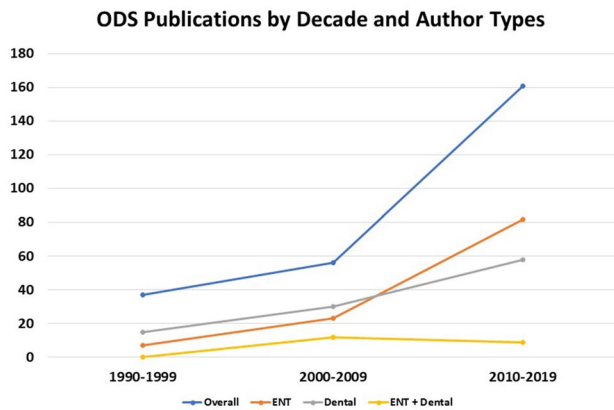
were categorized as unknown over all 3 decades: 10.6% for author type, 8.7% for geographic origin, 3.4% for study topics, 8.3% for study design, and 9.1% for levels of evidence. Table legends note the number of unknown variables per decade. Figure 1 demonstrates the flow diagram for ODS study selection, study exclusion, and numbers of missing variables in included studies.

Figure 2 shows the trends in numbers of ODS publications per decade, for all authors, and then separately for otolaryngologists, dental authors, and other authors. Overall, ODS publications increased about 4.4 times over the 3 decades, from 37 publications in 1990–1999 to 161 in 2010–2019.

Table 1 shows the distribution of author types publishing on ODS per decade. Otolaryngologists and dental authors published the majority of ODS articles every decade.



**Fig. 1** Odontogenic sinusitis (ODS) study selection process, including reasons for study exclusion, and number of missing variables in included studies. *LOE* level of evidence



**Fig. 2** Trends in total numbers of odontogenic sinusitis (ODS) publications from 1990 to 2019 for all authors (blue line), otolaryngologists/ENT (orange line), dental authors (gray line), and multidisciplinary studies with both otolaryngologists and dental authors (yellow line). There was about a 4.5-fold increase in total number of ODS publications, with a larger increase in the last decade

The proportion of ODS publications by otolaryngologists increased each decade from 24.1% in 1990–1999 to 55.0% in 2010–2019. While the individual decade-to-decade increases were not significantly different, the overall increase in publications over 3 decades was significant ( $P = 0.002$ ). The proportion of ODS publications by dental authors increased from 51.7% in 1990–1999 to 61.2% in 2000–2009, but this was not significant. The dental author publications then significantly decreased to 38.9% in 2010–2019 ( $P = 0.006$ ). Regarding multidisciplinary ODS publications between otolaryngologists and dental authors, while there was a significant increase from 0% in 1990–1999 to 24.5% in 2000–2009 ( $P = 0.003$ ), this was followed by a significant decrease to 6.0% in 2010–2019 ( $P = 0.001$ ). Radiologists comprised 8–15% of ODS publications per decade, with no significant changes between decades. Other author specialties generally represented 0–5% of publications per decade.

**Table 1** Numbers of odontogenic sinusitis publications by different author types, compared between successive decades, and between 1990–1999 and 2010–2019

Author types	1990–1999 ( $n = 29$ ) $x$ (%)	2000–2009 ( $n = 49$ ) $x$ (%)	2010–2019 ( $n = 149$ ) $x$ (%)	1990–1999 vs 2000–2009 $P$ value	2000–2009 vs 2010–2019 $P$ value	1990–1999 vs 2010– 2019 $P$ value
Dental	15 (51.7)	30 (61.2)	58 (38.9)	.412	<b>.006</b>	.200
ENT	7 (24.1)	23 (46.9)	82 (55.0)	<b>.046</b>	.325	<b>.002</b>
ENT + dental (multidisciplinary)	0 (0)	12 (24.5)	9 (6.0)	<b>.003</b>	<b>.001</b>	.359
Radiologist	5 (17.2)	7 (14.3)	15 (10.1)	.727	.415	.263
Neurosurgeon	1 (3.5)	1 (2.0)	4 (2.7)	1.000	1.000	1.000
Ophthalmologist	0	1 (2.0)	3 (2.0)	1.000	1.000	1.000
Pediatrician	1 (3.5)	6 (12.2)	0	.248	<b>.001</b>	.163
Pathologist	0	2 (4.1)	5 (3.4)	.531	1.000	1.000
Internal medicine	0	1 (2.0)	0	1.000	.248	1.000
General surgeon	0	1 (2.0)	0	1.000	.248	1.000
Allergist	0	1 (2.0)	0	1.000	.248	1.000
Infectious disease	0	1 (2.0)	0	1.000	.248	1.000

Note that the number of publications in each decade in this table was lower than overall reported totals due to some studies having unknown author specialties. There were eight unknowns in 1990–1999, seven in 2000–2009, and 12 in 2010–2019. Significant  $P$  values are bolded  
ENT otolaryngologist

**Table 2** Comparison between numbers of odontogenic sinusitis (ODS) publications between dental and otolaryngologists (ENT), in each decade

Authors	1990–1999 ( $n = 29$ ) $x$ (%)	$P$ value	2000–2009 ( $n = 49$ ) $x$ (%)	$P$ value	2010–2019 ( $n = 149$ ) $x$ (%)	$P$ value
Dental	15 (51.7)	.088	30 (61.2)	.194	58 (38.9)	<b>.030</b>
ENT	7 (24.1)		23 (46.9)		82 (55.0)	

Otolaryngologists published more ODS studies in 2010–2019, with no other significant differences between author types in previous decades. Significant  $P$  values are bolded

ENT otolaryngologist

Table 2 shows comparisons between otolaryngologists and dental authors regarding their numbers of ODS publications in each decade. While dental authors published more than otolaryngologists in the 1990s and 2000s, these differences were not significantly different. Of note in 2010–2019, otolaryngologists published 55.0% of ODS studies compared to 38.9% by dental authors, and this difference was significantly different ( $P=0.030$ ).

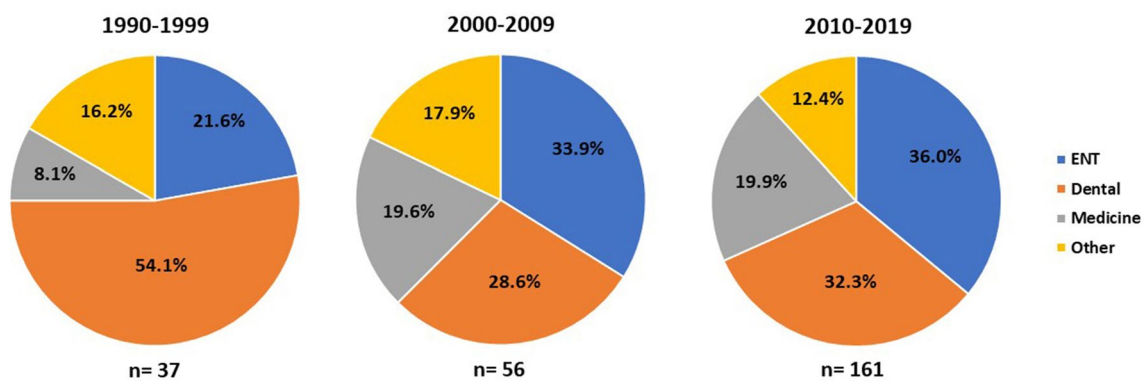
Figure 3 shows the types of specialty journals in which ODS studies were published each decade. The majority of ODS studies were published in either otolaryngology or dental journals every decade (60–75%). While 54% of ODS publications in the 1990s were in dental journals, there were roughly equal proportions of publications in each subsequent decade in both otolaryngology and dental journals (30–35% in each journal type). About 10–20% of ODS studies were published in internal medicine journals, and 10–20% were published in other medical or surgical journals.

Table 3 shows the distribution of ODS publications based on authors' geographic locations. European authors published the most on ODS each decade (45–50%), followed by authors from Asian countries (30–35%). North American authors published about 15–18% of ODS studies each decade. Other continents together represented about 1–5% of ODS publications per decade.

Table 4 shows the distribution of ODS study topics over the 3 decades. ODS treatment represented about 50–60% of publications per decade, and diagnosis represented about 25% per decade. Other topics mostly represented 0–10% of publications per decade. There were almost no significant changes in proportions of study topics between decades, except for a decrease in pathophysiology studies between the last 2 decades from 18.9% in 2000–2009 to 8.8% in 2010–2019 ( $P=0.045$ ).

Table 5 shows the distribution of study designs over the decades. Approximately 70–90% of publications were

**Journal Types with ODS Publications by Decade**



**Fig. 3** Proportions of different specialty journals in which odontogenic sinusitis (ODS) studies were published in each decade from 1990 to 2019. The different specialty journals represented here include otolaryngology (ENT), dental, internal medicine, and other.

Otolaryngology and dental journals contained 60–75% of ODS publications every decade. Note that all journal specialties could be determined for this analysis

**Table 3** Numbers of odontogenic sinusitis publications according to authors' geographic locations (continents) compared between and across decades

Author continents	1990–1999 ( <i>n</i> =28) <i>x</i> (%)	2000–2009 ( <i>n</i> =52) <i>x</i> (%)	2010–2019 ( <i>n</i> =152) <i>x</i> (%)	1990–1999 vs 2000–2009 <i>P</i> value	2000–2009 vs 2010–2019 <i>P</i> value	1990–1999 vs 2010– 2019 <i>P</i> value
Europe	13 (46.4)	26 (50.0)	66 (43.4)	.761	.411	.768
Asia	10 (35.7)	16 (30.8)	47 (30.9)	.652	.984	.616
North America	5 (17.9)	8 (15.4)	28 (18.4)	.775	.620	.944
South America	0	1 (1.9)	7 (4.6)	1.000	.683	.597
Africa	0	1 (1.9)	5 (3.3)	1.000	1.000	1.000
Australia	0	0	2 (1.3)	1.000	1.000	1.000

Note that the number of publications in each decade in this table was lower than overall reported totals due to some studies having authors from unknown continents. There were nine unknowns in 1990–1999, four in 2000–2009, and nine in 2010–2019



**Table 4** Frequencies of odontogenic sinusitis study topics compared between successive decades, and between 1990–1999 and 2010–2019

Topics	1990–1999 ( <i>n</i> = 32) <i>x</i> (%)	2000–2009 ( <i>n</i> = 53) <i>x</i> (%)	2010–2019 ( <i>n</i> = 159) <i>x</i> (%)	1990–1999 vs 2000–2009 <i>P</i> value	2000–2009 vs 2010–2019 <i>P</i> value	1990–1999 vs 2010– 2019 <i>P</i> value
Treatment	19 (59.4)	25 (47.2)	79 (49.7)	.275	.751	.317
Diagnosis	10 (31.3)	16 (30.2)	37 (23.3)	.918	.314	.339
Pathophysiology	3 (9.4)	10 (18.9)	14 (8.8)	.354	<b>.045</b>	1.000
Epidemiology	1 (3.1)	1 (1.9)	17 (10.7)	1.000	.318	.318
Review	0	5 (9.4)	11 (6.9)	.152	.549	.216
Microbiology	1 (3.1)	5 (9.4)	8 (5.0)	.402	.247	1.000

Note that the number of publications in each decade in this table was lower than the overall reported totals due to some studies having unknown topics. There were five unknowns in 1990–1999, three in 2000–2009, and two in 2010–2019. Significant *P* values are bolded

**Table 5** Frequencies of odontogenic sinusitis study designs compared between successive decades, and between 1990–1999 and 2010–2019

Study type	1990–1999 ( <i>n</i> = 27) <i>x</i> (%)	2000–2009 ( <i>n</i> = 55) <i>x</i> (%)	2010–2019 ( <i>n</i> = 151) <i>x</i> (%)	1990–1999 vs 2000–2009 <i>P</i> value	2000–2009 vs 2010–2019 <i>P</i> value	1990–1999 vs 2010– 2019 <i>P</i> value
Case report	11 (40.7)	9 (16.4)	41 (27.2)	<b>.016</b>	.110	.153
Retro CS	14 (51.9)	32 (59.2)	63 (41.7)	.587	<b>.036</b>	.378
Prosp CS	0	4 (7.3)	11 (7.3)	.297	.998	.220
Retro cohort	1 (3.7)	0	7 (4.6)	.329	.193	1.000
Prosp cohort	0	0	5 (3.3)	1.000	.327	1.000
Case–control	0	0	1 (0.7)	1.000	1.000	1.000
DB-RCT	0	0	0	1.000	1.000	1.000
Literature review	1 (3.7)	9 (16.4)	17 (11.3)	.154	.347	.317
Meta-analysis	0	0	4 (2.6)	1.000	.575	1.000
Expert panel	0	0	1 (0.6)	1.000	1.000	1.000
Survey	0	1 (1.8)	1 (0.7)	1.000	.464	1.000
Animal	0	1 (1.8)	0	1.000	.267	1.000

Note that the number of publications in each decade in this table was lower than overall reported totals due to some studies having unknown study designs. There were ten unknowns in 1990–1999, one in 2000–2009, and ten in 2010–2019. Significant *P* values are bolded

*DB-RCT* double-blinded randomized control trial, *prosp CS* prospective case series, *retro CS* retrospective case series

case reports or retrospective case series. Prospective case series represented about 7% of ODS publications per decade from 2000 to 2019. Literature reviews comprised 4–16% of publications per decade. There were no double-blinded randomized controlled trials. There were mostly no significant changes in frequencies of study designs over time, except for a decrease in case reports from the 1990s to 2000s ( $P = 0.016$ ), and a decrease in retrospective case series from 2000–2009 to 2010–2019 ( $P = 0.036$ ).

Table 6 shows the distribution of levels of evidence over the decades. Overall, 92–100% of publications per decade were levels 4 and 5. There was one level 3 case–control study published in 2010–2019. There were nine level 2 studies all published in 2010–2019, five of which were prospective cohort studies.

Note that when assessing changes of all the study variables between 1990–1999 and 2010–2019, there was only one significant change, which was the significant increase in the number of ODS publications by otolaryngologists mentioned previously. None of the other variables changed significantly between the 1990s and 2010–2019.

## Discussion

ODS is a distinct form of sinus disease and requires a different diagnostic and therapeutic approach from rhinosinusitis. While ODS is a relatively common cause of sinusitis, it has received significantly less attention in the literature compared to other forms of rhinosinusitis. Orlandi et al.

**Table 6** Frequencies of odontogenic sinusitis study evidence levels compared between successive decades, and between 1990–1999 and 2010–2019

LOE	1990–1999 ( <i>n</i> =26) <i>x</i> (%)	2000–2009 ( <i>n</i> =54) <i>x</i> (%)	2010–2019 ( <i>n</i> =151) <i>x</i> (%)	1990–1999 vs 2000–2009 <i>P</i> value	2000–2009 vs 2010–2019 <i>P</i> value	1990–1999 vs 2010– 2019 <i>P</i> value
Level 1	0	0	0	–	–	
Level 2	0	0	9 (6.0)	1.000	.112	.607
Level 3	0	0	1 (0.6)	1.000	1.000	1.000
Level 4	15 (57.7)	36 (66.7)	80 (53.0)	.434	.090	.681
Level 5	11 (42.3)	18 (33.3)	61 (40.4)	.434	.343	.875

Note that the number of publications in each decade in this table was lower than overall reported totals due to some studies having unknown levels of evidence. There were 11 unknowns in 1990–1999, 2 in 2000–2009, and 10 in 2010–2019

published an international consensus statement on rhinosinusitis and reported that from 2000 to 2014, nearly 13,000 articles had been published on rhinosinusitis [21]. Based on the current study, ODS represented approximately 1% of the sinusitis literature during that same time period. It is, therefore, no surprise that ODS has been underrepresented in recent North American and European sinusitis guidelines or position statements [20–22]. The main purpose of this review was to highlight trends in the quantity and quality of ODS publications, as a means to consider future directions for ODS research.

While the current review demonstrated an encouraging 450% increase in ODS publications from 1990 to 2019, evidence levels remained low without significant changes over time. Approximately 90–100% of ODS studies were level 4 or 5 evidence every decade. Of these, approximately 70–80% of publications were comprised of retrospective case reports or series, or literature reviews. Banglawala et al. reviewed 3 decades of chronic rhinosinusitis literature and identified 3604 chronic rhinosinusitis studies from 1993 to 2012. While grade C studies were most common overall in every decade, they showed that grade A and B studies both increased significantly over time. From 2003 to 2012, grade A studies represented 7.2%, and grade B studies represented 10.4% of chronic rhinosinusitis publications [28]. The current study showed that there were no level 1 ODS studies (grade A), and level 2 studies were only published in 2010–2019, representing 6% of ODS publications in that decade. While ODS publication volume and quality have lagged behind chronic rhinosinusitis publications, hopefully, the introduction of higher evidence level ODS studies in the last decade is the beginning of an upward trend in levels of evidence for future ODS research.

Between 1990 and 2019, otolaryngologists and dental authors published the majority of ODS studies. ODS publications by otolaryngologists increased over each of the 3 decades. While dental authors published more on ODS than otolaryngologists from 1990 to 2009, there was a decline

in dental publications in 2010–2019. Regarding journals in which ODS studies were published, the majority of articles were published in otolaryngology and dental journals in roughly equal proportions. This review also showed that a minority of ODS publications each decade were multidisciplinary with both otolaryngologists and dental authors, and the proportion of these collaborative studies actually decreased from 24.5% in 2000–2009 to 6% in 2010–2019. This highlights that dental and otolaryngologic readerships rarely derive both dental and rhinologic perspectives in ODS publications, which limits interdisciplinary understanding of the condition. Without an increase in multidisciplinary studies, it will be challenging to develop a shared, interdisciplinary understanding of ODS.

It was also interesting that only 10–15% of ODS studies were published by radiologists per decade, and only 5% of ODS articles were published in radiology journals each decade. This could contribute to why radiologists have been reported to miss odontogenic sources of ODS in 60–70% of cases [14, 15, 18, 19].

It was also evident that European and Asian authors published the majority of ODS studies, with their articles representing 75–80% of ODS publications every decade. Substantially fewer ODS studies were published by authors in North America, South America, Africa, and Australia. No studies to date have demonstrated regional differences in ODS prevalence internationally, and that could be a beneficial study to conduct in the future. A multitude of reasons could explain differences in publication volumes across regions, and future studies could explore why these discrepancies exist.

This review provides several interesting questions to address with future research. First, it would be beneficial for future ODS studies to be designed prospectively and involve both dental and rhinologic providers to ensure consistent and appropriate diagnostic and therapeutic protocols. Additionally, collaboration with radiologists would be very helpful in establishing well-defined radiographic criteria for both dental and sinus pathology seen on different imaging modalities.



For treatment studies, more cohort or case–control studies are needed, but ideally randomized controlled trials would be conducted as well. Again, multidisciplinary collaboration would greatly facilitate such treatment studies. Regarding ODS study topics, significantly more studies are needed on epidemiology, pathophysiology, and microbiology. Authors could also consider publishing across fields in other specialties' journals, to increase ODS awareness amongst other types of clinicians who manage the condition. This could also stimulate further multidisciplinary research collaborations. Lastly, the ODS literature would greatly benefit from collaboration between authors internationally. Such work would be beneficial in determining the prevalence of ODS globally, as well as differences in ODS prevalence between international regions. International collaboration could also facilitate the development of internationally recognized diagnostic and therapeutic approaches for managing ODS. Over time, a greater volume of higher quality ODS studies will provide the foundation upon which diagnostic and therapeutic recommendations can be made in sinusitis guidelines.

There were also limitations of this study to discuss. First, no bias analyses were reported for the reviewed studies, as have been recommended for systematic reviews. However, systematic reviews generally analyze outcomes of certain diagnostic or therapeutic interventions that can be significantly affected by study biases. The variables of interests in the current study were felt largely to be unaffected by individual study biases and, therefore, should not have significantly impacted the results of the review. Another limitation was that some variables could not be determined, mainly due to the inability to translate papers in non-English languages. Fortunately, this was uncommon overall, with about 3–10% of each study variable being unknown across all 3 decades. Additionally, while the review was conducted broadly across multiple online databases, some studies could have been missed due to the limits of performing keyword-based literature searches. Lastly, specific dental author type could not be determined reliably across studies to perform subgroup analyses on types of dental authors and the ODS study variables in this review. For example, it would have been interesting to identify trends in publication characteristics between dentists, endodontists, periodontists, and oral maxillofacial surgeons, as this could help guide areas of future research needed in each dental specialty. This could also have implications for developing multidisciplinary ODS research, as it may be beneficial for otolaryngologists to work with dental specialists who have specialty training in diagnosing and treating specific types of dental pathologies leading to ODS.

## Conclusion

While numbers of ODS publications have increased from 1990 to 2019, they still represent an extreme minority of sinusitis-related publications. Study evidence levels have remained low over the last 3 decades, with predominantly level 4 and 5 evidence. Otolaryngologists and dental providers have published the majority of the ODS literature, though infrequently have studies been multidisciplinary. Future ODS studies would benefit from improved study designs and multidisciplinary collaboration.

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**Author contributions** VG: conception and study design, acquisition of data, manuscript drafting and editing, and final approval. AS: acquisition of data, manuscript drafting and editing, and final approval. EP: data analysis, manuscript drafting and editing, and final approval. JC: conception and study design, acquisition of data, data analysis, manuscript drafting and editing, and final approval.

## Compliance with ethical standards

**Conflict of interest** The authors declare no conflict of interest.

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