Review

Diagnostic Criteria for Odontogenic Sinusitis: A Systematic Review

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Abstract

Background: Odontogenic sinusitis affects a significant proportion of patients with paranasal sinus infections. Nevertheless, no shared diagnostic criteria for this condition have yet been implemented and published studies differ in their definition of the disease.

Objective: The present systematic review of the literature was undertaken to characterize and analyze the different diagnostic criteria currently employed for odontogenic sinusitis.

Methods: Systematic searches for studies published between 2009 and 2019 were performed in Medline, Embase, Web of Science, Cochrane Library, and ClinicalTrials.gov databases. Search criteria were designed to identify all studies focusing, even partially, on odontogenic sinusitis. Human original studies except single case reports published in the English, French, German, Spanish, or Italian language were included. We removed duplicate abstracts and conducted full-text reads, data extraction, and quality assessment procedures (using the Oxford Centre for Evidence-based Medicine levels of evidence and National Heart Lung and Blood Institute Study Quality Assessment Tools). We reviewed articles for diagnostic criteria, both in terms of definition and etiology identification.

Results: Among 1,000 unique citations, 63 studies were deemed eligible. Most articles (n = 45) were retrospective case series; a single randomized clinical trial was available. Only 49 studies reported diagnostic criteria, yet relied marginally on published guidelines (n = 10 articles) for identifying sinusitis, often choosing instead to develop their own clinical (n = 15 articles), endoscopic (n = 12 articles), and/or radiologic (n = 30 articles) criteria. For odontogenic focus identification, 14 papers required a multidisciplinary evaluation, 11 papers required a time relationship between dental procedures and sinusitis, 24 papers required oroscopy and/or dental evaluation, and 53 papers required computed tomography.

Conclusions: Current diagnostic criteria for odontogenic sinusitis are extremely heterogeneous. Establishing shared diagnostic criteria aimed at defining both sinusitis and related odontogenic foci would spur collaboration between investigators and support more comprehensive outcomes evaluations together with a better understanding of treatment options.

Keywords

computed tomography, cone beam computed tomography, dental disease, dental implants, endoscopy, guidelines, maxillary sinus, paranasal sinus, rhinosinusitis grafting maxillary sinus

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Introduction

In an outrageously famous Italian B-movie, Attila the Hun is questioned by a local savant on the distance between Earth and the moon. The uncultivated barbarian replies elusively "It is a common knowledge. I know it, you know it—why should we tell each other?."[1]

Odontogenic sinusitis (OS), a disease first described in the scientific literature in 1943,[2] seems blighted by the same "common knowledge" syndrome. Despite a constant number of studies being published on this topic, the disease not only lacks shared diagnostic criteria but also is often featured in research where patients are diagnosed without meeting any specific criterion.

These data are even more striking if one takes into account that the definition of rhinosinusitis (RS), a disease diagnosed annually in 12% of the United States population,[3] required consensual codification so as to reduce heterogeneity in studies. The American Academy of Otolaryngology—Head and Neck Surgery (AAOHNS) clinical practice guideline for adult sinusitis, last updated in 2015[4]; the International Consensus Statement on Allergy and Rhinology: Rhinosinusitis (ICAR:RS), published in 2015[5]; and the recently updated European Position Paper on Rhinosinusitis and Nasal Polyps (EPOS), updated in 2020,[6] all constitute solid references for diagnosis and management. The current EPOS also recognizes odontogenic sources as a possible cause of acute RS or secondary RS, though it doesn't provide differentiated diagnostic and management pathways for OS.

Moreover, the research on OS suffers from abrupt shifts in terminology (e.g., from the more common classification of OS or odontogenic maxillary sinusitis to more complex definitions such as sinonasal complications of dental disease and treatment[7] or neologisms such as somatogenic sinusitis[8]) Even worse, OS has progressively over time become an umbrella term that different authors have adopted to designate protean sinonasal inflammatory conditions, which may be induced not only by dental disease but also by dental procedures, common implantological procedures, or maxillary sinus augmentations, thus going beyond the etymological definition of "odontogenic" (i.e., deriving from teeth).

OS is, at present, considered different from RS based on an etiological, microbiological, and management standpoint[9] and the failure to recognize it may jeopardize the outcome of conventional RS therapies.[10] Reported statistics suggest that OS may affect 5% of patients undergoing a head computed tomography (CT) scan for any reason[11] and influence as much as 75% of cases of unilateral maxillary sinusitis,[12] so it is understandable that the lack of diagnostic criteria leaves a significant population devoid of a correct diagnosis and, most probably, necessary therapy.

Separately, a lack of widespread systematization leaves, at present, study outcomes almost incomparable to one another and undermines chances to perform valid trials.

Following these considerations, we conducted a systematic review of the recent literature, focusing on the diagnosis of OS, its terminology, and its differential diagnosis with RS. The questions that guided this study were: *how is OS defined in clinical studies*, *is it possible to identify common diagnostic criteria*, and *which scenarios are commonly associated with OS*?

Methods

This review was registered in the international prospective register of systematic reviews (PROSPERO) (No. CRD42020163072) and the review protocol has been made publicly available https://www.crd.york.ac.uk/Prospero/Display_Record.php?ID=CRD42020163072.

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Search Strategy

A systematic review was conducted between January 2 and April 5, 2020, according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) reporting guidelines[13] (see, also, the PRISMA checklist provided as Supplementary Electronic Material). We conducted systematic electronic searches for studies in the English, Italian, German, French or Spanish language reporting original data obtained from humans and published between January 2009 and December 2019 which focused entirely or partly on OS.

On January 2, 2020, we searched the MEDLINE, Embase, Web of Science, Cochrane Library, and ClinicalTrials.gov databases for "sinusitis" and all terms usually associated with OS. The details of our full search strategies and the number of unique items retrieved from each database are available in Supplementary Table 1.

We included any study in which the whole patient population, a study population group, and/or a results patient group were explicitly diagnosed with sinonasal conditions that the original study authors linked to OS.

We excluded meta-analyses, systematic and narrative reviews, letters to the editor, and case reports. There was no minimum study population size that included studies were required to have. References from review articles were checked for additional potentially relevant studies.

Abstracts and full texts were reviewed in duplicate by different authors (C. R. and F. M. for abstracts and F. A. and G. F. for full texts). To maximize the rate

inclusivity in the early stages of the review, at the abstract stage, we included all studies deemed eligible by at least one rater. Then, at the full-text review stage, disagreements were resolved by consensus between raters.

PICO Criteria

The PICO criteria for the present review were as follows:

Patients: Patients with a potential diagnosis of OS.

Intervention: OS diagnostic process.

Comparison: No comparisons were made as no gold standard for OS diagnosis is currently available.

Outcome: Use of different specific diagnostic criteria for OS diagnosis (if any).

Data Extraction and Quality Assessment

For each included article, we recorded the number of OS patients included and the overall population size. We also collected information on the specific terminology used to indicate OS and the specific etiologies included or explicitly excluded in each article. Further, we reported, where available, the criteria for differential diagnosis between OS and RS (through this paper, we will use the term RS, which is more widely accepted, to define what many authors have defined as "rhinogenic" sinusitis, in contrast with OS). We collected data on the use of diagnostic criteria for OS and concerning which criteria were used in each specific article, both in terms of sinusitis identification (subdivided in rhinologic, endoscopic, and radiologic sinonasal evaluations) and odontogenic source identification (focusing on requirements of multidisciplinary evaluation, the temporal relationship between odontogenic focus and signs/symptoms of sinusitis, oroscopy, and dental radiological evaluation).

Selected studies were assessed for both quality and methodological bias according to the National Heart, Lung, and Blood Institute Study Quality Assessment Tools (NHI-SQAT).[14] Articles were rated in duplicate by two authors (A. M. S. and F. A.) and disagreements were resolved by consensus. Items were rated as good if they fulfilled at least 80% of the items required by the NHI-SQAT, fair if they fulfilled between 50% and 80% of the items, and poor if they fulfilled less than 50% of the items, respectively.

Also, the level of evidence was scored according to the Oxford Centre for Evidence-based Medicine (OCEBM) level of evidence guide.[15]

Due to the heterogeneity of data and owing to their qualitative characteristics, a meta-analysis could not be performed.

Results

Search Results

Among the 1,000 unique research items initially identified, a total of 225 articles were selected for full-text evaluation, amongst which 63 relevant studies published between January 2009 and December 2019 were retained for further analysis (Supplementary Figure S1).

A single randomized clinical trial on this topic, albeit not blinded, was found in the literature,[16] while most included studies were retrospective case series (n = 45 studies). One open registered clinical trial was found.[17] Concerning the level of evidence, seven studies were rated as level 2 studies according to the OCEBM scale, eight studies were rated as level 3 studies, and the remaining 47 studies were rated as level 4 studies. The ongoing clinical trial was not rated. According to the NHI-SQAT, 18 articles were rated as good-, 38 articles were rated as fair- and 6 articles were rated as poor-quality studies, respectively. Most articles lacked ample information to support the comparability of patients. As this review didn't focus on therapeutic outcomes, the degree of publication bias was considered negligible and all articles were included in the present review independently of their rating. Supplementary Table 2 reports the characteristics of the included studies.

Use of Diagnostic Criteria and Terminology for OS

Forty-nine studies reported specific diagnostic criteria[7,10,16–62] and 14 studies did not report any diagnostic criteria (either original or referenced) for OS.[8,11,63–74] It should be noted that four articles[10,21,31,39] were retrospective radiological analyses and provided radiologic diagnostic criteria only. Figure 1 reports a graphical analysis of the 63 included articles in terms of their overall use of diagnostic criteria.

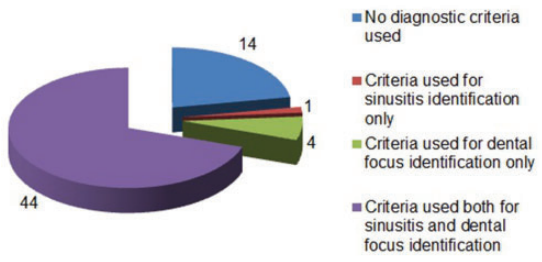

Figure 1. Pie chart reporting the use of diagnostic criteria in the 63 selected studies.

The most used definition remains "odontogenic sinusitis" (n = 29 articles), followed by "odontogenic maxillary sinusitis" (n = 16 articles). Six papers (albeit from only three different study groups) used the more recent classification "sinonasal complications of dental disease and treatment." Finally, just two papers[23,29] proposed the use of "rhinosinusitis" instead of "sinusitis."

OS Etiologies and Differential Diagnosis With RS

A total of 16 papers did not specify which kind(s) of etiology they had included for OS. A majority of the included papers included dental diseases (DD), such as periodontitis or periapical infections (n = 36 papers), and OS following dental treatments (DT) such as extractions or failed endodontic treatments (n = 36 papers). Twenty papers included OS related to dental implants (DI), 12 papers included OS related to maxillary sinus elevation (MSE), and three patients included OS related to medication-related osteonecrosis of the jaw (MRONJ).

Twenty-nine papers compared OS and RS; of these, 27 stated that the differential diagnosis among the two conditions is based on the exclusion of underlying dental causes. Among these 27 papers, a single paper stated that OS should be excluded also in case of bilateral disease or primary ostiomeatal complex obstruction[22] and another one suggested excluding both dental causes and sinonasal neoplasms.[55]

Analysis of Diagnostic Criteria

Among the 49 studies reporting diagnostic criteria, specific information on the seven evaluated parameters (i.e., rhinological evaluation, endoscopic evaluation, sinonasal radiology, requirements of multidisciplinary evaluation, temporal relationship between odontogenic focus and signs/symptoms of sinusitis, oroscopy, and dental radiological evaluation) are analytically reported in Supplementary Table 3 and summarized in Tables 1 and 2. Figure 2 presents a graphical analysis for the 49 studies providing diagnostic criteria based on the aforementioned seven evaluated parameters.

Notably, only the paper by Ly and Hellgren[38] diagnosed OS according to all seven evaluated parameters.

Discussion

This systematic review included a total of 63 studies involving 3,315 patients diagnosed with OS, allowing for a comprehensive evaluation of the pertinent literature of the last decade. Most of the included studies were of good or fair methodological quality, albeit marred by a lack of prospectively collected data, which remains a major issue.[9]

This systematic review revealed the existence of extreme heterogeneity in choosing diagnostic criteria for OS. First and foremost, while RS has garnered the development of specific diagnostic criteria,[4–6] OS emerges as an ill-defined pathology. Interestingly, 14 of 63 articles included in this review failed to propose any diagnostic criteria. Similarly, only four articles in this review[21,31,39,42] share the same criteria (which were only radiological in nature).

An analysis of the present review data suggests that there are two main aspects to deal with in making an OS diagnosis: identifying sinusitis and identifying odontogenic foci. Regarding the former, the use of definitions already accepted by international consensus would appear to be a reasonable choice, yet this route appeared severely underused, adopted in 10 of the 63 articles. Given that both EPOS and AAOHNS guidelines require specific symptoms for the diagnosis of RS,[4,6] only secondarily supported by endoscopy and CT imaging, so articles not reporting or investigating clinical features might not provide a correct representation of the OS population. As a result, we may hypothesize that OS is overdiagnosed in articles or even in clinical practice, leading both to unjustified medical and surgical treatments and biased study results. Endoscopy, which indeed helps in the identification of sinusitis, is even less-frequently employed for diagnosing OS, probably as an indirect result of the cross-specialty management of this condition.

The routine use of standard or cone-beam CT (CBCT) imaging in OS is more widespread, even more than in RS (seven papers used imaging according to international guidelines and another 36 routinely used CT or CBCT). Such diffusion of radiological evaluation could also be due to the frequent need for a dental radiological evaluation in the same patient, which makes the use of CT imaging cost-effective in identifying both sinusitis and dental foci. Despite CT being a sensitive tool for OS diagnosis,[31] its specificity drops significantly when it is used for making a diagnosis without any reference to the patient's clinical presentation. Sinonasal mucosal alterations are extremely common in proximity to diseased teeth but do not necessarily imply the existence of sinonasal disease.[11] In these regards, the widespread use of the criteria suggested by Abrahams and Glassberg,[75] subsequently re-elaborated by Maillet et al.,[39] goes beyond what was originally proposed by the authors. In fact, upon examining the original paper from Abrahams and Glassberg, these authors never once mention the term "sinusitis" throughout the entirety of their study. As such, their indications can be useful in examining the mucosal alterations linked to dental pathology but cannot accurately represent the mainstay of radiological OS diagnosis.

Table 1. Summary of Diagnostic Criteria Provided in the Reviewed Articles Used for Identification of Sinusitis.

Broad Categories of Criteria Used for Sinusitis Identification (Reported in 49 Out of 63 Reviewed Studies), Further Categorized in Rhinologic, Endoscopic and Radiologic Sinonasal Evaluation Criteria		
Rhinological Clinical Evaluation (Reported 25 Out of 49 Studies)	Nasal Endoscopy (Reported in 21 Out of 49 Studies)	Sinonasal Radiological Evaluation (Reported in 42 Out of 49 Studies)
Referencing international consensus (10 out of 25 studies)	Referencing international consensus (8 out of 21 studies)	Referencing international consensus (7 out of 42 studies)
Reporting defined original clinical evaluations (11 out of 25 studies)	Reporting defined endoscopic findings (3 out of 21 studies)	Referencing other published literature (6 out of 42 studies)
Reporting unspecified clinical evaluations (4 out of 25 studies)	Reporting unspecified endoscopic findings (10 out of 21 studies)	Reporting unspecified radiological evaluations (1 out of 42 studies)
		Reporting use of CT/CBCT with detailed findings (15 out of 42 studies)
		Reporting use of CT/CBCT without detailed findings (13 out of 42 studies)

Abbreviations: CBCT, cone-beam computed tomography; CT, computed tomography.

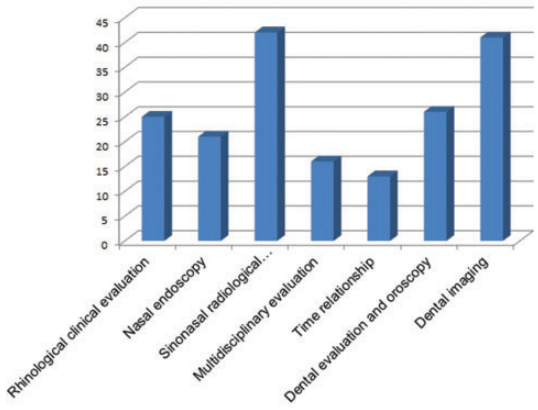

Figure 2. Bar chart based on the 49 studies reporting diagnostic criteria for odontogenic sinusitis indicating the number of articles reporting specific use of criteria according to the 7 parameters evaluated in the systematic review.

The identification of dental foci for diagnosing OS appears almost as varied. A specific analysis shows the need for its systematization, as already summarized by other authors.[9] First and foremost, dental radiological evaluation is advocated for by nearly all authors by means of CT/CBCT scan (n = 53 papers), again often referring to the works of Abrahams and Glassberg[75] and Maillet et al.[39] The need for further specific radiological evaluations such as orthopantomography and periapical radiographs, which convey different and complementary information, should follow the indication of the dental specialist and be determined on a case-by-case basis.[7,49] There are indeed some frequent scenarios such as oroantral communications or DI dislodgements where the use of CT imaging is enough to enable localization of the problem, but endodontic and periapical problems often require further exploration.[57]

While it may sound from the above as if a dental evaluation would be pivotal in diagnosing OS, this approach was surprisingly cited by less than half of the studies included. Further, while dental evaluation may have been implied in some studies, it is still advisable to specify all evaluations performed, again so as to minimize heterogeneity. The need for a multidisciplinary evaluation, required only by 14 papers and most often combining otolaryngology and dental specialists (whether dentists or maxillofacial surgeons), is a highly delicate matter. It is indeed true that some specialists have thorough knowledge of both sinonasal and dental problems in terms of clinical and surgical management,[9] yet we cannot safely infer that these skills exist to an adequate degree in all physicians. Therefore, to ensure a complete OS patient evaluation, it would be advisable to perform a multidisciplinary assessment, either by involving different specialists (e.g., rhinologist and dentist) or a single specialist with adequate training in multiple areas. The last feature we considered, i.e., a temporal link between odontogenic focus and sinusitis symptoms—reported only by 11 papers—is again often implied and considered self-evident but nevertheless important.

Given the importance of establishing shared criteria in building a collective clinical knowledge base concerning any disease and enabling the conduct of well-constructed, comparable, and prospectively designed studies with acceptable external validity, the persistent lack of diagnostic criteria for OS is inexcusable. Hypothetically, this might be rooted either in its multidisciplinarity in that different specialists approach the same disease with different formae mentis, thus leaving different footprints. Meanwhile, another explanation

Table 2. Summary of Diagnostic Criteria Provided in the Reviewed Articles Used for Identification of the Dental Focus.

Broad Categories of Criteria Used for Dental Focus Identification (Reported in 49 Out of 63 Reviewed Studies), Further Categorized: Need for Multidisciplinary Evaluation; Requirement of a Time Relationship Between Dental Problem and Sinusitis; Need for Dental Evaluation/Oroscopy; and Need of Dental Imaging

Multidisciplinary Evaluation (16 Out of 49 Studies)	Time Relationship Between Dental Problem and Sinusitis (13 Out of 49 Studies)	Dental Evaluation and Oroscopy (26 Out of 49 Studies)	Dental Imaging (41 Out of 49 Studies)
Referencing other published literature(1 out of 16 studies)	Referencing other published literature (1 out of 13 studies)	Referencing other published literature (1 out of 26 studies)	Referencing other published literature (6 out of 49 studies)
Referencing patients' dental records (1 out of 16 studies)	Referencing patients' dental records (1 out of 13 studies)	Referencing patients' dental records (1 out of 26 studies)	Reporting use of CT/CBCT (with or without other imaging) with detailed findings (20 out of 49 studies)
Reporting otolaryngologist and dental specialists evaluation (13 out of 16 studies)	Requiring a clear time relationship (7 out of 13 studies)	Reporting detailed original oroscopic findings (5 out of 26 studies)	Reporting use of CT/CBCT (with or without other imaging) with detailed findings (14 out of 49 studies)
Reporting otolaryngologist and radiologist evaluation (1 out of 16 studies)	Reporting unspecified time relationships (4 out of 13 studies)	Reporting unspecified oroscopic findings (19 out of 26 studies)	Reporting use of imaging techniques other than CT/CBCT (1 out of 49 studies)

Abbreviations: CBCT, cone-beam computed tomography; CT, computed tomography.

may lie in the apparently more mechanistic pathophysiological development of OS relative to RS, which has led to a narrower interest in terms of basic research on OS. Whereas research on RS endotypes and immune responses thrive, along with experimental biological therapy trials, OS is still explained as a consequence of a dental problem that acts much like a Trojan horse by allowing the oral microflora into the maxillary sinus[48] and is a disease that can be successfully and easily addressed with surgery. The lack of attention given to the subject in the already mentioned international guidelines does not help in expanding the consciousness regarding OS. While it is true that these guidelines are aimed at RS and not OS, it is still striking that the ICAR:RS and AAOHNS guidelines do not mention OS as a differential etiology and/or diagnosis, while the EPOS guidelines mention OS only briefly without any indication of its diagnosis or management.

Our review also shows that the terminology issue that revolves around OS follows the choice of etiologies considered valid for its diagnosis. When OS was first described,[2] it was somehow easy to define the condition as arising from a diseased tooth, but the evolution of dental science has led to better treatments, such as endodontics, rehabilitation tools (such as DI and MSE), and insight into new pathologies (such as MRONJ). As a consequence of this evolution, choosing which etiologies to accept into the definition of OS and determining how to define them remains a major issue, both in terms of diagnosis and management. Our analysis shows that the general trend is to accept all sinonasal conditions related to teeth and maxillary alveolar bone and processes, whether iatrogenic or not, under the umbrella of OS. At present, given the lack of international consensus, the choice of other, more complex terminologies, while formally correct, makes the identification of studies and patients more difficult. On the other hand, the specific use of "maxillary" odontogenic sinusitis appears limited in the context of a proven extra maxillary and often bilateral sinonasal involvement.[25,47,58] Given that different OS etiologies represent extremely varied clinical scenarios, it would be advisable to formally state which kind of dental foci are included in a study (e.g., dental diseases, dental treatments, DI, or MSE and MRONJ).

The last feature we briefly explored in our review was the differential diagnosis between RS and OS. Although the viewpoint might be biased, having analyzed only literature pertaining to OS, 27 of 29 papers stated that the differential diagnosis is based on the exclusion of dental foci. Given that OS and RS are recognized as radically different diseases,[9,45,48] this point should be further explored. Its passive acceptance would imply the need for dental evaluation in all sinusitis patients.

Importantly, this systematic review has some limitations, albeit intended, in its design. First of all, we imposed a time restriction on our search to include only articles that mirror the current clinical management of OS. More specifically, the latest addition among

currently employed diagnostic tools for OS is CBCT (introduced to the United States market in 2001[76]) which was first used for OS diagnosis in 2010.[77] Consequently, we extended our time frame to 2009 to potentially include all relevant studies that might have exploited currently available and routinely used techniques. Therefore, our systematic review is not designed to report diagnostic criteria for OS that may have been in use before the introduction of CBCT. Nevertheless, no included study cites pre-2009 diagnostic criteria other than the one proposed by Abrahams and Glassberg.[75] Furthermore, we chose to include into this review original studies of all designs, not just prospective studies, and designed our review to include even those not reporting diagnostic criteria but instead simply focusing on OS. At the expense of greater strength of our report, we therefore aimed to provide a detailed description of the current state of the pertinent literature. The last major drawback of this systematic review was the impossibility to restrict the search to articles dealing with the validity of diagnostic tests and tools for OS, given that, at present, no accepted gold standard for OS diagnosis is available.

A comprehensive proposal for OS diagnostic criteria would require the establishment of a formal expert consensus. Based on the data enclosed in this review, it seems reasonable that a solid proposal should take into account both the need to correctly identify sinusitis and the need to adequately define the dental focus triggering the infection. At present, diagnostic criteria for OS currently used in the literature are extremely heterogeneous, with heavy emphasis on radiological evaluations, which raises calls for further calibration. Establishing shared diagnostic criteria aimed at defining both sinusitis and related odontogenic foci is the only method for enabling collaboration between authors and the comparison of outcomes. Standardizing reporting of OS etiologies included in studies and choosing consistent inclusion criteria would allow for future meta-analyses and a better understanding of treatment options for OS. Furthermore, better OS definitions would help in the differential diagnosis with RS, which, at present, might act as a major confounder for studies. In these regards, a multidisciplinary effort going beyond the simple otolaryngological perspective would be pivotal.

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Supplemental Material

Supplemental material for this article is available online.

References

1. Cecchi Gori M, Cecchi Gori V, (Producers) Castellano F, et al. *Attila Flagello di Dio [Attila, Scourge of God; Motion Picture]*. Italy: Intercapital; 1982.
2. Bauer WH. Maxillary sinusitis of dental origin. *Am J Orthod Dentofacial Orthop*. 1943;29(3):B133–B151.
3. Blackwell DL, Lucas JW, Clarke TC. Summary health statistics for U.S. adults: national health interview survey, 2012. *Vital Health Stat 10*. 2014;(260):1–161.
4. Rosenfeld RM, Piccirillo JF, Chandrasekhar SS, et al. Clinical practice guideline (update): adult sinusitis. *Otolaryngol Head Neck Surg*. 2015;152(Suppl 2):S1–S39.
5. Orlandi RR, Kingdom TT, Hwang PH, et al. International consensus statement on allergy and rhinology: rhinosinusitis. *Int Forum Allergy Rhinol*. 2016;6(Suppl 1):S22–S209.
6. Fokkens WJ, Lund VJ, Hopkins C, et al. European position paper on rhinosinusitis and nasal polyps 2020. *Rhinology*. 2020;58(Suppl S29):1–464.
7. Felisati G, Chiapasco M, Lozza P, et al. Sinonasal complications resulting from dental treatment: outcome-oriented proposal of classification and surgical protocol. *Am J Rhinol Allergy*. 2013;27(4):e101–6–e106.
8. Varzhapetian SD, Gulyuk AG, Barannik NG, et al. Chronic inflammation of the Schneiderian membrane of patients with stomatogenical maxillary sinusitis according to the results the data of the lectin histochemistry. *World Med Biol*. 2018;3(65):17–23.
9. Workman AD, Granquist EJ, Adappa ND. Odontogenic sinusitis: developments in diagnosis, microbiology, and treatment. *Curr Opin Otolaryngol Head Neck Surg*. 2018;26(1):27–33.
10. Fredriksson MV, Öhman A, Flygare L, et al. When maxillary sinusitis does not heal: findings on CBCT scans of the sinuses with a particular focus on the occurrence of odontogenic causes of maxillary sinusitis. *Laryngosc Investig Otolaryngol*. 2017;11(2):442–446.
11. Drumond J, Allegro B, Novo N, et al. Evaluation of the prevalence of maxillary sinuses abnormalities through spiral computed tomography (CT). *Int Arch Otorhinolaryngol*. 2017;21(2):126–133.
12. Albu S, Baciut M. Failures in endoscopic surgery of the maxillary sinus. *Otolaryngol Head Neck Surg*. 2010;142(2):196–201.
13. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate healthcare interventions: explanation and elaboration. *BMJ*. 2009;339:b2700.
14. Study Quality Assessment Tools. National Heart, Lung, and Blood Institute (NHLBI). https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools. Accessed March 2, 2020.

15. "The Oxford Levels of Evidence 2. Oxford Centre for Evidence-Based Medicine. https://www.cebm.net/index.aspx?o=5653. Accessed March 2, 2020.
16. Albu S, Baciut M, Opincariu I, et al. The canine fossa puncture technique in chronic odontogenic maxillary sinusitis. *Am J Rhinol Allergy*. 2011;25(5):358–362.
17. Prospective Study on the Efficacy of Exclusive Odontological and Medical Treatment in Chronic Dental Maxillary Sinusitis. https://clinicaltrials.gov/ct2/show/NCT04085536. Accessed, March 27, 2020.
18. Abu-Ghanem S, Kleinman S, Horowitz G, et al. Combined maxillary sinus floor elevation and endonasal endoscopic sinus surgery for coexisting inflammatory sinonasal pathologies: a one-stage double-team procedure. *Clin Oral Implants Res*. 2015;26(12):1476–1481.
19. Akiyama K, Nakai Y, Samukawa Y, et al. Assessment of simultaneous surgery for odontogenic sinusitis: endoscopic sinus surgery with endoscopic apicoectomy. *J Craniofac Surg*. 2019;30(1):239–243.
20. Andric M, Saranovic V, Drazic R, et al. Functional endoscopic sinus surgery as an adjunctive treatment for closure of oroantral fistulae: a retrospective analysis. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*. 2010;109(4):510–516.
21. Bajoria AA, Sarkar S, Sinha P. Evaluation of odontogenic maxillary sinusitis with cone beam computed tomography: a retrospective study with review of literature. *J Int Soc Prev Community Dent*. 2019;9(2):194–204.
22. Cartwright S, Hopkins C. Odontogenic sinusitis an underappreciated diagnosis: our experience. *Clin Otolaryngol*. 2016;41(3):284–285.
23. Chen Y-W, Huang C-C, Chang P-H, et al. The characteristics and new treatment paradigm of dental implant-related chronic rhinosinusitis. *Am J Rhinol Allergy*. 2013;27(3):237–244.
24. Craig JR, McHugh CI, Griggs ZH, et al. Optimal timing of endoscopic sinus surgery for odontogenic sinusitis. *Laryngoscope*. 2019;129(9):1976–1983.
25. Crovetto-Martínez R, Martin-Arregui F-J, Zabala-López-de-Maturana A, et al. Frequency of the odontogenic maxillary sinusitis extended to the anterior ethmoid sinus and response to surgical treatment. *Med Oral Patol Oral Cir Bucal*. 2014;19(4):e409–e413.
26. Czarnecka P, Rutkowska M, Popecki P, et al. Chronic odontogenic paranasal sinusitis in the material provided by the otorhinolaryngology unit of the 4th military teaching hospital in wroclaw. *Dent Med Probl*. 2017;54(1):29–34.
27. Fadda GL, Berrone M, Crosetti E, et al. Monolateral sinonasal complications of dental disease or treatment: when does endoscopic endonasal surgery require an intraoral approach? *Acta Otorhinolaryngol Ital*. 2016;36(4):300–309.
28. Fusetti S, Emanuelli E, Ghirotto C, et al. Chronic oroantral fistula: combined endoscopic and intraoral approach under local anesthesia. *Am J Otolaryngol*. 2013;34(4):323–326.
29. Gaudin RA, Hoehle LP, Smeets R, et al. Impact of odontogenic chronic rhinosinusitis on general health-related quality of life. *Eur Arch Otorhinolaryngol*. 2018;275(6):1477–1482.
30. Giovannetti F, Priore P, Raponi I, et al. Endoscopic sinus surgery in sinus-oral pathology. *J Craniofac Surg*. 2014;25(3):991–994.
31. Guerra-Pereira I, Vaz P, Faria-Almeida R, et al. CT maxillary sinus evaluation—a retrospective cohort study. *Med Oral Patol Oral Cir Bucal*. 2015;20(4):e419–e426.
32. Haider AA, Marino MJ, Yao WC, et al. The potential of high-throughput DNA sequencing of the paranasal sinus microbiome in diagnosing odontogenic sinusitis. *Otolaryngol Head Neck Surg*. 2019;161(6):1043–1047.
33. Huang Z, Xu H, Xiao N, et al. Predictive significance of radiographic density of sinus opacity and bone thickness in unilateral maxillary sinus mycetoma. *ORL J Otorhinolaryngol Relat Spec*. 2019;81(2–3):111–120.
34. Kasikcioglu A, Gulsahi A. Relationship between maxillary sinus pathologies and maxillary posterior tooth periapical pathologies. *Oral Radiol*. 2016;32(3):180–186.
35. Kende P, Mathai PC, Landge J, et al. Combined endoscopic and intra-oral approach for chronic maxillary sinusitis of dental origin-a prospective clinical study. *Oral Maxillofac Surg*. 2019;23(4):429–437.
36. Kim SJ, Park JS, Kim HT, et al. Clinical features and treatment outcomes of dental implant-related paranasal sinusitis: a 2-year prospective observational study. *Clin Oral Implants Res*. 2016;27(11):e100–e104.
37. Lee KC, Lee SJ. Clinical features and treatments of odontogenic sinusitis. *Yonsei Med J*. 2010;51(6):932–937.
38. Ly D, Hellgren J. Is dental evaluation considered in unilateral maxillary sinusitis? A retrospective case series. *Acta Odontol Scand*. 2018;76(8):600–604.
39. Maillet M, Bowles WR, McClanahan SL, et al. Cone-beam computed tomography evaluation of maxillary sinusitis. *J Endod*. 2011;37(6):753–757.
40. Matsumoto Y, Ikeda T, Yokoi H, et al. Association between odontogenic infections and unilateral sinus opacification. *Auris Nasus Larynx*. 2015;42(4):288–293.
41. McCarty JL, David RM, Lensing SY, et al. Root cause analysis: an examination of odontogenic origins of acute maxillary sinusitis in both immunocompetent & immunocompromised patients. *J Comput Assist Tomogr*. 2017;41(3):484–488.
42. Pereira IG, Vaz P, Almeida RF, et al. IRAK4 gene polymorphism and odontogenic maxillary sinusitis. *Clin Oral Investig*. 2015;19(8):1815–1824.
43. Pokorny A, Tataryn R. Clinical and radiologic findings in a case series of maxillary sinusitis of dental origin. *Int Forum Allergy Rhinol*. 2013;3(12):973–979.
44. Prakash BG, Biyyapu S. Incidence of odontogenic sinusitis—experience in a tertiary care center. *Int J Sci Stud*. 2016;3(12):105–109.
45. Puglisi S, Privitera S, Maiolino L, et al. Bacteriological findings and antimicrobial resistance in odontogenic and non-odontogenic chronic maxillary sinusitis. *J Med Microbiol*. 2011;60(Pt 9):1353–1359.
46. Raman A, Papagiannopoulos P, Kuhar HN, et al. Histopathologic features of chronic sinusitis precipitated by odontogenic infection. *Am J Rhinol Allergy*. 2019;33(2):113–120.

47. Saibene AM, Pipolo GC, Lozza P, et al. Redefining boundaries in odontogenic sinusitis: a retrospective evaluation of extramaxillary involvement in 315 patients. *Int Forum Allergy Rhinol*. 2014;4(12):1020–1023.
48. Saibene AM, Vassena C, Pipolo C, et al. Odontogenic and rhinogenic chronic sinusitis: a modern microbiological comparison. *Int Forum of Allergy Rhinol*. 2016;6(1):41–45.
49. Saibene AM, Collurà F, Pipolo C, et al. Odontogenic rhinosinusitis and sinonasal complications of dental disease or treatment: prospective validation of a classification and treatment protocol. *Eur Arch Otorhinolaryngol*. 2019;276(2):401–406.
50. Simuntis R, Kubilius R, Padervinskis E, et al. Clinical efficacy of main radiological diagnostic methods for odontogenic maxillary sinusitis. *Eur Arch Otorhinolaryngol*. 2017;274(10):3651–3658.
51. Simuntis R, Vaitkus J, Kubilius R, et al. Comparison of Sino-Nasal outcome test 22 symptom scores in rhinogenic and odontogenic sinusitis. *Am J Rhinol Allergy*. 2019;33(1):44–50.
52. Sutanegara SWD, S, Suditha IB. Characteristics sinusitis of outpatients ENT clinic in Sanglah hospital, period January to December 2014. *Biomed Pharmacol J*. 2018;11(1):191–195.
53. Tomomatsu N, Uzawa N, Aragaki T, et al. Aperture width of the osteomeatal complex as a predictor of successful treatment of odontogenic maxillary sinusitis. *Int J Oral Maxillofac Surg*. 2014;43(11):1386–1390.
54. Trimarchi M, Galli A, Capparè P, et al. Odontogenic infections in the head and neck: a case series. *J Osseointegr*. 2019;11(1):29–37.
55. Troeltzsch M, Pache C, Troeltzsch M, et al. Etiology and clinical characteristics of symptomatic unilateral maxillary sinusitis: a review of 174 cases. *J Craniomaxillofac Surg*. 2015;43(8):1522–1529.
56. Tsuji T, Tanaka S, Nishide Y, et al. Clinical implications of taste thresholds in patients with odontogenic maxillary sinusitis. *Int J Oral Maxillofac Surg*. 2018;47(3):379–385.
57. Turfe Z, Ahmad A, Peterson EI, et al. Odontogenic sinusitis is a common cause of unilateral sinus disease with maxillary sinus opacification. *Int Forum Allergy Rhinol*. 2019;9(12):1515–1520.
58. Ungar OJ, Yafit D, Kleinman S, et al. Odontogenic sinusitis involving the frontal sinus: is middle meatal antrostomy enough? *Eur Arch Otorhinolaryngol*. 2018;275(9):2291–2295.
59. Wang KL, Nichols BG, Poetker DM, et al. Odontogenic sinusitis: a case series studying diagnosis and management. *Int Forum Allergy Rhinol*. 2015;5(7):597–601.
60. Ye J, Hu S, Bian M, et al. Endoscopic sinus surgery plays an essential role in systematic treatment of odontogenic maxillary sinusitis. *Laparosc Endosc Robot Surg*. 2018;1(1):19–23.
61. Zhang Y, Lan F, Li Y, et al. Formation of papillary mucosa folds and enhancement of epithelial barrier in odontogenic sinusitis. *Int Forum Allergy Rhinol*. 2019;9(11):1281–1288.
62. Zirk M, Dreiseidler T, Pohl M, et al. Odontogenic sinusitis maxillaris: a retrospective study of 121 cases with surgical intervention. *J Craniomaxillofac Surg*. 2017;45(4):520–525.
63. Barannik NG, Varzhapetyan SD, Moseyko AA, et al. Choice of optimal medical therapy for chronic odontogenic maxillary sinusitis by determining antibacterial response in microflora of maxillary sinuses. *N Armen Med J*. 2014;8(3):65–69.
64. Bomeli SR, Branstetter BF, Ferguson BJ. Frequency of a dental source for acute maxillary sinusitis. *Laryngoscope*. 2009;119(3):580–584.
65. Chemli H, Mnejja M, Dhouib M, et al. [Maxillary sinusitis of odontogenic origin: surgical treatment]. *Rev Stomatol Chir Maxillofac*. 2012;113(2):87–90.
66. Costa F, Emanuelli E, Franz L, et al. Single-step surgical treatment of odontogenic maxillary sinusitis: a retrospective study of 98 cases. *J Craniomaxillofac Surg*. 2019;47(8):1249–1254.
67. Hoskison E, Daniel M, Rowson JE, et al. Evidence of an increase in the incidence of odontogenic sinusitis over the last decade in the UK. *J Laryngol Otol*. 2012;126(1):43–46.
68. Huang Y-C, Chen W-H. Caldwell-Luc operation without inferior meatal antrostomy: a retrospective study of 50 cases. *J Oral Maxillofac Surg*. 2012;70(9):2080–2084.
69. Landsberg R, Warman M, Margulis A, et al. The rationale for endoscopic inferior meatal antrostomy. *ORL J Otorhinolaryngol Relat Spec*. 2019;81(1):41–47.
70. Mattos JL, Ferguson BJ, Lee S. Predictive factors in patients undergoing endoscopic sinus surgery for odontogenic sinusitis. *Int Forum Allergy Rhinol*. 2016;6(7):697–700.
71. Varzhapetian S, Makarenko O, Sydoryako A, et al. Aerobic microflora in the pathogenesis of maxillary sinusitis after the treatment of caries complications. *Georgian Med News*. 2019;289:42–46.
72. Varzhapetyan SD, Gulyuk AG. The study of histotopography of glycoconjugates in the perspective of the development of local therapy of stomatological maxillary sinusitis. *WOMAB*. 2018;14(64):126–131.
73. Venetis G, Bourlidou E, Liokatis PG, et al. Endoscopic assistance in the diagnosis and treatment of odontogenic maxillary sinus disease. *Oral Maxillofac Surg*. 2014;18(2):207–212.
74. Wuokko-Landén A, Blomgren K, Välimaa H. Acute rhinosinusitis—are we forgetting the possibility of a dental origin? a retrospective study of 385 patients. *Acta Otolaryngol*. 2019;139(9):783–787.
75. Abrahams JJ, Glassberg RM. Dental disease: a frequently unrecognized cause of maxillary sinus abnormalities? *AJR Am J Roentgenol*. 1996;166(5):1219–1223.
76. Hatcher DC. Operational principles for cone-beam computed tomography. *J Am Dent Assoc*. 2010;141(S3):3S–6S.
77. Cymerman JJ, Cymerman DH, O'Dwyer RS. Evaluation of odontogenic maxillary sinusitis using cone-beam computed tomography: three case reports. *J Endod*. 2011;37(10):1465–1469.