POTRYKUS, Maria, MUSYT, Wiktoria, PIETRUSZKA, Wiktoria and KLASICKI, Przemysław. Odontogenic Maxillary Sinusitis: Etiological Pathways and Clinical Implications – A Contemporary Review. Quality in Sport. 2025;43:62409. eISSN 2450-3118.
https://doi.org/10.12775/QS.2025.43.62409
https://apcz.umk.pl/QS/article/view/62409

The journal has been awarded 20 points in the parametric evaluation by the Ministry of Higher Education and Science of Poland. This is according to the Annex to the announcement of the Minister of Higher Education and Science dated 05.01.2024, No. 32553. The journal has a Unique Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 Lp. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).
The authors declare that there is no conflict of interest regarding the publication of this paper.
Received: 15.06.2025. Revised: 11.07.2025. Accepted: 11.07.2025. Published: 14.07.2025.

Odontogenic Maxillary Sinusitis: Etiological Pathways and Clinical Implications – A Contemporary Review

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ABSTRACT

Introduction: Odontogenic sinusitis (OS) constitutes a significant yet frequently underdiagnosed clinical entity at the intersection of dental and otorhinolaryngological disorders. The primary etiological factors include periapical lesions affecting the maxillary premol ars and molars, as well as complications related to endodontic treatment. Cone beam computed tomography (CBCT) is crucial for accurate diagnosis, enabling detailed assessment of the anatomical relationship between the teeth and the maxillary sinus.

Aim of the Study: The aim of this study is to present current diagnostic and therapeutic guidelines for odontogenic sinusitis, with an emphasis on the importance of interdisciplinary collaboration in achieving effective management and minimizing complications.

Methods: A literature review was conducted based on the PubMed and Google Scholar databases using the keywords: „*odontogenic sinusitis”*, „*chronic maxillary sinusitis”*, „*FESS”*, „*oroantral fistula”*, „*dental sinusitis treatment”.*

Conclusion: Effective management of odontogenic sinusitis requires an interdisciplinary approach, integrating elimination of the infectious source, restoration of sinus ostium patency, and tailored pharmacotherapy. Coordinated collaboration between dental and otorhinolaryngological specialists plays a key role in optimizing treatment outcomes and reducing the risk of complications.

Keywords: chronic maxillary sinusitis, dental sinusitis treatment, odontogenic sinusitis, oroantral fistula

INTRUDUCTION

Odontogenic maxillary sinusitis (OMS) accounts for approximately 10–30% of maxillary sinusitis cases and most commonly results from infections of the maxillary premolars and molars (1) (2). The main etiological factors include chronic inflammatory lesions in periapical tissues, complications from endodontic treatment or tooth extraction, and the presence of oroantral fistulas (3). Unlike rhinosinusitis of rhinogenic origin, OMS typically presents unilaterally. Its nonspecific clinical presentation poses a diagnostic challenge (4) (5). Inadequate or delayed diagnosis may result in chronic inflammation, recurrence, and the development of both local and systemic complications, ultimately impairing patients ’quality of life. Given the growing importance of an interdisciplinary approach and the need for early and accurate diagnosis—particularly via advanced imaging techniques-OMS remains a significant clinical challenge (6). This study aims to present current guidelines for OMS diagnosis and management, emphasizing the role of imaging and interdisciplinary collaboration.

ANATOMY

The complex anatomical relationships between the maxillary sinus and the roots of the maxillary premolars and molars play a crucial role in the pathogenesis of odontogenic sinusitis (OS) and in the development of complications after dental procedures. Thorough knowledge of this anatomy is essential to recognize potential pathways through which infections may spread from dental and periodontal sites into the sinus cavity. The floor of the maxillary sinus - particularly in its lateral aspect-is often located in close proximity to the roots of the teeth, especially the first and second molars. In some cases, the root apices are separated from the sinus cavity only by this thin mucosal layer, with no intervening bone. This anatomical configuration markedly increases the risk of infection spreading from dental sources into the sinus. The thickness of the Schneiderian membrane varies among individuals, ranging from 0.3 to 1 mm under physiological conditions. However, it becomes thickened in inflammatory states, which may have diagnostic and therapeutic implications (7) (8).

The distance between the root apices and the sinus floor ranges from 0.5 to 2 mm. In some cases, there is no separation at all. This close proximity facilitates the extension of inflammation from periapical tissues to the sinus mucosa, leading to OS. Additionally, individual anatomical variations - including the degree of sinus pneumatization, thickness of the bony septum, and extent of alveolar process resorption - affect the risk of inflammatory complications and should be considered when planning dental and surgical treatments (1) (3).

DIAGNOSIS

The diagnosis of OMS relies on an integrated otolaryngological and dental approach, requiring collaboration between specialists. A detailed clinical history is crucial, including questions about recent dental procedures, tooth pain worsened by chewing, and the unilateral nature of symptoms. An atypical clinical course characterized by absence of classic nasal congestion, malodorous discharge, localized sinus pain, and a sensation of fullness should raise suspicion for OMS (2) (9).

Otorhinolaryngological examination - including anterior rhinoscopy and nasal endoscopy - assesses the maxillary sinus ostium, presence of purulent discharge in the middle nasal meatus, and mucosal changes such as asymmetry, hypertrophy, and edema (9).

OMS typically presents with unilateral sinus involvement and purulent contents, suggesting an infectious origin.

Dental examination should focus on identifying infectious foci, such as periapical lesions, abscesses, previous endodontic treatments, extractions, and oroantral fistulas. Imaging diagnostics are an important adjunct to the evaluation process.

Cone beam computed tomography (CBCT) is the preferred imaging modality. CBCT, the preferred imaging modality, enables precise assessment of the spatial relationship between tooth roots and the sinus floor, as well as detection of inflammatory changes, foreign materials (e.g., gutta-percha), fistulas, cysts, and fluid levels (10) (11) (12). Conventional panoramic radiography (OPG) enables simultaneous evaluation of multiple teeth; however, its spatial resolution and sensitivity are lower. Computed tomography (CT) of the sinuses is primarily used to assess the extent of lesions, presence of fluid, and complications (13).

The Lund-Mackay scale is a recognized tool for assessing the severity of chronic rhinosinusitis based on CT scan results. It provides standardized classification of sinus aeration impairment and ostiomeatal complex patency, which is important for diagnosis and treatment evaluation (14) (15).

In diagnostically challenging or treatment-resistant cases, culturing purulent discharge is recommended to guide targeted antibiotic therapy. Additionally, in patients with suspected systemic involvement or complications, laboratory tests such as C-reactive protein (CRP), and complete blood count (CBC) may be considered. In cases of suspected non-infectious etiology - particularly allergic - appropriate allergy testing is warranted (13) (16).

DIFFERENTIAL DIAGNOSIS

OMS often presents atypically, requiring increased clinical vigilance and interdisciplinary collaboration during diagnosis and treatment. Symptoms suggestive of OMS include unilateral facial pain in the maxillary sinus area exacerbated by bending forward, halitosis, purulent nasal discharge, and postnasal drip - usually limited to one side. In severe inflammation, swelling of the cheek or adjacent soft tissues may occur, accompanied by a sensation of sinus fullness. Fever is often absent. Symptoms may also include toothache or pain localized to the area of a previous tooth extraction. An oroantral fistula may allow fluids to pass from the oral to the nasal cavity during drinking (17) (18).

Table 1. Differences between Rhinogenic and Odontogenic Rhinosinusitis (1) (6) (19) (20)

Feature	Odontogenic Rhinosinusitis (ORS)	Rhinogenic Rhinosinusitis (RRS)
Onset	Often follows endodontic treatment, tooth extraction, or periapical inflammation	After viral infection, common cold, or allergy
Location	Usually unilateral (left or right maxillary sinus)	Often bilateral, involving multiple sinuses
Pain	Severe, localized, may radiate to tooth or temporal region	Diffuse, pressure-like, located in the forehead or nasal root
Toothache	Common and pronounced	Rare or absent
Nasal discharge	Thick, purulent, unilateral	Often clear or bilateral purulent (bacterial etiology)
Oral malodor	Often markedly unpleasant	Less frequently altered

Imaging diagnostics	Root-sinus contact visible, sometimes fistula or fluid in sinus	Changes in multiple sinuses, no dental origin
Treatment	Requires dental treatment or surgical intervention plus antibiotics	Mainly symptomatic, antibiotics if bacterial infection

OS should be suspected in patients with unilateral symptoms, purulent nasal discharge, pain near upper molars or premolars, recent endodontic treatment, tooth extraction or advanced caries, halitosis, and absence of typical viral infection signs. In these cases, examination of the oral cavity and dentition is recommended. If periapical lesions, tenderness on percussion, or a fistula are detected, CBCT or OPG imaging should be performed. OMS diagnosis is confirmed when clinical and radiological findings show coexisting dental and sinus inflammation (2) (5).

ETIOLOGY

OMS is a distinct clinical entity among paranasal sinus infections, differing in pathogenesis, clinical features, and treatment. Current epidemiological data indicate that dental causes are responsible for approximately 10–30% of chronic maxillary sinusitis (CMS) cases (1) (5).

Infection can spread to the maxillary sinus via direct contact between infected tooth roots and the sinus floor, through an oroantral fistula, or as a complication of dental procedures including tooth extractions, endodontic treatment, implant placement, or sinus floor elevation. Predisposing anatomical factors include a low - lying sinus floor relative to the roots of premolars and molars, a thin or absent bony lamina separating roots from the sinus cavity, bony septa that impede mucus drainage, and accidental displacement of dental materials or root fragments into the sinus (3).

The most common cause of OMS is chronic periapical inflammation, typically originating from maxillary teeth 4–7. The inflammatory process may spread through the root canal and apical foramen into the sinus, leading to chronic mucosal inflammation, purulent discharge, and persistent changes in the Schneiderian membrane (11). Histopathological examinations frequently reveal epithelial metaplasia and chronic inflammatory infiltrates (2).

Advanced periodontal disease involving alveolar bone destruction can also result in perforation into the maxillary sinus and subsequent secondary inflammation. Peri-implantitis, causing bone loss around implants, may also allow infection to penetrate the sinus cavity (6).

Iatrogenic causes of OMS commonly include oroantral fistula formation after tooth extraction, retention of endodontic materials (e.g., gutta-percha, sealers), and sinus wall perforation during dental procedures. Improper implant placement into the sinus without proper diagnostic planning is also a frequent cause. These conditions facilitate colonization of the sinus by oral flora, including both aerobic and anaerobic bacteria such as *Fusobacterium, Prevotella, Peptostreptococcus*, and *Streptococcus* species (13) (21).

Accurate diagnosis requires thorough differential diagnostics supported by modern imaging - most notably CBCT - which enables detailed assessment of root-sinus proximity, fistulas, inflammatory changes, and foreign materials. Effective management requires an interdisciplinary approach involving otolaryngologists and dental specialists. Prevention depends on careful dental procedures in the posterior maxilla, thorough preoperative diagnostics, and appropriate treatment of dental and periodontal inflammation.

COMPLICATIONS

Chronic rhinosinusitis (CRS) is defined as inflammation of the nasal and paranasal sinus mucosa lasting at least 12 weeks. Two main clinical subtypes are distinguished: CRS with nasal polyps (CRSwNP) and CRS without nasal polyps (CRSsNP). If left untreated or inadequately managed, CRS may result in a range of complications, typically classified as local, orbital, intracranial, or systemic. Local complications arise from the spread of inflammation to adjacent anatomical structures. Specifically, this includes periostitis and osteomyelitis, which, in the context of CRS, most commonly affect the frontal bone. This can result in the formation of a so-called Pott's puffy tumor, a manifestation of a subperiosteal abscess. The chronic inflammatory infiltrate causing this condition results in bone destruction and can serve as a source of intracranial infection. This clinical scenario requires aggressive management, combining broad-spectrum antibiotic therapy with surgical intervention (22) (23).

Orbital complications are among the most commonly observed, particularly in children and young adults. They are primarily associated with inflammation of the ethmoid and maxillary sinuses, whose thin bony walls facilitate infection spread into the orbit. One such manifestation is orbital cellulitis - diffuse inflammation of the orbital soft tissues without abscess formation - characterized by pain with eye movement, eyelid edema, and restricted ocular motility. In more advanced cases, a subperiosteal abscess may develop, characterized by a localized collection of pus between the periosteum and the orbital wall, often necessitating surgical intervention. Orbital abscess represents a more severe complication, involving the formation of a pus-filled cavity within the orbit. This condition may lead to globe displacement, optic nerve damage, visual impairment, and potentially complete vision loss (24) (25) (26) (27). One of the most severe orbital complications is cavernous sinus thrombosis, which develops as a result of infection spreading via the facial venous system. This condition has a rapid and potentially fatal course, with clinical manifestations including proptosis, cranial nerve palsies, and signs of systemic inflammatory response (28).

Intracranial complications are among the most severe and life-threatening sequelae. In the course of CRS, meningitis may develop, spreading either by direct extension or via venous channels. Clinical manifestations include high fever, neck stiffness, photophobia, and neurological symptoms, often necessitating intensive care unit admission. A brain abscess most commonly develops in the frontal lobe as a complication of frontal sinusitis and presents with progressively worsening headache, signs of increased intracranial pressure, neurological deficits or seizures (29).

Another serious complication is septic cerebral venous sinus thrombosis, most commonly affecting the cavernous sinus or superior sagittal sinus, resulting in rapid deterioration of the patient's general condition and posing a life-threatening risk (30).

Systemic complications of CRS are associated with chronic immune system activation and the potential for infection dissemination. Exacerbations of coexisting bronchial asthma are frequently observed, particularly in patients with CRSwNP. A clinical syndrome exemplifying the association between CRS and systemic diseases is Samter's triad (Widal's triad), which includes CRSwNP, asthma, and aspirin hypersensitivity (31). In rare cases, sepsis may develop as a result of bacterial dissemination into the bloodstream (32). This phenomenon primarily affects immunocompromised patients, who may also develop disseminated bacterial infections involving multiple organs (33) (34). Cases of endocarditis have also been reported as originating from chronic inflammatory foci within the sinuses, with etiological agents including *Streptococcus pneumoniae* (21).

In summary, complications of CRS, although less frequent than in acute inflammatory states, can lead to severe and sometimes irreversible consequences. Their development requires thorough diagnostics, and treatment should be carried out in an interdisciplinary manner involving an otorhinolaryngologist, neurologist, ophthalmologist, and infectious disease specialists. Early diagnosis and prompt initiation of appropriate therapy are crucial to improving the prognosis and preventing long-term complications.

DENTAL TREATMENT

Deep dental caries is an advanced pathological process characterized by the destruction of hard dental tissues, including enamel and dentin demineralization, as well as proteolysis of the organic matrix, extending toward the dental pulp. In advanced cases, it can lead to pulpitis or necrosis. A key aspect is the accurate differential diagnosis between reversible and irreversible pulpitis, based on a thorough medical history, clinical examination - including responses to thermal stimuli, palpation, and percussion - and radiographic assessment of periapical changes and caries depth. If the pulp remains vital, conservative treatment involves the application of bioactive materials such as mineral trioxide aggregate (MTA) or Biodentine - in procedures of indirect or direct pulp capping. These materials exhibit bioinductive properties that promote reparative dentin formation and pulp tissue regeneration. Literature reports confirm the high effectiveness of these therapies in the treatment of deep carious lesions (35).

In cases of irreversible pulpitis or pulp necrosis, endodontic treatment is required. This involves the chemomechanical preparation of the root canal system using manual or rotary instruments, followed by intensive irrigation with disinfecting solutions - most commonly sodium hypochlorite (2.5–5.25%) and ethylenediaminetetraacetic acid (EDTA). The procedure is completed by the obturation of the canal with gutta-percha and a sealer to ensure a hermetic seal. Final restoration of the tooth crown restores both function and coronal integrity, concluding the treatment process. Techniques such as passive ultrasonic irrigation (PUI) and negative pressure systems (e.g., EndoVac) enhance the effectiveness of decontaminating the canal system by improving the removal of bacterial biofilm and necrotic tissue (36) (37).

A dental abscess is an acute, localized infection of the periapical tissues or periodontium, characterized by the accumulation of purulent exudate. Periapical abscesses most commonly arise as a consequence of pulp necrosis, with the infection spreading through the apical foramen into the periradicular tissues. Clinical manifestations typically include severe pain, localized swelling, erythema, increased warmth, fever, and often a palpable area of fluctuation. Diagnosis is established through a comprehensive clinical examination, including percussion sensitivity testing and radiographic imaging. Management involves the elimination of the infection source—either by means of root canal therapy or tooth extraction—along with drainage of the abscess through endodontic access or surgical incision. Adjunctive antibiotic therapy (e.g., amoxicillin with clavulanic acid, clindamycin, or metronidazole) is indicated in patients exhibiting systemic signs of infection or when there is a risk of infection spreading into the deep cervical fascial spaces (38).

An oroantral fistula is a pathological communication between the oral cavity and the maxillary sinus, most frequently arising as a complication following the extraction of maxillary premolars or molars. Clinical manifestations include the unintended passage of fluids between the oral and nasal cavities, persistent unilateral nasal discharge, and signs of maxillary sinusitis. Diagnostic confirmation involves the use of the Valsalva maneuver, probing of the fistulous tract, and CBCT. CBCT is particularly valuable for evaluating the size of the defect and the presence of coexisting inflammatory changes within the sinus. Small fistulas (typically <5 mm in diameter) may undergo spontaneous closure, provided that inflammation is adequately controlled and appropriate surgical management is implemented. Larger defects require surgical closure, most commonly via advancement of a buccal mucoperiosteal flap—commonly known as the Rehrmann flap - or alternatively, by utilizing a rotational palatal flap. (39). In recent years, regenerative techniques have gained increasing prominence in the management of oroantral fistulas. These include the use of collagen membranes, resorbable bone graft substitutes, and platelet-rich fibrin (PRF), which promotes tissue regeneration, accelerates wound healing, and reduces postoperative discomfort. In chronic cases, adjunctive pharmacological therapy with systemic antibiotics, combined with sinus irrigation using antiseptic solutions, is often necessary to control infection and prepare the site for surgical closure. (40).

Tooth extraction procedures, particularly in anatomically complex cases - such as impacted teeth, multi-rooted teeth, or teeth in close proximity to the maxillary sinus - are associated with an increased risk of complications. The most common include alveolar wall fractures, retained root fragments, displacement of root segments into the maxillary sinus, nerve injuries (notably to the inferior alveolar or lingual nerve), postoperative infections, oroantral fistula formation, and alveolar osteitis (dry socket). Diagnosis is based on thorough clinical examination and imaging, with CBCT being the preferred modality for evaluating complications. Management strategies vary according to the specific complication: surgically removing retained fragments, retrieving displaced material from the sinus via the Caldwell–Luc approach, and addressing nerve injuries through neurological consultation, analgesia, and neuroprotective therapy (e.g., B-complex vitamins, pregabalin, or gabapentin). In cases of dry socket, treatment involves gentle wound debridement, the application of eugenol-containing dressings, and symptomatic pain control. (41) (42). Particular caution and meticulous planning of the extraction procedure are essential to prevent these complications.

LARYNGOLOGICAL TREATMENT

In early and mild cases of OMS, conservative treatment may be effective, including empirical antibiotic therapy and symptomatic management. The first-line pharmacological treatment remains amoxicillin with clavulanic acid (875 mg + 125 mg twice daily for 10–14 days). For patients with penicillin hypersensitivity, alternative antibiotics such as cefuroxime, clindamycin, or fluoroquinolones like levofloxacin can be administered. Concurrently, the use of intranasal glucocorticosteroids, such as mometasone furoate, is recommended to reduce inflammation and facilitate drainage of the sinus ostium (43). Supportive treatment includes nasal irrigation with isotonic or hypertonic saline solutions, often combined with mucolytics such as acetylcysteine to enhance mucus clearance. However, conservative management alone in OS often has limited effectiveness, typically providing only temporary symptomatic relief without addressing the underlying cause of the disease (5) (20) (32).

In cases of CRS, comprehensive and coordinated diagnostic and therapeutic management is essential. While pharmacological treatment may be effective in mild cases, surgical intervention remains the standard approach for advanced or recurrent disease, most commonly performed endoscopically via Functional Endoscopic Sinus Surgery (FESS). This procedure enables the opening of the natural sinus ostium, removal of hypertrophic and inflamed mucosal tissue, elimination of foreign materials and purulent contents, as well as the collection of samples for histopathological and microbiological examination. In cases with a coexisting oroantral fistula, surgery can be combined with simultaneous closure of the fistula, typically performed by a dental or maxillofacial surgeon (44).

An alternative to FESS, particularly when it proves insufficient or in cases of recurrent sinus disease with deeply located infectious material, is the Caldwell-Luc operation. This surgical technique provides direct access to the floor of the maxillary sinus and is often necessary for managing chronic fungal infections, large odontogenic cysts, or the removal of foreign bodies that are difficult to extract (45).

A fundamental element of effective OMS treatment is interdisciplinary cooperation between the otorhinolaryngologist and the dentist or maxillofacial surgeon. Simultaneous elimination of the odontogenic infection source - through tooth extraction, endodontic treatment or retreatment, fistula closure, and oral cavity sanitation - significantly enhances treatment efficacy and prevents recurrences. Combined surgical and dental management achieves success rates exceeding 90%, whereas interventions limited to a single specialty more often lead to infection recurrence (1).

OMS, often underestimated in clinical practice, represents a significant therapeutic challenge. Due to its complex etiopathogenesis, effective management requires a comprehensive, interdisciplinary approach. FESS remains the gold standard for treating chronic cases resistant to pharmacotherapy, especially when associated with fistulas, retained dental materials, or other factors impeding spontaneous lesion resolution.

PREVENTION

Effective prevention of OS relies on meticulous planning of dental procedures and close interdisciplinary collaboration among dentists, maxillofacial surgeons, and otolaryngologists. Imaging diagnostics are fundamental, with particular emphasis on CBCT, which provides detailed assessment of anatomical relationships - especially between the root apices of molars and premolars and the maxillary sinus floor - as well as identification of anatomical variants that may predispose patients to sinus-related complications (1) (3). During endodontic treatment and tooth extractions, special care must be taken when handling periapical tissues to avoid perforating the sinus floor or inadvertently introducing materials into the sinus cavity. Overfilling root canals with sealing materials - particularly those containing paraformaldehyde or zinc oxide-eugenol - can cause chronic inflammation of the sinus mucosa (2). In implantology, treatment planning must consider both the height of the alveolar ridge and the quality of the bone. When bone volume is insufficient, maxillary sinus floor elevation (sinus lift) is essential for the safe placement of implants, ensuring the Schneiderian membrane remains intact (18) (46).

Equally important is the management of periodontal diseases, especially inflammation of the deeper tissues. Progressive destruction of the periodontium can facilitate the spread of infection to the maxillary sinus. Additionally, retained foreign materials - such as root fragments, broken endodontic instruments, or filling materials - can serve as chronic sources of inflammation and must be removed to prevent complications (44).

Regular dental check-ups - especially for patients with anatomical predispositions (e.g., low-lying maxillary sinuses, teeth with long roots) or a history of sinus infections - are a vital part of secondary prevention. Thorough application of these preventive measures substantially reduces the risk of iatrogenic maxillary sinusitis and enhances long-term dental treatment outcomes.

SUMMARY

OMS constitutes a significant subset of paranasal sinus infections, predominantly linked to pathological conditions affecting the upper maxillary premolars and molars. The most frequent causes include chronic periapical lesions, complications following endodontic treatments or tooth extractions, and the presence of oroantral fistulas. OMS typically presents with unilateral sinus involvement and an atypical clinical course, often leading to diagnostic challenges. Accurate diagnosis depends on close interdisciplinary collaboration between dentists and otolaryngologists, supported by advanced imaging modalities - especially CBCT - which provides detailed evaluation of the anatomical relationships between teeth and the maxillary sinus. Effective treatment focuses on eliminating the infectious source, restoring proper sinus drainage, and administering targeted antibiotic therapy. If left untreated, OMS may result in serious local, orbital, intracranial, and systemic complications. Consequently, early diagnosis, a comprehensive therapeutic strategy, and prevention of iatrogenic harm are essential to ensure successful outcomes and reduce complication risks.

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All authors have read and agreed with the published version of the manuscript.

Funding Statement
The study did not receive special funding.

Institutional Review Board Statement
Not applicable.

Informed Consent Statement
Not applicable.

Data Availability Statement
The data presented in this study is available upon request from the corresponding author.

Acknowledgments
Not applicable.

Conflict of Interest Statement
All authors declare that they have no conflicts of interest.

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