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## SIGNIFICANCE

Endodontic infections in posterior superior teeth can cause pathologic changes in the maxillary sinus. All cases reported in this series showed dental and/or sinus signs and symptoms that resolved after dental intervention. All cases, except 1 further diagnosed as a nonodontogenic sinusitis, showed a satisfactory response of the periradicular tissues and maxillary sinus to therapies that consisted of root canal treatment, root amputation, extraction, or trauma management.

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# Effects of Endodontic Infections on the Maxillary Sinus: A Case Series of Treatment Outcome

## ABSTRACT

This article shows the follow-up of several cases of maxillary sinusitis of dental (usually endodontic) origin, with different manifestations, diagnostic challenges, and outcomes. Cases from 14 patients from 3 countries and treated by 7 different endodontists are presented, all of them with inflammatory sinus changes represented by mucositis, osteoperiostitis, and/or partial/full obstruction. All cases showed dental and/or sinus signs/symptoms that resolved after dental management. In 13 cases, the sinus condition had an endodontic origin, 4 of them concurrently with periodontal involvement. In 1 case, sinusitis was caused by trauma to the face. All cases but 1 had a satisfactory response of the periradicular tissues and maxillary sinus to treatment that consisted of root canal therapy, root amputation, extraction, or trauma management. The successful management of most cases reported in this article emphasizes the importance of endodontics as a specialty engaged in saving teeth and promoting health not only in the oral cavity but also in other areas that may be affected by infections of endodontic origin, including the maxillary sinus. (*J Endod* 2021;47:1166–1176.)

## KEY WORDS

Apical periodontitis; maxillary sinusitis; root canal treatment; treatment outcome

Sinusitis, also known as rhinosinusitis, is an inflammatory condition involving the mucous membranes of the paranasal sinuses and nasal cavity<sup>1</sup>. It can be acute, recurrent acute, subacute, or chronic depending on the duration; the main causes are infection (bacterial or viral), allergies, and pollution<sup>2</sup>. Given the anatomic proximity, oral infection, iatrogenic dental procedures, and dentomaxillofacial trauma involving the maxillary posterior teeth may affect the maxillary sinus to cause a type of sinusitis referred to as odontogenic sinusitis<sup>3</sup>. Endodontic or periodontal infections in maxillary posterior teeth cause inflammation in the periradicular tissues that may spread and reach the sinus. These are the most common causes of odontogenic sinusitis. Nonetheless, sinusitis resulting from iatrogenic surgical procedures, such as displacement of tooth apices or other foreign bodies into the sinus, as well as dental implants that penetrate the sinus, is not uncommon<sup>4–6</sup>. Odontogenic sinusitis differs from sinogenic sinusitis in both pathogenetic and therapeutical aspects. For instance, although the latter is usually treated with an exclusive focus on the symptoms, odontogenic sinusitis usually requires professional intervention to remove the cause<sup>7</sup>.

Numerous studies have shown that infections in maxillary posterior teeth can cause pathologic changes in the maxillary sinus in 60%–80% of cases<sup>8–10</sup>. Although several studies mentioned a prevalence of approximately 12% of maxillary sinusitis cases with a dental etiology<sup>1,5,11–13</sup>, recent studies have shown a dental etiology for maxillary sinusitis in 30%–40%<sup>14,15</sup>, 50%<sup>16</sup>, and 72%<sup>17</sup> of cases. In more severe cases of sinusitis, this association becomes stronger; a dental etiology may account for up to 86% of the cases<sup>18</sup>.

The proximity of the root apices of the maxillary posterior teeth to the maxillary sinus is the most important risk factor for the endodontic infection to spread into the sinus to cause pathologic changes<sup>19</sup>. The root apex of maxillary posterior teeth may even project into the maxillary sinus and directly contact the sinus mucosa. Even if the root apex does not penetrate the sinus floor, an apical periodontitis lesion may expand and perforate the cortical floor and the periosteum of the sinus. Sinus involvement commonly associated with apical periodontitis includes periapical osteoperiostitis and periapical mucositis<sup>20</sup>.

If untreated, these conditions may evolve to partial or total obstruction of the maxillary sinus. The term *maxillary sinusitis of endodontic origin* (MSEO) has been proposed to specifically describe the sinus manifestations resulting from endodontic infections, which is arguably the main cause of “odontogenic sinusitis”<sup>21</sup>. This new terminology assumes special relevance because it not only addresses the specific etiology of the disease but also helps guide therapeutic management.

There are several previous case reports showing adequate management of odontogenic sinusitis, especially MSEO, by proper dental treatment<sup>8,22–31</sup>. The purpose of this case series was to contribute to this documentation by presenting the follow-up of several cases of maxillary sinusitis of dental (usually endodontic) origin, with different manifestations, diagnostic challenges, and outcomes.

## CASE SERIES

This case series is composed of 14 patients (5 men, 9 women; mean age = 51 years; range, 21–77 years) who were treated in the private practice of endodontic specialists from Brazil (4 endodontists, 8 patients), Argentina (2 endodontists, 5 patients), and Dominican Republic (1 endodontist, 1 patient). All patients had a diagnosis of sinus involvement as revealed by cone-beam computed tomographic (CBCT) imaging and sought treatment or were referred to the endodontist because of symptoms, 5 of which were already suggestive of sinus disease. The patients’ chief complaint and dental and medical histories were obtained. The medical history was noncontributory to all patients, except for cases 5 (hypothyroidism) and 11 (hypertension), both medicated and under control. Only 1 of the patients reported a previous history of allergy. For the evaluation of all patients, preoperative periapical radiographs and CBCT examination were conducted. Intraoral and extraoral examinations as well as pulp and periapical tests of the suspected teeth were performed. The presence of swelling and/or actively draining sinus tracts was recorded. The pulp and periradicular diagnosis was based on the chief complaint, signs and symptoms, pulp and periradicular tests, and radiographic and CBCT findings. If no endodontic origin was confirmed, the patient was referred to an otolaryngologist for further evaluation. CBCT findings of sinus involvement were incidental in most cases, except cases 5, 6, 7, 9, and 12, for which sinus involvement was suspected based on symptoms. Patient demographics

and preoperative data are depicted in Table 1, and treatment details and outcome evaluation are presented in Table 2.

### Case 1

A 77-year-old Brazilian man had a chief complaint of pain in the maxillary right molar region. Teeth 1, 2, and 4 had previous endodontic treatments, but the patient could not recall precisely when they were concluded. The periapical diagnosis for these teeth was asymptomatic apical periodontitis, except for tooth 2, which had symptomatic apical periodontitis. The patient reported that he had been asymptomatic since the first treatments, and the symptoms were new. Radiographs and CBCT imaging revealed a large periapical radiolucency on the palatal root of tooth 2 and an extensive area of mucositis in the maxillary sinus. Endodontic retreatment was performed in tooth 2 in 2 appointments using sodium hypochlorite (NaOCl) irrigation and calcium hydroxide medication. The patient also took amoxicillin for 7 days. After complete endodontic retreatment, the mesiobuccal root of tooth 2 was resected because of an extensive periodontal defect. The patient returned 13 months later for a follow-up CBCT scan, which revealed that the apical periodontitis lesion in tooth 2 had healed completely and the periapical mucositis had resolved (Fig. 1A and B).

### Case 2

A 43-year-old Brazilian woman had a chief complaint of pain in the maxillary left quadrant. On clinical examination, tooth 14 presented a carious lesion, and tooth 15 responded with pain to periapical tests. The pulp diagnosis for both teeth 14 and 15 was necrosis. Radiographic and CBCT examinations revealed that both teeth had apical periodontitis lesions, which in tooth 15 was symptomatic and associated with periapical osteoperiostitis and mucositis affecting the sinus. Endodontic treatment was performed on both teeth 14 and 15 in 2 visits using NaOCl irrigation and calcium hydroxide medication, and the patient reported that the symptoms disappeared. The follow-up examination after 18 months revealed satisfactory healing of the apical periodontitis lesions of both teeth, including the osteoperiostitis, but the opacified area increased in the maxillary sinus to cause almost full obstruction (Fig. 1C–E). The patient was referred to an otolaryngologist, and a CBCT panoramic reconstruction showed bilateral involvement of the maxillary sinus, suggesting a nonendodontic origin.

### Case 3

A 65-year-old Brazilian woman had a chief complaint of severe pain in the upper left molar

region and presented with swelling of the alveolar mucosa. Clinical and radiographic examinations led to the diagnosis of an acute apical abscess in tooth 14. After the emergency treatment, the clinician prescribed amoxicillin for 7 days and dipyrone for 5 days. CBCT examination revealed sinus mucositis. Endodontic treatment was performed in 2 visits using NaOCl irrigation and calcium hydroxide medication. After 9 months, a CBCT examination showed that the apical periodontitis lesion was almost completely healed, and the sinus was clear, free of the periapical mucositis (Fig. 2A–D).

### Case 4

A 50-year-old Brazilian man was referred for endodontic evaluation because of a sinus tract located between the apices of teeth 14 and 15. CBCT and radiographic examinations revealed that both teeth had their root canals previously treated and obturated with silver points; both were associated with apical periodontitis lesions. The previous treatments were performed 25 years ago, but the sinus tract appeared only recently. The sinus tract was traced back to tooth 14. CBCT imaging revealed that the palatal roots of both teeth were associated with a thickening of the maxillary sinus membrane and periapical osteoperiostitis on tooth 14. Endodontic retreatment was performed in 2 visits using NaOCl irrigation and calcium hydroxide medication. The patient returned 26 months later for a follow-up CBCT scan, which revealed that the apical periodontitis lesions were healed in tooth 14 and healing in tooth 15 (Fig. 2E–J). The sinus condition had completely resolved.

### Case 5

A 49-year-old Argentinian woman had chief complaints of unpleasant taste, severe facial pain, and nasal congestion in the maxillary right quadrant. She also reported a feeling that the right cheekbone area was heavier when lowering her head. At clinical examination, a sinus tract was detected at the level of tooth 2. Tenderness to palpation and vertical percussion were present in teeth 2, 3, and 4. A periodontal pocket was present on probing. CBCT examination showed an extensive apical periodontitis lesion and bone loss compatible with a radicular fracture in the palatal root of tooth 2. The right maxillary sinus was completely obstructed. Teeth 2 and 4 had previous root canal treatments (concluded 8 years before), intraradicular posts, and well-adapted restorations. The patient was referred to an otolaryngologist, who diagnosed maxillary sinusitis of dental origin. Extraction was indicated for tooth 2, and the symptoms resolved 1 week later. The 24-month follow-up

**TABLE 1** - Demographics, Signs and Symptoms, and Diagnosis of Patients with Sinus Pathologic Changes of Dental Origin

Case	Sex	Age (y)	Signs/symptoms	Involved tooth no.	Periapical tests	Periodontal probing	Root canal conditions	Periradicular diagnosis	Maxillary sinus findings
1	Male	77	Pain in the maxillary right side	2	Pp (+) Pc (+)	Periodontal pocket (localized)	Treated	Symptomatic AP	Mucositis
2	Female	43	Pain in the maxillary left side	14	Pp (-) Pc (-)	Normal	Necrosis	Asymptomatic AP	Osteoperiostitis/ mucositis
3	Female	65	Swelling and severe dental pain	14	Pp (+) Pc (+)	Normal	Necrosis	Symptomatic AP	Mucositis
4	Male	50	Sinus tract	14	Pp (-) Pc (-)	Normal	Treated	Acute apical abscess	Osteoperiostitis/ mucositis
				15	Pp (-) Pc (-)	Normal	Treated	Chronic apical abscess	
5	Female	49	Facial pain Nasal congestion Discomfort to head positional change Sinus tract	2	Pp (+) Pc (+)	Periodontal pocket (localized)	Treated	Asymptomatic AP Chronic apical abscess	Full obstruction
6	Male	58	Pain when chewing Discomfort to head positional change Sinus tract	4	Pp (+) Pc (+)	Periodontal pocket (localized)	Treated	Symptomatic AP	Mucositis/partial obstruction
				5	Pp (+) Pc (+)	Periodontal pocket (localized)	Treated	Chronic apical abscess	
7	Female	52	Facial pain Pain in the maxillary right molar area, Difficulty in chewing Discomfort to head positional change Intraoral swelling	1	Pp (+) Pc (+)	Periodontal pocket	Necrosis	Symptomatic AP	Osteoperiostitis/ partial obstruction
				2	Pp (+) Pc (+)	pocket (localized to tooth 2)	Necrosis	Symptomatic AP	
				3	Pp (+) Pc (+)		Treated	Symptomatic AP	
8	Female	45	Dental pain Intraoral swelling	13	Pp (+) Pc (+)	Normal	Treated	Symptomatic AP	Mucositis
				14	Pp (+) Pc (+)	Normal	Incompletely treated	Symptomatic AP	
9	Female	21	Trauma (extrusive luxation) Discomfort when chewing Nasal discharge Alveolar fracture	9	Pp (+) Pc (-) Pp (+) Pc (-)	Normal	Necrosis	Normal	Mucositis
10	Female	70	Dental pain Pain on chewing	14	Pp (+) Pc (+)	Normal	Treated	Symptomatic AP	Osteoperiostitis/full obstruction
11	Female	61	Pain in the maxillary left side	14	Pp (+) Pc (+)	Normal	Incompletely treated	Acute apical abscess	Osteoperiostitis/ mucositis
12	Female	40	Pain on chewing Nasal discharge	15	Pp (+) Pc (+)	Normal	Treated	Acute apical abscess	Partial obstruction
13	Male	46	Dental pain Intraoral swelling	15	Pp (+) Pc (+)	Normal	Treated	Acute apical abscess	Mucositis/partial obstruction
14	Male	38	Pressure on the maxillary right side Dental pain	3	Pp (+) Pc (+)	Normal	Treated	Symptomatic AP	Partial obstruction

AP, apical periodontitis; Pc, percussion; Pp, palpation.

CBCT examination showed complete resolution of the sinus congestion (Fig. 3A and B).

### Case 6

A 58-year-old Argentinian man had chief complaints of pain in the maxillary right premolars when chewing, unpleasant taste, and a sensation of heaviness in the right cheekbone area when lowering his head. Intraoral examination revealed a sinus tract between teeth 4 and 5, both of which had treated canals and were positive to periapical

testing. Probing revealed a deep periodontal pocket affecting both teeth. The CBCT scan revealed thickening of the periodontal ligament space of tooth 4, and tooth 5 had an apical periodontitis lesion. CBCT imaging disclosed a large area of sinus mucositis associated with teeth 4 and 5. A visit to an otolaryngologist was indicated, who diagnosed odontogenic maxillary sinusitis. After presenting the treatment options to the patient, a decision for extraction was made for both teeth 4 and 5. The 5-month clinical follow-up showed closure

of the sinus tract, and CBCT imaging revealed resolution of the maxillary sinus condition (Fig. 3C–F).

### Case 7

A 52-year-old Argentinian woman had a chief complaint of pain in the area of the maxillary right molars with difficulty chewing and heaviness sensation when lowering her head. Periapical tests were positive in teeth 1, 2, and 3. A deep periodontal pocket was found on probing examination of tooth 2 and

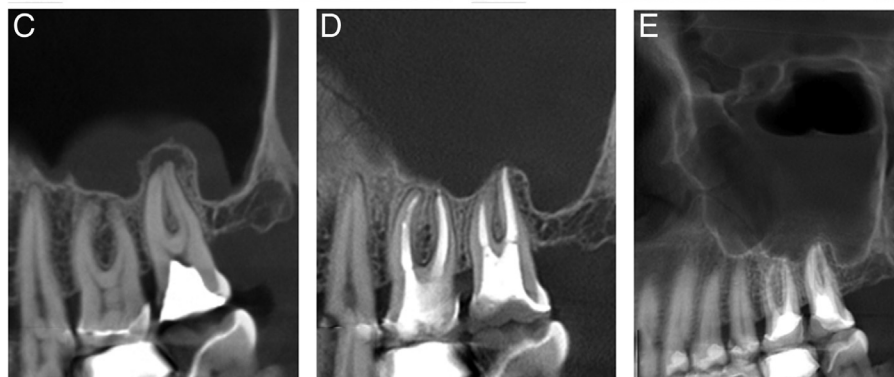
**TABLE 2** - Sinus and Periradicular Outcome after Dental Treatment

Case	Tooth	Treatment	Coronal restoration	Periradicular tissue status	Maxillary sinus status	Follow-up (months)
1	2	Root canal retreatment/root amputation	Adequate	Healed	Healed	13
2	14	Root canal treatment	Adequate	Healed	Diseased	18
	15	Root canal treatment	Adequate	Healed		
3	14	Root canal treatment	Adequate	Healing	Healed	9
4	14	Root canal retreatment	Adequate	Healed	Healed	26
	15	Root canal retreatment	Adequate	Healing		
5	2	Extraction	—	Healed	Healed	24
6	4	Extraction	—	Healed	Healed	5
	5	Extraction				
7	1	Root canal treatment	Adequate	Healed	Healed	15
	2	Extraction	—	Healed		
	3	Root canal retreatment	Adequate	Healed		
8	13	Root canal retreatment	Adequate	Healing	Healed	6
	14	Root canal retreatment	Adequate	Healing		
9	—	Trauma management	Adequate	Healed	Healed	4
10	14	Extraction	—	Healed	Healed	28
11	14	Root canal treatment	Adequate	Healing	Healed (osteoperiostitis) Healing (mucositis)	17
12	15	Root canal retreatment	Adequate	Healed	Healed	3
13	15	Root canal retreatment	Adequate	Healed	Healing	36
14	3	Root canal retreatment	Adequate	Healing	Healing	12

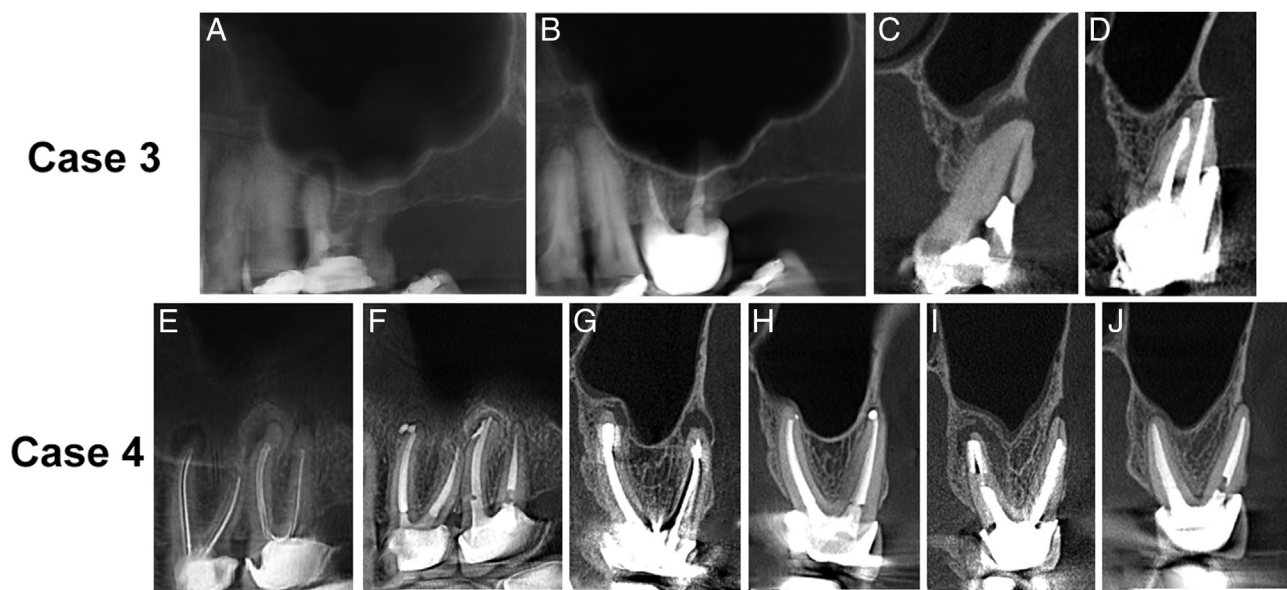
## Case 1



## Case 2



**FIGURE 1** – CBCT scans of cases 1 and 2. (A and B) Case 1. (A) A CBCT scan showing sinus mucositis associated with teeth with endodontic and periodontal infections. (B) A CBCT scan taken 13 months after endodontic retreatment and root amputation showing full resolution of the sinus condition. (C–E) Case 2. (C) A CBCT scan revealing sinus osteoperiostitis and mucositis associated with apical periodontitis lesions. (D and E) A CBCT scan taken 18 months later, showing periradicular tissue healing after endodontic treatment, including resolution of the osteoperiostitis, but the sinus condition aggravated to almost full obstruction.



**FIGURE 2** – CBCT scans of cases 3 and 4. (A–D) Case 3. (A and C) Sinus mucositis associated with a tooth with an acute apical abscess. (B and D) Full resolution of the sinus condition 9 months later. The apical periodontitis lesion is partially healed. (E–J) Case 4. (E, G, and I) Root canal–treated teeth with apical periodontitis lesions associated with sinus osteoperiostitis and mucositis. (F, H, and J) Resolution of the periradicular and sinus conditions 26 months after root canal retreatment of the 2 maxillary molars.

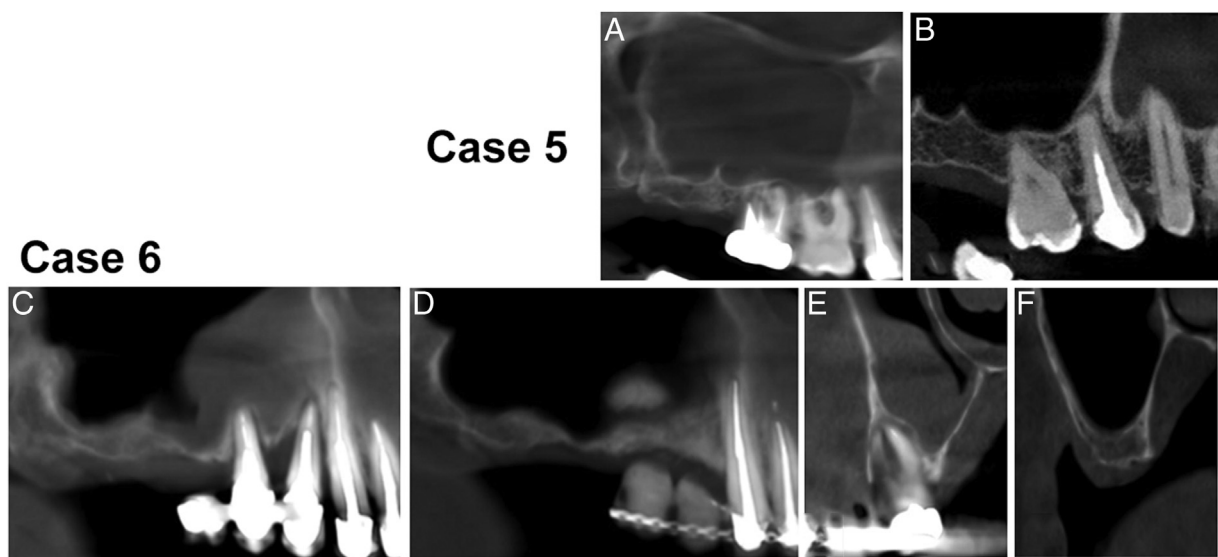
distally to tooth 3. Tooth 2 had a large apical periodontitis lesion that extended to the maxillary sinus leading to severe bone loss at the floor of the sinus and buccal plate, as revealed by CBCT imaging. Teeth 1 and 3 showed thickening of the periodontal ligament space. The patient was referred to an otolaryngologist, who diagnosed odontogenic maxillary sinusitis. Tooth 2 was extracted. Tooth 1 was endodontically

treated, and tooth 3 was retreated (previous treatment concluded 11 years before); they were both concluded in 1 session. NaOCl was used for irrigation during instrumentation, and a final passive ultrasonic irrigation was performed. The patient was prescribed amoxicillin/clavulanic acid for 7 days after root canal treatment. The patient returned 15 months later, and the CBCT imaging and periapical radiographs showed

complete resolution of the sinus condition and repair of the periradicular tissues (Fig. 4A–D).

#### Case 8

A 45-year-old Dominican woman presented with a chief complaint of persistent moderate pain in teeth 13 and 14 for a period of 3 months and for which she was taking analgesics. The patient reported sporadic allergic rhinitis



**FIGURE 3** – CBCT scans of cases 5 and 6. (A and B) Case 5. (A) Full obstruction of the maxillary sinus associated with a large apical periodontitis in tooth 2. (B) The sinus is completely clear 24 months after tooth extraction. (C–F) Case 6. (C and E) Mucositis and partial sinus obstruction associated with maxillary teeth with endodontic and periodontal infections. (D and F) A CBCT scan showing sinus improvement 5 months after extraction of the 2 involved teeth.

episodes. Both teeth 13 and 14 were endodontically treated and showed tenderness to percussion. The treatments were performed 20 years previously, but the symptoms appeared only recently. CBCT and radiographic examinations revealed apical periodontitis lesions in both teeth. The CBCT scan revealed destruction of the buccal bone associated with tooth 13, possibly related to a lateral canal. CBCT imaging also revealed mucositis in the maxillary sinus area related to the apex of both teeth. Endodontic retreatment was performed in tooth 13 in 3 visits and in tooth 14 in 2 visits. In both teeth, NaOCl was used as the main irrigant; then, it was ultrasonically agitated, and a calcium hydroxide interappointment medication was placed. The patient was completely asymptomatic at the conclusion of the retreatments. After 6 months, a follow-up CBCT scan showed resolution of the sinus mucosa inflammation (Fig. 4E–H). Additionally, partial repair of the periradicular tissues of tooth 13 as well as a complete periapical repair at the level of the palatal and distobuccal roots and a considerable decrease in the periapical lesion of the mesiobuccal root of tooth 14 were observed. Part of the buccal cortical bone was repaired.

#### Case 9

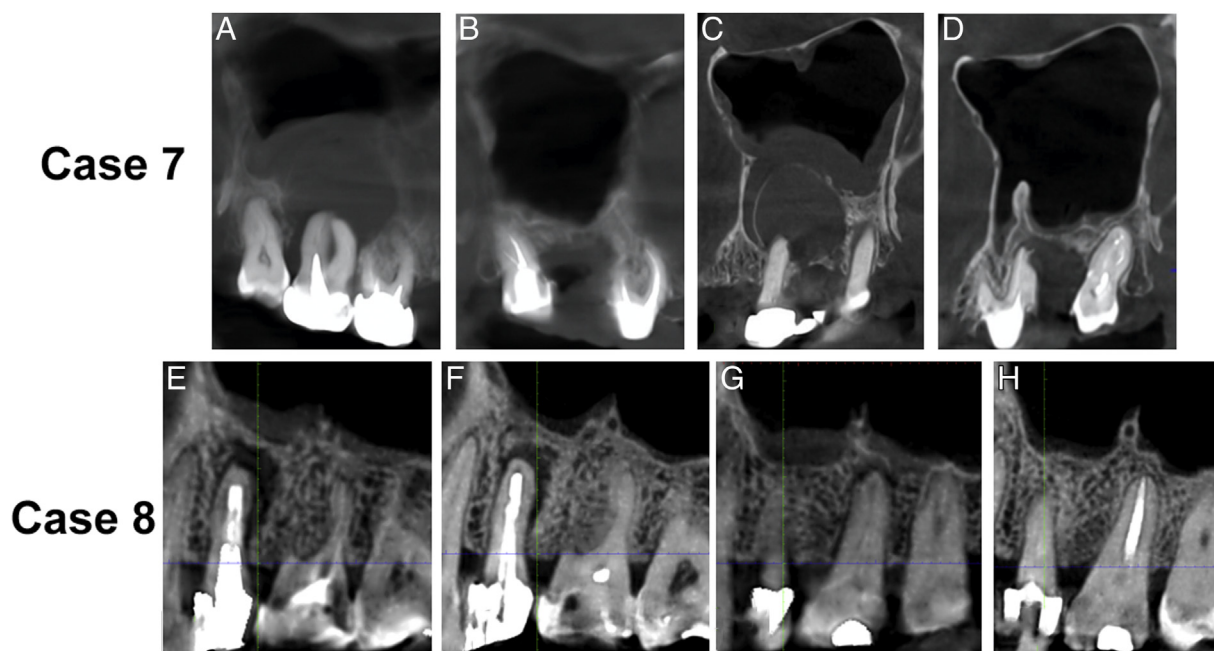
A 21-year-old Argentinian woman consulted an endodontist 7 days after being punched in

the maxillary left area in a nightclub fight. Her chief complaint was a significant discomfort on teeth 9 and 11 on biting. Clinical inspection revealed an occlusal interference and premature contacts in both teeth caused by extrusive luxation. Mobility was not observed in any of the maxillary teeth. Teeth 9 to 13 responded negatively to pulp tests. Periapical radiographs showed a bone fracture line above the root apices that extended from tooth 9 to 13, including the mesial wall of the maxillary sinus. A CBCT scan was taken 7 days after the trauma and showed, in greater detail, the extent of the fracture line in the buccal alveolar cortical bone that affected the apical portion of several teeth. An increase in the radiopacity of the left maxillary sinus was noted. The patient also consulted an otolaryngologist for nasal discharge, and maxillary sinusitis secondary to the alveolar fracture was the diagnosis. In the first treatment session with the endodontist, a semirigid splint was placed from tooth 7 to 15, and teeth 9 and 11 were slightly repositioned. At 24 days, the patient noticed a change of color in tooth 9, which was diagnosed as pulp necrosis, and root canal treatment was performed. Four weeks after the trauma, the splint was removed, and the patient was asymptomatic. At the 4-month follow-up, CBCT imaging showed that the maxillary sinusitis had completely resolved (Fig. 5A and B). Bone repair in the fracture line was also observed. At the 8-month follow-up, tooth #11

was diagnosed with pulp necrosis and asymptomatic apical periodontitis and was endodontically treated. The other teeth that had not initially responded to pulp tests now gave positive responses. At the 19-month follow-up, both periapical radiographs and CBCT imaging showed normality of the maxillary sinus and the periradicular tissues along the previously affected area.

#### Case 10

A 70-year-old Brazilian woman was referred to an endodontist with chief complaints of pain when chewing and palpation in tooth 14. The tooth was endodontically treated, and the diagnosis was symptomatic apical periodontitis. The primary treatment was conducted 20 years previously, and the patient was asymptomatic until recently. The root canal retreatment was concluded in 2 visits using NaOCl irrigation and calcium hydroxide medication. One month after obturation, the patient returned, reporting discomfort in the treated tooth. CBCT examination at this point revealed a large apical periodontitis lesion associated with tooth 14, periapical osteoperiostitis, and complete obliteration of the right maxillary sinus. The patient was referred to a maxillofacial surgeon, who decided to extract this tooth and fill the extraction site with a synthetic biphasic calcium phosphate material for sinus floor augmentation. A 28-month CBCT follow-up

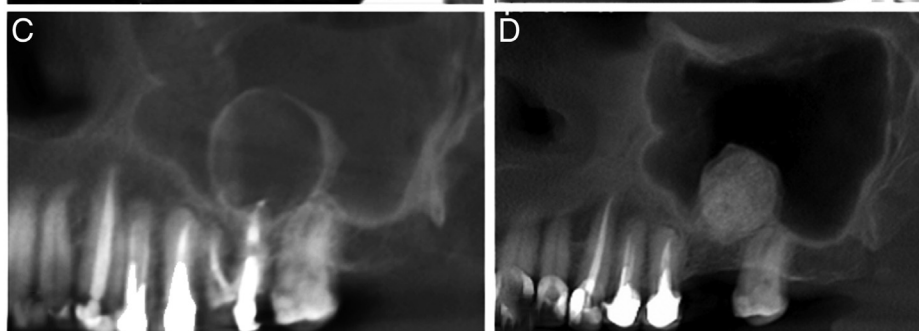


**FIGURE 4** – CBCT scans of cases 7 and 8. (A–D) Case 7. (A and C) A large apical periodontitis lesion resulting in sinus osteoperiostitis and partial obstruction. (B and D) Both sinus and periradicular tissues healed 15 months after tooth extraction. (E–H) Case 8. (E and G) Sinus mucositis associated with apical periodontitis lesions in 2 maxillary teeth. (F and H) Although healing of apical periodontitis is still in progress 6 months after endodontic intervention, the sinus condition is resolved.

## Case 9



## Case 10



**FIGURE 5** – CBCT scans of cases 9 and 10. (A and B) Case 9. (A) Fracture of the alveolar bone and associated sinus mucositis after traumatic injury to the face. (B) Full repair of both bone fracture and sinus condition 4 months after trauma management. (C and D) Case 10. (C) Large apical periodontitis causing sinus osteoperiostitis and full obstruction, (D) fully resolved 28 months after extraction.

examination showed complete resolution of the maxillary sinusitis (Fig. 5C and D).

### Case 11

A 61-year-old Brazilian woman was referred for dental evaluation because of pain in the upper left maxillary area. The patient had taken amoxicillin for 7 days previously. An examination with an endodontist resulted in the diagnosis of an acute apical abscess in tooth 14, in which root canal treatment had been previously initiated but not completed. CBCT imaging confirmed the radiographic findings and allowed the observation of sinus involvement with osteoperiostitis and thickening of the sinus membrane related to the affected tooth. Endodontic treatment was performed in 2 visits using NaOCl irrigation and calcium hydroxide medication. The 17-month follow-up CBCT scan revealed that the periapical radiolucency was almost completely resolved, and the patient was asymptomatic. As for the maxillary sinus, the osteoperiostitis was completely healed and the bone remodeled, but some mucosal edema remained (Fig. 6A and B).

### Case 12

A 40-year-old Argentinian woman complained of pain when chewing on tooth 15, which had been endodontically treated 5 months previously. The symptoms appeared later; she was given amoxicillin/clavulanic acid for 7 days

by the clinician, who referred her to an endodontist for evaluation. Clinical examination revealed severe pain to percussion and palpation. The periapical radiographs showed previous root canal treatment, caries, and inadequate coronal restoration in the mesial surface and an untreated distobuccal root canal but no periradicular radiolucencies. CBCT imaging confirmed the radiographic findings and additionally showed an unfilled wide palatal canal. The apex of the palatal root was within the maxillary sinus and was associated with an extensive area of fluid accumulation. The diagnosis of sinusitis was confirmed by the patient, who reported a brownish nasal discharge through her left nostril when she lowered her head. Retreatment was indicated, and a discharge of pus occurred after removal of the previous filling material. NaOCl was used as the main irrigant during preparation. Ten days after placing a calcium hydroxide intracanal medication, the patient was asymptomatic, and the nasal discharge was completely absent. All canals, including the previously untreated ones, were obturated. At the 3-month follow-up, CBCT imaging showed complete resolution of the maxillary sinusitis (Fig. 6C and D).

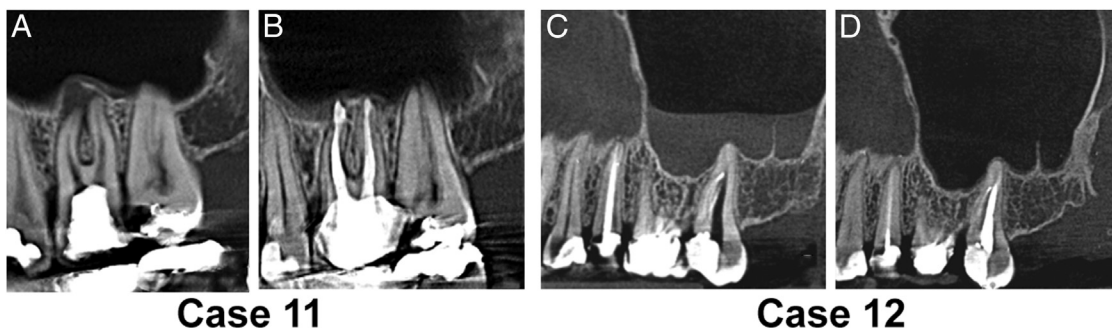
### Case 13

A 46-year-old Brazilian man was referred to an endodontist with the chief complaint of

spontaneous pain associated with tooth 15. Intraoral examination revealed mucosal swelling adjacent to this tooth. The tooth was tender to vertical percussion and palpation in the apical area. Periapical radiographs showed an apical periodontitis lesion associated with the mesiobuccal root of tooth 15, which had been endodontically treated 2 years before. The symptoms were new, and the diagnosis was acute apical abscess. Amoxicillin/clavulanic acid was prescribed for 7 days. CBCT imaging revealed an apical periodontitis lesion associated with the mesiobuccal root of tooth 15, communicating with the left maxillary sinus, which had an extensive mucositis. An otolaryngologist diagnosed the condition as MSEO. By that time, the patient had scheduled a spinal surgery at the cervical level, which was postponed because of the infection in the left maxillary sinus. Root canal retreatment was performed in 3 sessions using NaOCl for irrigation and calcium hydroxide as the intracanal medication. The 36-month CBCT follow-up revealed a substantial reduction in the mucosal edema on the left maxillary sinus floor (Fig. 7A and B). Healing of the apical periodontitis lesion of tooth 15 with repair of the cortical bone of the antral floor was observed.

### Case 14

A 38-year-old Brazilian man was referred to an endodontist with the chief complaint of feeling



**FIGURE 6** – CBCT scans of cases 11 and 12. (A and B) Case 11. Sinus osteoperiostitis and mucositis associated with an apical periodontitis lesion, which healed 17 months after endodontic treatment. (C and D) Case 12. (C) A CBCT scan showing partial obstruction of the maxillary sinus possibly by pus draining from an acute apical abscess in tooth 15. (D) The sinus condition is back to normal 3 months after endodontic procedures.

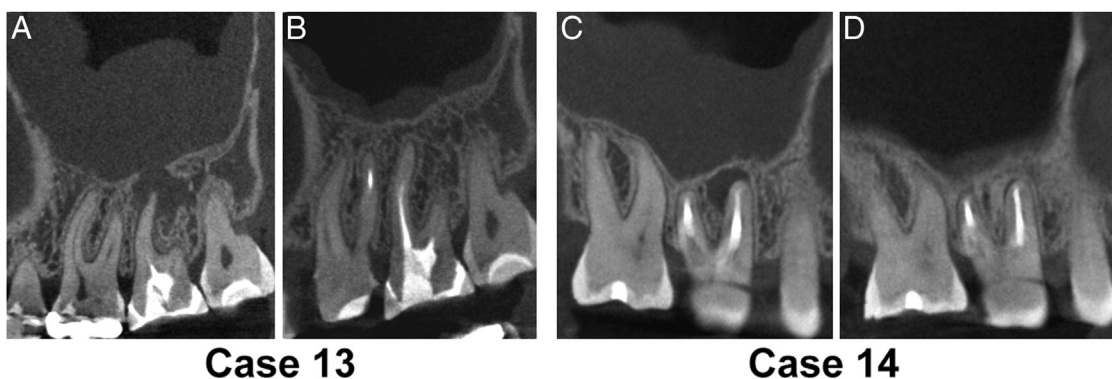
pressure on the upper right maxillary region associated with tooth 3. This tooth was tender to palpation and percussion, and the periapical radiograph showed an apical periodontitis lesion associated with the mesiobuccal root, which was endodontically treated. The patient did not recall when the primary treatment was performed, but the symptoms were new. CBCT imaging revealed that the lesion expanded to the right maxillary sinus periosteum to cause a slight osteoperiostitis and edema that caused partial obstruction of the right maxillary sinus. The second mesiobuccal canal was not treated. The diagnosis was symptomatic apical periodontitis. Root canal retreatment was performed in 2 visits using NaOCl as the irrigant and calcium hydroxide medication and this time including the previously missed canal. The 12-month CBCT follow-up revealed substantial reduction of the mucosal edema in the maxillary sinus (Fig. 7C and D). The periradicular tissues of tooth 3 were nearly healed.

## DISCUSSION

This article reports on 14 patients who showed sinus pathologic conditions suspected to have an odontogenic cause. Most patients showed pain of dental or sinus origin and were referred to the endodontist for further examination and treatment. The treatment indicated for maxillary sinusitis of odontogenic origin normally includes nonsurgical root canal treatment, periradicular surgery, intentional replantation, or extraction of the responsible tooth. Antibiotics can promote the relief of symptoms and help prevent the spread of the infectious process, but if a MSEO is diagnosed, successful management requires infection control of the root canal system. Most sinus conditions reported in this case series were successfully managed by dental treatment only, occasionally with the additional use of systemic antibiotics, decongestants, and analgesics. With the exception of the trauma case, all the others had sinus involvement associated with endodontic

infection and apical periodontitis. In 4 cases, a concomitant periodontal pocket was present, which precludes a diagnosis of exclusive endodontic origin. Of these 13 cases with an odontogenic etiology, 8 were remedied by root canal treatment, 4 by extraction, and 1 by root amputation/root canal treatment. The 4 teeth that had both apical periodontitis and a periodontal pocket were successfully treated by root amputation or extraction. Eight of the 9 cases that had an exclusive endodontic origin showed improvement of the sinus condition after root canal treatment (7 teeth) or extraction (1 tooth).

It has been reported that sinus conditions of odontogenic origin usually heal in 3–6 months after treatment<sup>2</sup>. All cases reported herein but 1 showed total or partial resolution of the sinus condition in a few months after root canal treatment, extraction, or trauma management. The cases that showed decreased mucosal edema may have been healing, and an extended follow-up could reveal complete resolution. Alternatively, these



**FIGURE 7** – CBCT scans of cases 13 and 14. (A and B) Case 13. (A) Extensive sinus mucositis and partial obstruction associated with an acute apical abscess in tooth 15. (B) Control CBCT scan at 36 months shows full periradicular healing and substantial reduction of the mucositis. (C and D) Case 14. (C) Partial obstruction of the maxillary sinus associated with an apical periodontitis lesion in tooth 3. (D) The apical periodontitis lesion and the sinus condition were almost completely healed 12 months after endodontic retreatment.

cases could represent a simultaneous dental and sinus involvement that would require complementary treatment with an otolaryngologist. Cases that demonstrate a worsened sinus condition may represent either a nonodontogenic cause or a failure in the dental treatment. These cases may be difficult to approach and properly diagnose for the best management. In the specific case shown in this study that evolved to almost full obliteration (case 2), CBCT imaging revealed that the apical periodontitis lesions suspected to be associated with the sinus involvement were nearly healed. This strongly suggests that the sinus aggravation condition had a nonodontogenic cause, and the patient was referred to the otolaryngologist for further evaluation, who confirmed the diagnosis of sinogenic sinusitis.

Because of the anatomic proximity, apical periodontitis in maxillary posterior teeth may induce inflammatory changes in the mucosa and periosteum of the antral floor, which can be asymptomatic and persist for months to years if the tooth is not treated<sup>32</sup>. With time, the affected mucosa may become more susceptible to infection and then represent a risk factor for sinusitis<sup>33,34</sup>. If left untreated, the apical periodontitis lesion may also penetrate the sinus and cause increased inflammation. The sinus inflammation may be restricted to the floor of the maxillary sinus as osteoperiostitis or mucositis but can progress to cause a partial or full obstruction of the sinus by mucous secretion and inflammatory exudate, with clinical and radiographic features similar to sinogenic sinusitis. Therefore, root canal treatment that is indicated for the tooth with apical periodontitis can also help prevent future sinus complications by removing the cause of sinusal mucosal inflammation, even in the early stages of sinus involvement. It is recommended that patients with an apical periodontitis lesion and associated sinus floor mucosal changes, even if asymptomatic, be referred to an endodontist for evaluation<sup>35</sup>.

Most of the cases with sinus involvement reported here presented mucositis (8 cases). Five had periapical osteoperiostitis, and 7 showed partial/total obstruction of the maxillary sinus. Periapical mucositis is a localized antral mucosal edema that can be seen on CBCT imaging as a thickening of the mucosa or a dome-shaped soft tissue expansion in the floor of the sinus adjacent to the root apex of an infected

tooth<sup>20</sup>. Periapical osteoperiostitis, in turn, is formed when the apical periodontitis lesion pushes the sinus cortical floor to cause expansion of the periosteum, which is displaced and stimulated to deposit a layer of bone with a dome shape<sup>20</sup>. This condition may expand deeper in the sinus and be associated with mucosal edema and fluid accumulation. As the cause of periradicular and sinus inflammation is successfully removed, the conditions resolve satisfactorily, usually after a short period of evaluation, including bone remodeling in osteoperiostitis and mucosa returning to normal, as demonstrated in this case series.

Five patients presented with signs/symptoms of sinusitis, including facial pain, pain in the maxillary posterior area involving several teeth, congestion, nasal discharge, and/or discomfort to head positional changes<sup>36,37</sup>. Dental symptoms of endodontic origin occurred in 10 teeth, 4 of which were acute abscesses that were very likely to be draining into the sinus. Symptoms resolved in all symptomatic patients after dental treatment, even in the case that had the sinus condition aggravated.

In 1 case, the maxillary sinus pathology was secondary to a traumatic injury, which resulted in fracture of the alveolar bone that reached the maxillary sinus. The cause of sinus mucosal inflammation was possibly traumatic, but one cannot exclude a preexisting condition because no previous radiographs were available. Two teeth developed necrosis as a consequence of the trauma, but this was very likely not the cause of sinusitis, which was already evident in the CBCT scan taken 7 days after the traumatic episode. After proper management, including splint placement and treatment of 1 of the teeth that became necrotic, the 4-month follow-up showed total repair of the bone fracture and resolution of the sinus inflammation.

Differentiation of sinogenic and odontogenic causes of sinusitis is usually difficult based only on clinical findings. Dental examination is of paramount importance to help reach a proper diagnosis. The detection of vital pulp excludes an endodontic origin. The causative tooth must have a necrotic pulp or a failing root canal treatment. However, a definitive diagnosis cannot be reached without imaging examination<sup>38</sup>. Although conventional periapical radiographs are not reliable to disclose mucosal and other changes in the

maxillary sinus, the use of CBCT imaging is crucial to identify changes in the maxillary sinus associated with dental infections<sup>15,22,39</sup>. All cases reported here had the benefit of CBCT examination for proper sinus diagnosis. In all reported cases, the periapical radiographs were of little informative value, if any, as for sinus involvement.

The American Association of Endodontists published a position article for managing MSEO and recommended that this condition be firstly approached by controlling the endodontic infection<sup>21</sup>. After endodontic management, the patient should be followed up for clinical and radiologic evaluation, with most sinus changes resolving in a few months. In recalcitrant cases, the patient should be returned or referred to the otolaryngologist for evaluation. If untreated or not properly treated, sinus infection may aggravate and evolve to complications such as orbital cellulitis, meningitis, subdural empyema, brain abscess, and cavernous sinus thrombosis<sup>10,40–43</sup>. Both endodontists and otolaryngologists should participate in the decision-making process for the best treatment, and each one should take over the treatment procedures of respective competence and expertise.

## CONCLUSION

An endodontic infection that manifests in the maxillary sinus can cause inflammatory changes more commonly than previously appreciated before the widespread use of CBCT imaging in dentistry. In most cases, the patient may look for care from his or her physician, but the treatment is not successful if the endodontic cause is overlooked. Similarly, dentists may have difficulties in diagnosing MSEO because radiographs are usually not informative. Endodontic examination and treatment are crucial for the diagnosis and prognosis of this category of maxillary sinus infectious conditions. The cases reported in this article emphasize the importance of endodontics as a clinical discipline engaged in saving teeth and promoting health not only in the oral cavity but also in other areas that may be affected by endodontic infections, such as the maxillary sinus.

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