

Educational Article

Teeth roots displacement in the maxillary sinus: characteristics and management

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Abstract – Introduction: Teeth displacement in the maxillary sinus is one of the most frequently described peri-extraction complications in oral surgery. Roots or whole teeth accidentally displaced during an avulsion process are the most common cause of foreign bodies in the maxillary sinus. It exposes the patient to more or less serious complications that can go as far as development of pneumonia or septic thrombosis of the cavernous sinus in rare cases. Several therapeutic solutions can be proposed to manage this complication, ranging from therapeutic abstention to the removal of the dental component using various techniques. **Corpus:** The pedagogical objectives of this article are to explain the main characteristics of this complication as well as its treatment. Through a systematic review of the literature according to the PRISMA methodology, the risk factors, prevention, diagnosis, complications, and management of teeth displacement will be discussed. A treatment decision tree will be proposed to guide practitioners in the management of a tooth or dental root displaced into the sinus. **Conclusion:** This article summarizes the importance of pre-extraction radiographic examinations for preventive purposes and their analysis to guide the practitioner in the choice of an appropriate surgical technique. Furthermore, the surgical management in almost all cases must be carried out early to prevent later infectious complications.

Introduction

Teeth displacement in the maxillary sinus is one of the most frequently described peri-extraction complications in oral surgery without a precise quantification in the literature [1]. Yet an apex, root, or tooth accidentally displaced during an avulsion process is the most common cause of foreign bodies in the maxillary sinus [1–3]. The intrasinus displacement of drills [4], endodontic material [5], or implants [6] has also been reported in the literature. Such a displacement exposes the patient to potentially serious complications, including the development of pneumonia or septic thrombosis of the cavernous sinus in rare cases [7]. Several therapeutic solutions can be proposed ranging from therapeutic abstention to the removal of the intrasinus foreign body using different techniques. The alveolar crestal approach and the Caldwell-Luc procedure are well documented surgical techniques in the literature [8–10]. In addition, endoscopic nasal surgery has seen a rise in recent years [2,7,11].

The pedagogical objectives of this article are to describe the main characteristics of this complication as well as its treatment. Through a systematic review of the literature according to the PRISMA methodology, we will answer the

following questions regarding the displacement of a dental root in the adjacent maxillary sinus:

- What are the factors contributing to this complication?
- How can we prevent this complication?
- What are the displacement-related complications/risks associated with the persistence of an intrasinus dental element?
- How should we manage this peri-/post-operative complication?

Corpus

Research methodology

A bibliographic search was conducted on the online database PubMed according to the PRISMA methodology. The MeSH keywords “maxillary sinus,” “tooth extraction,” and “root” were used. The research equation was: “ (“maxillary sinus [MeSH Terms] AND (“tooth extraction” [MeSH Terms] AND (“plant roots [MeSH Terms]”). Only publications in English or French were selected. No time limit was set. A manual search from the bibliographic references found in the selected articles completed this main search.

The selection of articles and results was based on:

Inclusion criteria

- Prospective controlled or uncontrolled, randomized and nonrandomized clinical studies, and prospective cohorts

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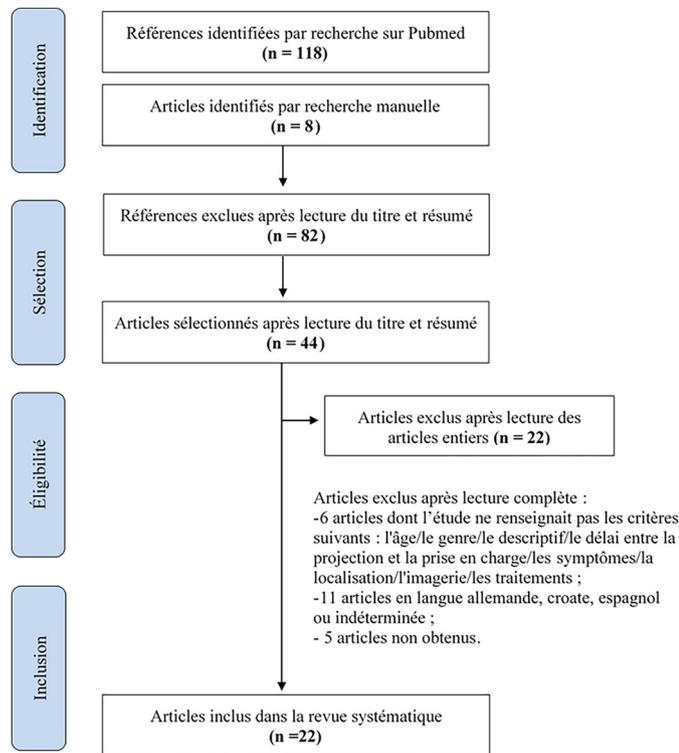


Fig 1. PRISMA flowchart of the systematic literature review.

- Retrospective clinical study: controlled or not, case/control, single cohort
- Case series
- Case studies/Case reports
- Exclusion criteria
- Animal studies
- Studies on displacement of a foreign body other than a dental root into the maxillary sinus
- Studies of tooth or root displacement in areas other than that in the maxillary sinus
- Literature reviews

The results of this research are summarized on the organization chart (Fig. 1). The selected publications were analyzed according to the guide of the l'Agence Nationale d'Accréditation et d'Évaluation en Santé (ANAES) [National Agency for Accreditation and Evaluation in Health] adopted by the Haute Autorité de santé (HAS) [French High Authority of Health]. In this analysis of the literature, 22 articles over a period of 60 years (1955–2018) were selected (Tab. I). We included one case series, one comparative study, two retrospective studies, and 18 case reports. All these publications are Level 4 and therefore have a low level of scientific evidence (Tab. I) [1,2,7,9–27].

Responses to pedagogical objectives

Encouraging factors

The displacement of a tooth or root into the maxillary sinus would be mainly explained by a preoperative X-ray analysis defect and poorly controlled surgery [16,28]. Other factors,

such as the extent of loss of dental substance indicating avulsion (large carious lesions) or adverse anatomical features (atypical dental anatomy, dental roots near the maxillary sinus), may point toward this complication [8,9,28]. Therefore, significant pneumatization of the maxillary sinus (age-related and progressive edentulous) or a complex or blind avulsion increases the risk of tooth displacement [16,28,29].

Our systematic literature review identified 159 cases of maxillary intrasinus teeth roots displacement. Of the 65 cases, 28 (43%) were male and 37 (57%) were female (sex ratio = 0.76). The age of the patients ranged from 14 to 77 years for the 61 cases that mentioned age with a mean of 37.2 years (Tab. I). Therefore, no patient can be considered excluded from the possibility of intrasinus displacement of an apex, root, or whole tooth during an avulsion.

In addition, molars and maxillary premolars appear to be more frequently involved due to the anatomical proximity of their roots to the maxillary sinus [8,9,29]. Of the 159 cases reported, 114 (72%) were maxillary molars, 11 (7%) premolars, and 34 (21%) were unspecified. The molar most affected was the first maxillary molar with 87 (55%) cases. Among the roots of this tooth, the palatal was the most affected with 41 (26%) cases (Tab. II).

The preponderance of the displacement of the palatal root of the first maxillary molar is particularly high due to its degree of divergence with the other roots, thus increasing the risk of fracture [28,30]. In addition, this tooth is most often extracted because of carious decay as it is the first tooth to erupt in the arch. In addition, in 20 cases, the laterality of the displacement was specified, 13 were on the left side and seven on the right side. This phenomenon can be explained by the fact that most practitioners are right-handed; therefore they have less motor control of the left side [28].

A summary table of root displacement risk factors in the maxillary sinus was developed to allow the practitioner to assess whether there is any risk (Tab. III).

Prevention

It is possible to minimize the probability of displacement of a tooth or tooth root into the maxillary sinus through preventive management [16].

On one hand, an in-depth analysis of preoperative clinical and radiographic examinations using a retroalveolar X-ray or a panoramic dental X-ray most often makes it possible to anticipate possible complications. The interpretation of preoperative imaging on the number of roots, their anatomy, and their relationship with the adjacent maxillary sinus should be rigorous (Fig. 2). On the other hand, if the practitioner does not master the surgical technique, they must refrain from any attempt at avulsion and refer the patient to a practitioner with oral surgery skills to limit potential complications.

Diagnosis

There are various diagnostic ways to confirm that a tooth or tooth root is displaced into the maxillary sinus. The existence of bucco-sinus communication following the

Table I. Main information of the selected articles. NP: not specified; M: molar; M1: first molar; M2: second molar; M3: third molar; PM: premolar; PM1: first premolar; PM2: second premolar; √P: palatal root; √MV: mesio-vestibular root; MD: dental equipment; CBS: bucco-sinus communication; EP: spontaneous expulsion; AA: alveolar approach; CL: Caldwell-Luc; LA: lateral approach; ES: sinus endoscopy by meatotomy; Early: <1 week; Late: between >1 week and <1 year; Very late:>1 year; NDP: standard of proof.

Auteurs & Année de publication	Type de publication	Age (année)	Genre	Dent projetée	Délai entre la projection et la prise en charge	Symptômes associés	Localisation avec imagerie	Traitements	NDP
Parker et al., 1955 [12]	Rapport de cas	20	♂	1 (M1)	Très tardif	Sinusite, CBS	Basse: plancher alvéolaire	EP (par éternuement)	4
Fickling et al., 1956 [13]	Série de cas, étude comparative	NP	NP	32	Précoce : 11 Tardif : 19 (2 NP)	Infection: 11 (NP:21)	Plancher alvéolaire: 5 (NP:27)	AA : 19 CL : 11 (2 NP)	4
Herd et al., 1974 [14]	3 rapports de cas	35-37 et 64	♀ : 2 ♂ : 1	3 (1M, 1M1 et 1 NP)	Très tardif: 2 1:NP	Non	Paroi médiale : 1 Plancher alvéolaire : 1 NP : 1	CL : 1 AL : 1 (1 NP)	4
Lee et al., 1978 [9]	Série de cas	NP	NP	62 (2 PM1, 2 PM2, 46 M1 dont 35 √P, 9 M2, 3 M3)	Précoce : 57 Tardif : 5	NP	NP	AA	4
Sims et al., 1985 [15]	Rapport de cas	19	♀	1 (M1, √P)	Tardif	Non	Haute: ostium	CL	4
Barclay et al., 1987 [16]	Rapport de cas	48	♂	1 (M1, √P)	Tardif	Douleurs, ecchymose, epistaxis, CBS	Basse: plancher alvéolaire	EP	4
Woolley et al., 1997 [17]	Rapport de cas	NP	♂	1 (PM)	NP	Sinusite et empyème sous dural avec hémiplégié	NP	CL	4
Ong AH et al., 1997 [1]	Rapport de cas	35	♂	1 (M1, √P)	Précoce	CBS	NP	CL (sous endoscopie)	4
Sethi et al., 2009 [18]	Rapport de cas	NP	♀	1 (M1, √P)	NP	Sinusite, CBS	Haute: ostium	NP	4
Ramsay et al., 2010 [19]	Rapport de cas	NP	♀	1	Tardif	Sinusite	Haute: ostium	CL (sous endoscopie)	4
Chandrasena et al., 2010 [11]	Rapport de cas	NP	♂	1 (M1, √MV)	NP	NP	Haute: ostium	ES	4
Huang et al., 2011 [10]	Série de cas, étude rétrospective	14-55	♀ : 14 ♂ : 10	24 (15 M1, 6 M3 et 3 PM1)	Précoce	Oui : 2 sinutes (1 avec écoulement nasal, 1 avec CBS) (NP:22)	Plancher alvéolaire: 4 (NP:20)	CL	4
Krishnan et al., 2013 [20]	Rapport de cas	45	♀	1 (M2) (et 2 MD)	Tardif	Sinusite, CBS	Haute: plancher orbitaire	CL	4
Nashawany et al., 2014 [2]	Rapport de cas	50	♀	1 (M1)	Très tardif	Sinusite récurrente, CBS	Au centre	ES	4
Hu et al., 2015 [21]	Série de cas, étude rétrospective	22-60	♀ : 12 ♂ : 9	21 (2 PM2, 15 M1 et 4 M2)	Précoce : 17 Tardif : 4	CBS : 3 (NP:18)	NP	AL : 19 (dont 2 sous endoscopie)	4
Andrea et al., 2016 [7]	Rapport de cas	27	♂	1 (M1, √P)	Tardif	Sinusite, CBS	Haute: plancher orbitaire	ES	4
Gao et al., 2016 [22]	Rapport de cas	30	♀	1 (M2)	Très tardif	Douleurs sourdes faciales homolatérales	Basse: plancher alvéolaire	AL (sous endoscopie)	4
Rani et al., 2016 [23]	Rapport de cas	42	♀	1 (PM2)	Tardif	Sinusite, CBS, aspergillose	Basse: plancher alvéolaire	AA	4
Asmael et al., 2017 [24]	Rapport de cas	33	♂	1 (M1, √P)	Tardif	CBS	Haute: plancher orbitaire	CL	4
Cheng et al., 2017 [25]	Rapport de cas	77	♀	1 (M2)	Tardif	Sinusite récurrente	NP	CL (sous endoscopie) + ES	4
Wang et al., 2018 [26]	Rapport de cas	48	♀	1 (M2)	Précoce	Sinusite aiguë	basse: plancher alvéolaire	CL (sous endoscopie) + ES	4
Tocaciu et al., 2018 [27]	Rapport de cas	32	♂	1 (M1, √MV)	Précoce	Douleurs +++	Haute: ostium	EP	4

displacement can be checked using the Valsalva maneuver [1,13].

If the latter is positive, a retroalveolar X-ray should be taken. In fact, in rare cases, the displaced tooth or dental root or the foreign body of dental origin can remain anywhere near the operating site, and this will be enough to proceed to immediate management. Otherwise, most often, the patient should be referred for a three-dimensional radiological examination, i.e., a CBCT or CT, to confirm the localization of the root in the maxillary sinus (Figs. 3 and 4).

This imaging should use a large scope to visualize the entirety of the sinus and meatus. In fact, it is well known that the position of a tooth or root localized in the maxillary sinus varies due to the movement of the ciliary cells of the epithelial

mucosa of the maxillary sinus. In fact, this ciliary function of the sinus mucosa plays the role of draining the normal or pathological secretions of the mucosa, against the influence of gravity, along the nasal wall of the sinus to the ostium [15,27]. In addition, other factors such as the position of the head when a person is lying down, the negative pressure created by inhaling, and the size of the ostium contribute to the expulsion of the root into the maxillary ostium [15,16]. Of the 25 cases in the literature that contained information on the radiological status of the displaced root, 15 (60%) roots were in the low position at the base of the alveolar bone, eight roots were in the high position; either in the ostium (five cases, 20%) or at the level of the orbital floor (three cases, 12%). One root (4%) was at the level of the medial wall of the maxillary sinus and

another (4%) at the center of the maxillary sinus. Therefore, it is necessary to perform imaging before performing the extraction of the tooth or displaced root to verify its precise location and to ensure that the least invasive approach possible is selected [16,30].

X-ray examination is urgent because the persistence of a root in the maxillary sinus exposes the patient to potentially serious complications.

Complications

The most frequent complications of teeth displacement in the maxillary sinus are acute or chronic sinusitis [31,32]. Oral bacterial flora is introduced into the sinuses, which is in principle, a germless cavity, via the antral floor perforation during avulsion. The presence of a foreign body irritates the sinus mucosa or blocks the ostium, sometimes causing an inflammatory reaction over time [20]. The latter leads to a partial or total interruption of mucociliary clearance and reduces the permeability of the ostium. Intrasinus drainage will then be disturbed, and bacterial proliferation is facilitated, which causes sinus superinfection.

Table II. Distribution of teeth displacement according to the tooth type.

Tooth	N	%
Molar		
- M1	87	55
- M2	17	11
- M3	9	5.5
- Not specified	1	0.5
Total	114	72
Premolar		
- PM1	5	3
- PM2	5	3
- Not specified	1	1
Total	11	7
Not specified	4	21
Total	159	100

In the literature search, 35 cases contained information on the presence or absence of associated symptoms; the vast majority of patients (31 cases, 88.6%) were symptomatic and four (11.4%) cases were asymptomatic. The majority of patients had symptoms of sinusitis and/or bucco-sinus communication (29 cases, 82%). Pain was reported in 11 (35.5%) cases.

In addition, a documentary research has revealed a correlation between the duration of the presence of tooth in the sinus and the occurrence of complications. The treatment duration varies greatly; early (<1 week, 74%), late (between 1 week and 1 year, 23%) or very late (>1 year, 3%). However, only 18 case reports provided accurate information on both the time lapse before management and the presence of symptoms.



Fig 2. 25 appears to not be salvageable. This retroalveolar X-ray shows an anatomical proximity to the adjacent maxillary sinus and external root resorptions making avulsion of this tooth complex with a high risk of fracture.

Table III. Distribution of risk factors for the displacement of a root in the maxillary sinus to assess whether there is any risk.

Risk factors for displacement of a root in the maxillary sinus	
Practitioner-related factors	Patient-related factors
<ul style="list-style-type: none"> - Absence or limited oral surgery skills - Poor clinical and radiological analysis of the situation: lack of anticipation of potential complications - Absence or poor-quality imaging: blind avulsion - Left laterality and absence of adjacent teeth: limited dexterity 	<ul style="list-style-type: none"> - Loss of dental substances (voluminous caries, resorptions) or unfavorable anatomical features (long, thin, hook-shaped, or bell-shaped roots): complex avulsion with a fracture risk - Proximity to the sinus: + + + palatal roots of molars or premolars - Significant sinus pneumatization: age-related, progressive edentulous and ethnic (e.g. Asians have less voluminous sinuses)

Of these 18 cases, 15 were symptomatic, and of these, 10 (66.7%) had late or very late management. These results show that most cases eventually develop complications over time and that rapid management is therefore indicated.

In addition, a few rare cases of septic thrombosis of the cavernous sinus [33], facial pain, intracranial abscess, meningitis [34], and subdural empyema [17], are also described in the literature. All these complications also justify early management. In addition, the practitioner should be aware of the possibility of migration of a root displaced into the maxillary sinus to the nasal ostium, especially in the case where the patient does not have an inflammatory and infectious

clinical sign that may affect mucociliary clearance (Fig 4). The latter is a very little described possibility in oral surgery; five (20%) cases of roots present in the ostium alone have been reported in the literature [11,15,18,19,27].

The initial situation becomes more difficult to manage and exposes the patient to a risk of a more serious complication, such as ostium obstruction [7]. The root can be displaced by coughing or during a sneeze into the nasal cavity through the ostium [12,16,27]. In this situation, there is a potential risk of developing a lung infection related to inhalation of the root following its expulsion into the nasal cavity [7,16].

Management

Although surgical treatment is chosen as the first line of treatment in most cases, it should be emphasized that therapeutic abstention is mentioned in some situations. In fact, therapeutic abstention or deferred treatment may be recommended in cases with an absence of clinical and radiological symptomatology, in the presence of a healthy sinus, and if the foreign body, without initial acute infection, is small in size compared with the ostium (<3 mm) [14,27,35]. Some publications have described long-term follow-up (>12 months) without mucosal irritation that shows that dental roots can be accepted into the maxillary sinus environment [14,35]. However, given the risk of possible complications, this attitude should remain exceptional and the patient should be clearly informed of the long-term infection risk.

Several surgical therapeutic solutions can be proposed to remove the displaced dental element; they differ depending on its size and intrasinus location as well as on the patient's symptoms [8,9,36].

Of the 159 case reports, four cases did not provide information on the technique used. The alveolar crestal (AA) approach and the Caldwell-Luc (CL) approach were used in 82 cases (53%) and 42 cases (27%), respectively. While lateral approach (LA) and sinus endoscope (SE) removal after a meatotomy were used in 23 cases (15%) and three cases (2%), respectively.

In addition, among the cases operated using transoral approaches (CL, AA, and LA), five cases were performed under endoscopy. A combination of transoral and transnasal



Fig 3. The palatal root of 25 is discernible closely in the adjacent maxillary sinus in the immediate vicinity of the maxillary sinus floor and the initial site (arrow).

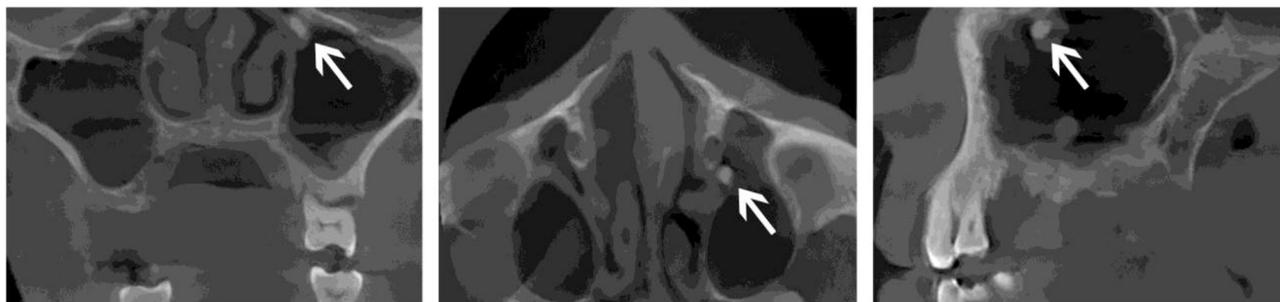


Fig 4. CBCT – Frontal/axial/sagittal section: the root is clearly discernible in the left ostium (arrow).

approaches under endoscopy has also been found in the literature (two cases, 1%). Spontaneous root expulsion into the nasal cavity was reported in three cases (2%) (Tab. I).

The AA and CL approaches are well documented surgical techniques in the literature [13]. The AA approach allows for the immediate removal of the displaced root through an oroantral opening [8,9,23], while the CL approach consists of removing the foreign body through the canine fossa [10,17,24].

The AA and CL approaches are generally recommended as a first line procedure when the avulsion has just been performed or when there is incomplete healing of the site, as it leads to few complications thereafter [8–10]. Removal of the root by enlargement of the crestal cavity and closure of the bucco-sinus communication are done during the same session. However, to accomplish this, the displaced dental element must be in close proximity to the floor of the maxillary sinus and the initial site (Fig. 3). The CL approach remains the gold standard for this type of maxillary sinus surgery for several authors. However, it can sometimes be responsible for inconveniences, such as facial pain, hypoesthesia due to a lesion of the infraorbital nerve, and anesthesia or paresthesia of the upper anterior teeth due to a lesion of the anterior superior alveolar nerve [37,38].

Nevertheless, today’s endoscopes help to limit these disadvantages [19,21,22,25]. They provide excellent visibility of the surgical site, which reduces the bone access window.

The exclusive use of SE by the nasal route for root removal in the maxillary sinus was first reported in the literature only in 2010 [11]. This technique is based on the use of optical aids combined with computed tomography imaging (Fig. 5). It is indicated to treat unilateral repeated sinusitis whose medical

treatment has failed. It is also used to eradicate foci of aspergillosis, foreign bodies, cysts, or polyps [39,40]. This technique has several advantages: it is reliable and safe with low morbidity [2,3,6]. It is less invasive and less traumatic because it avoids causing damage, such as nerve damage, and preserves adjacent dental roots, as well as the alveolar bone [37]. It allows not only to dislodge the root while preserving mucociliary integrity and function but also to drain the clogged maxillary ostium by recreating optimal permeability (Fig. 6). It also helps in treating, in a more conservative way, anatomical abnormalities possibly associated with sinusitis, such as an

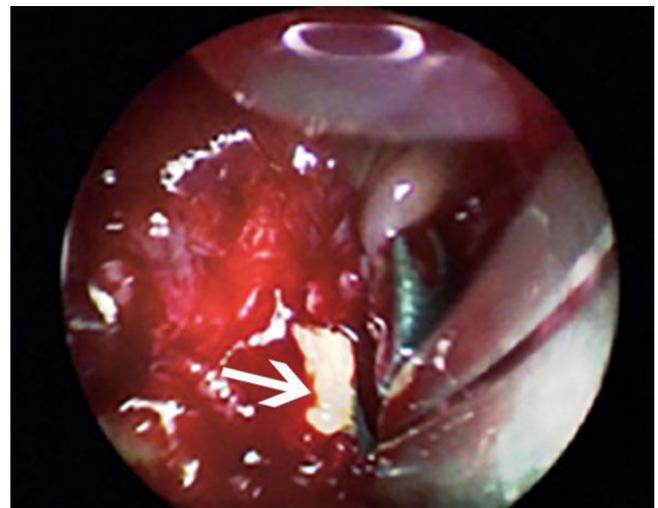


Fig 5. Endoscopic image showing the root of 25 taken from inside the left maxillary sinus (arrow).

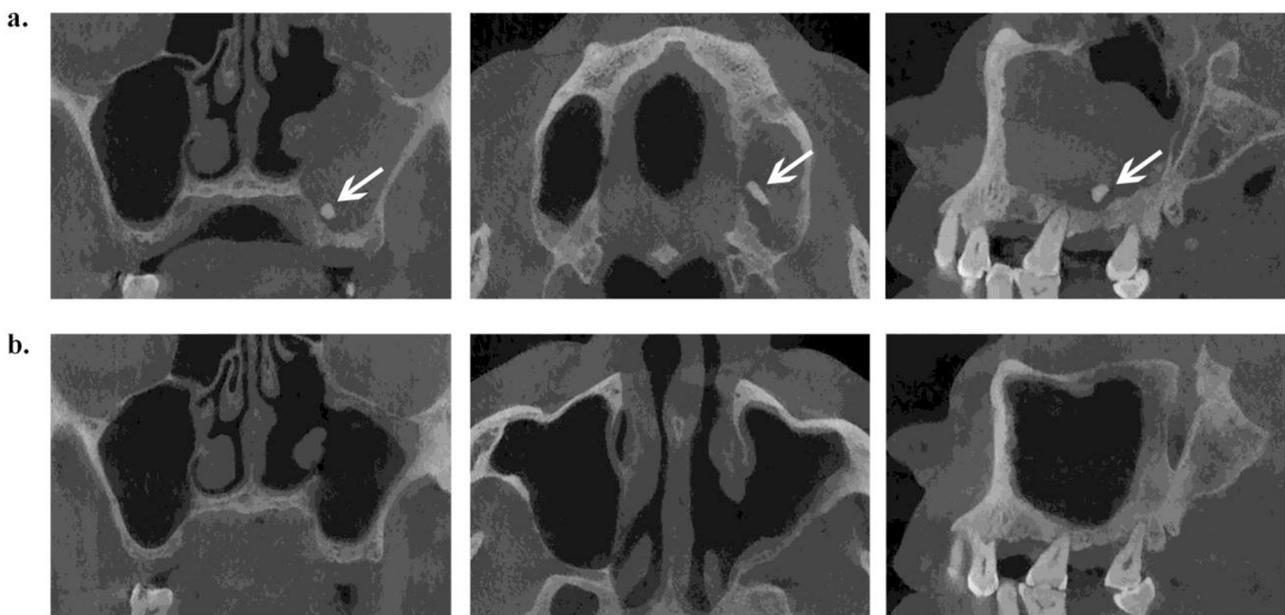


Fig 6. Radiological monitoring—CBCT: Frontal/axial/sagittal section a. The root is visible at the bottom of the left maxillary sinus. This examination reveals a partial but significant filling of the left maxillary sinus (arrow). b. Postoperative radiological examination performed 6 months after tooth recovery, showing good healing of the left maxillary sinus and ethmoid cells. This examination also shows a widened meatus following the meatotomy operation.

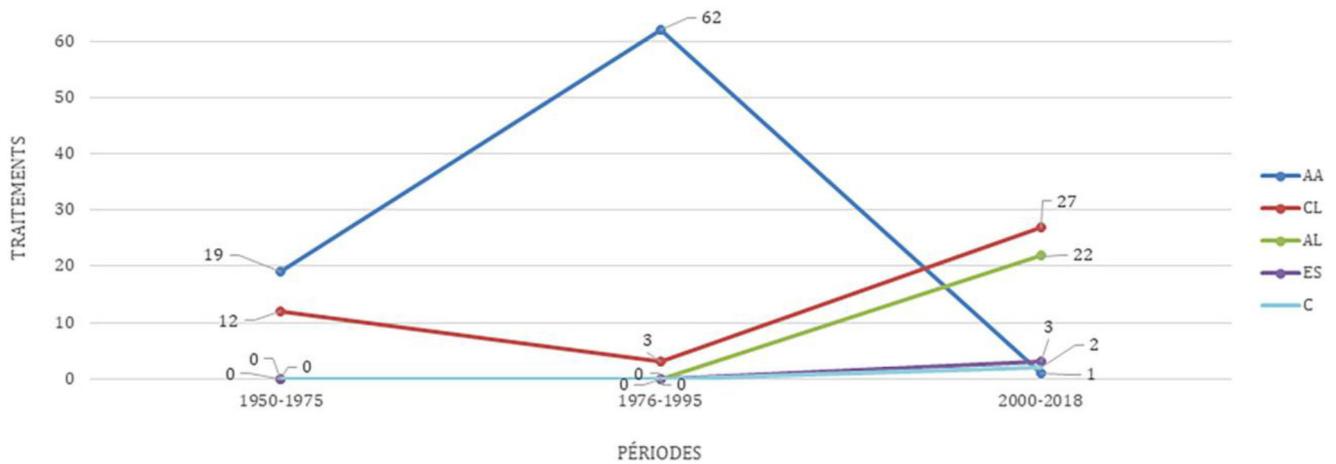


Fig 7. Surgical approaches as a function of time. AA: alveolar approach; CL: Caldwell-Luc; LA: lateral approach; SE: sinus endoscopy by meatotomy; C: combination of transoral and transnasal approaches.

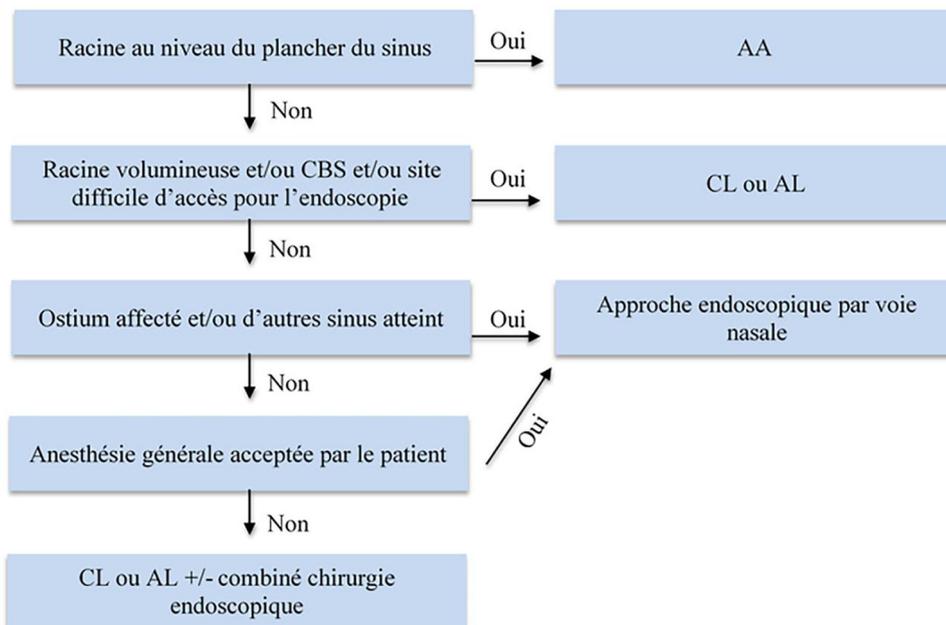


Fig 8. Decision tree on treatment approaches for removing a root in the maxillary sinus. AA: alveolar approach; CL: Caldwell-Luc; LA: lateral approach.

inflammatory or infected hypertrophic mucosa. Treatment and healing times are reduced. In addition, inflammation or infection of the maxillary sinus can develop and reach the ethmoid and frontal sinuses, and therefore, the SE will drain them in the same session if necessary.

While some authors still advocate the conventional surgical approach [10,20,24], others prefer to use a more conservative endoscopic surgical approach today [2,7,11]. Documentary research shows that endoscopic nasal surgery has seen an increase in recent years. The 159 cases included in this study were divided into three periods and analyzed to possibly highlight a change in practices in this area. The periods are 1955–1975, 1976–1999, and 2000–2018. Until the late 90s,

the AA approach was widely used. It has been used significantly less since the early 2000s. The CL approach has always been practiced. It is still in use today. The emergence of LA and SE since the early 2000s is worth noting (Fig. 7).

In addition, nowadays endoscopy is increasingly used also for transoral approaches [1,21,22] or for combinations between transoral and transnasal approaches [25,26]. However, clinical publications reporting the nasal endoscopic approach in this indication are still rare (five cases, 3%). These are clinical case reports with a small number of patients included. Therefore, further clinical studies with a higher level of evidence must be conducted to validate the results of this technique.

In summary, a management organization chart, based on the results of our literature review, is proposed to guide practitioners (Fig. 8).

Conclusion

This article highlights the importance of pre-extraction X-ray examinations and their analyses for preventive purposes and to guide the practitioner in choosing an appropriate surgical technique. In addition, for curative purposes, it also seems important to quickly orient the patient with a root displacement in the maxillary sinus to a suitable treatment program.

Treatment of a root displacement in the maxillary sinus should be done early and be mainly surgical. The article also summarizes the different therapeutic possibilities. The AA and CL approaches have good results according to the literature, but they can be invasive and responsible for significant complications, especially nerve-related and hemorrhagic complications. A special look into nasal endoscopy shows that this approach looks very promising due to its low morbidity and good effectiveness.

Conflicts of interests: The authors declare that they have no conflicts of interest in relation to the publication of this article.

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