

## COMPLICATIONS OF FRONTAL SINUSITIS. BIBLIOGRAPHIC REVIEW

### *Complicaciones de la sinusitis frontal. Revisión bibliográfica*

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**SUMMARY:** Introduction and objective: Frontal rhinosinusitis usually resolves with medical therapy. However, when the sinonasal infection persists, the anatomy of this region can lead to severe and life-threatening complications due to infection spreading beyond the sinus namely to the intracranial compartment. This review aims to highlight the more recent developments on the management of frontal rhinosinusitis and its complications, from a practical perspective that is essential to accurately diagnose these complications. Method: A review of the literature was performed by the authors. PubMed database was searched with relevant terms, which included the following: «frontal sinusitis complications», «pediatric frontal sinusitis» and «frontal sinusitis imaging». Relevant scientific treaties were also used as ancillary to this review. A comprehensive review of the English and Portuguese literature was carried out, including papers published between 2000 and 2021. Our inclusion criteria included clinical trials, expert opinion papers, literature reviews, systematic reviews and clinical guidelines. Duplicate articles, case reports or very small sample studies were excluded prior general screening. Results: Twenty-one studies met the inclusion criteria. Most of them concerned the adult population, with four papers directly addressing the pediatric population. Two clinical guidelines, one large retrospective cohort study and two systematic reviews were selected. Twelve clinical review articles and small retrospective studies were selected, comprising most of the papers addressed. Four clinical textbooks were also consulted for this review. Discussion: Morbidity and mortality from complicated sinusitis

are mainly related to intracranial involvement. Although the mortality rate was higher before the era of antibiotic therapy, intracranial abscess still carries high mortality. Frontal sinusitis can be complicated by periorbital cellulitis, abscess formation, both periorbital and subperiosteal in the frontal bone anterior wall (Pott puffy tumor), and, rarely, cavernous sinus thrombosis. Intracranial complications include subdural and epidural empyema, meningitis, and intracerebral abscess. These complications will be reviewed in this paper. Conclusions: Complications of frontal sinusitis can be severe and life threatening, mainly due to the proximity of the frontal sinus with the intracranial compartment. Due to its high availability, CT frequently is the first imaging technique performed in the emergency setting. The excellent bone and high-spatial resolution make CT the preferred imaging examination in presurgical planning. However, contrast-enhanced MRI is far superior in soft-tissue evaluation and should be considered whenever an orbital or intracranial complication is suspected. These complications are mostly treated with intravenous antibiotics and surgical drainage procedures. Early aggressive intervention has decreased morbidity and shortened hospital stay, although significant morbidity and mortality from complications can still occur.

KEYWORDS: frontal sinusitis; Pott Puffy tumor; epidural abscess; brain abscess

RESUMEN: Introducción y objetivo: La rinosinusitis frontal suele resolverse con tratamiento médico. Sin embargo, cuando la infección de los senos paranasales persiste, la anatomía de esta región puede dar lugar a complicaciones graves y potencialmente mortales debido a que la infección se propaga más allá del seno, es decir, al compartimento intracraneal. Esta revisión tiene como objetivo resaltar las publicaciones más recientes sobre el manejo de la rinosinusitis frontal y sus complicaciones, desde una perspectiva práctica que es esencial para diagnosticar con precisión estas complicaciones. Método: Se realizó una revisión de la literatura por parte de los autores. Se buscó en la base de datos PubMed con términos relevantes, que incluían los siguientes: «complicaciones de la sinusitis frontal», «sinusitis frontal pediátrica» y «imagen de la sinusitis frontal». Los tratados científicos pertinentes también se utilizaron como complemento de esta revisión. Se llevó a cabo una revisión de la literatura en inglés y portugués, incluidos artículos publicados entre 2000 y 2021. Nuestros criterios de inclusión incluyeron ensayos clínicos, artículos de opinión de expertos, revisiones de literatura, revisiones sistemáticas y guías clínicas. Los artículos duplicados, los informes de casos o los estudios de muestras muy pequeñas se excluyeron antes de la selección general. Resultados: Veintiún estudios cumplieron los criterios de inclusión. La mayoría de ellos se referían a la población adulta, con cuatro artículos dirigidos directamente a la población pediátrica. Se seleccionaron dos guías clínicas, un gran estudio de cohorte retrospectivo y dos revisiones sistemáticas. Se seleccionaron doce artículos de revisión clínica y pequeños estudios retrospectivos, que comprenden la mayoría de los trabajos abordados. También se consultaron cuatro libros de texto clínicos para esta revisión. Discusión: La morbimortalidad por sinusitis complicada se relaciona principalmente con la afectación intracraneal. Aunque la tasa de mortalidad era más alta antes de la era de la terapia con antibióticos, el absceso intracraneal todavía conlleva una alta mortalidad. La sinusitis frontal puede complicarse con celulitis periorbitaria, formación de abscesos, tanto periorbitarios como subperiósticos en la pared anterior del hueso frontal (tumor de Pott) y, en raras ocasiones, trombosis del seno cavernoso. Las complicaciones intracraneales incluyen empiema subdural y epidural, meningitis y absceso intracerebral. Estas complicaciones son revisadas en este artículo. Conclusiones: Las complicaciones de la sinusitis frontal pueden ser graves y potencialmente mortales, principalmente por la proximidad del seno frontal con el compartimento intracraneal. Debido a su alta disponibilidad, la TC es frecuentemente la primera técnica de imagen que se realiza en el ámbito de urgencias. La excelente resolución ósea y la alta resolución espacial hacen de la TC el examen de imagen preferido en la planificación quirúrgica. Sin embargo, la resonancia magnética con contraste es muy superior en la evaluación de tejidos blandos y debe considerarse siempre que se sospeche una complicación orbitaria o intracraneal. Estas complicaciones se tratan principalmente con antibióticos intravenosos y procedimientos de drenaje quirúrgico. La intervención

agresiva temprana ha disminuido la morbilidad y ha acortado la estancia hospitalaria, aunque aún puede ocurrir una morbilidad y mortalidad significativas por complicaciones.

PALABRAS CLAVE: sinusitis frontal; Pott Puffy tumor; absceso epidural; absceso cerebral

## INTRODUCTION

Acute rhinosinusitis often follows an upper respiratory tract infection. It is estimated that only 0.5 % to 2 % of viral upper respiratory tract infections are complicated by bacterial superinfection, with the prevalence rates for acute rhinosinusitis varying from 6 % to 12 % [1].

Regarding rhinosinusitis complications, epidemiological studies estimate an incidence of three cases per million per year [2].

Acute bacterial frontal sinusitis [FS] is relatively uncommon and, in the case of isolated frontal involvement, is usually unilateral at presentation [1,3].

Typically, patients with acute FS come to medical attention with low-grade fever, malaise and frontal headaches, often accompanied by marked tenderness of the medial aspect of the infraorbital margin [1,4]. The majority of complications tend to occur in children and young adults due to the relative thinness of the sinus walls and increased vascularity of the frontal bone [5].

The infection usually responds to antibiotics with the correct antimicrobial spectrum coverage, which varies geographically, depending on the prevalence of amoxicillin resistance [3].

The most common organisms implicated in FS are *Streptococcus pneumoniae*, *Haemophilus influenzae* and anaerobic streptococci [2].

The anatomic location and venous drainage pattern of the frontal sinus can lead to severe and life-threatening complications when the infection spreads to adjacent structures. Complications arising from the frontal sinus usually involve the intracranial compartment, although the infectious process can also progress to the orbit or adjacent bone and soft-tissue structures [4].

With this article, we aim to provide a concise and practical review of the published work on complications of frontal rhinosinusitis that will be useful for the day-to-day use in the clinical practice.

## MATERIAL AND METHODS

A review of the literature was performed by the authors (Figure 1).

PubMed ([www.ncbi.nlm.nih.gov/pubmed/](http://www.ncbi.nlm.nih.gov/pubmed/)) database was searched with relevant terms, which included the following: «frontal sinusitis complications», «pediatric frontal sinusitis» and «frontal sinusitis imaging». Relevant scientific treaties were also used as ancillary to this review.

A comprehensive review of the English and Portuguese literature was carried out, including papers published between 2000 and 2021. Our inclusion criteria included clinical trials, expert opinion papers, literature reviews, systematic reviews, and clinical guidelines. Duplicate articles, case reports or very small sample studies were excluded prior general screening. One epidemiological retrospective study outside the time scope of this review [21] was added for epidemiological data.

## RESULTS

Twenty-one studies met the inclusion criteria (Appendix 1, Table 1). Most of them concerned the adult population, with four papers directly addressing the pediatric population. Two clinical guidelines [1,6], one large retrospective cohort study [2] and two systematic reviews were selected [5,7]. Twelve clinical review articles and small retrospective studies were selected, [8, 9, 18,10–17]

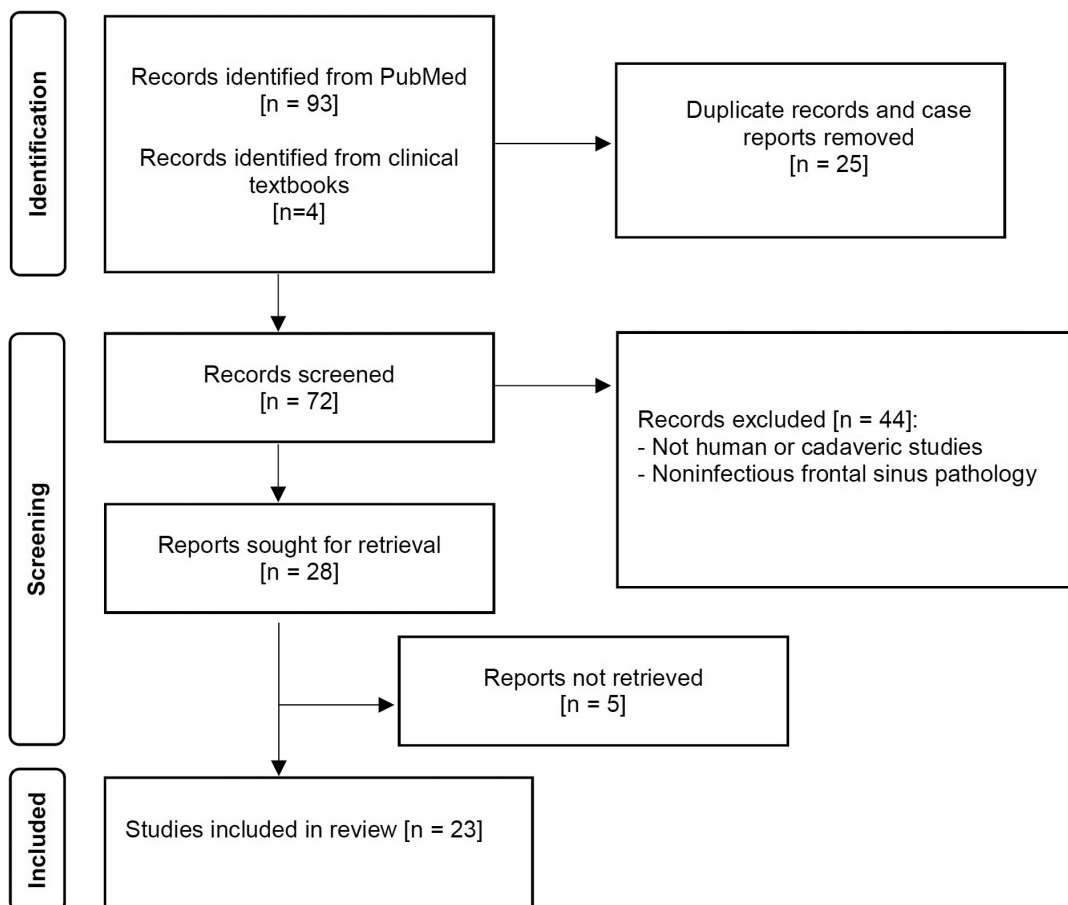


Figure 1. PRISMA diagram illustrating the search strategy for this review. Adapted from Page *et al.* [22].

comprising most of the papers addressed. Four clinical textbooks [3,4,19,20] were also consulted for this review.

## DISCUSSION

The true incidence of FS is still controversial [1, 2]. One study reported 91 treated patients from a population of 250.000 inhabitants over 9 years. The age range was 9 to 65 years, with a male preponderance, with a male to female ratio of 3:1 [21].

These numbers are probably underestimated due to the fact that not all patients with frontal sinusitis seek medical attention [1,2,6].

Numerous predisposing factors for frontal sinusitis have been proposed in the literature, including [1,8]: allergic and vasomotor rhinitis, mucociliary disorders, immunosuppression, previous sinus surgery, chemical exposure, previous surgery or cocaine abuse.

Morbidity and mortality from complicated sinusitis are mainly related to intracranial involvement.

In the setting of high clinical suspicion of intraorbital and intracranial complications, Magnetic Resonance Imaging [MRI] with and without intravenous contrast is most appropriate, due to its excellent soft-tissue resolution. However, its limited availability and need for sedation in pediatric patients may impair its use [13]. From a practical stand point, the fact that most of these complications are approached in emergency setting (where MRI is often not readily available) makes contrast-enhanced Computed Tomography (CT) the most performed first-line imaging modality by far [3].

Although the mortality rate was higher before the era of antibiotic therapy [4], intracranial abscess still carries a mortality rate as high as 40%, with an additional 40 %of patients suffering permanent physical disabilities [9].

## EXTRACRANIAL COMPLICATIONS

### OSTEOMYELITIS AND POTT PUFFY TUMOR

Frontal sinusitis can involve adjacent bone either by direct extension or by thrombophlebitis of the diploic veins [4]. The bone marrow of the frontal bone can become involved giving rise to osteomyelitis, which constitutes about 9 %of acute rhinosinusitis complications with the frontal sinus being the most frequently involved sinus [10].

Pott puffy tumor (Figure 2) is a subperiosteal abscess that results from osteomyelitis of the frontal bone, located in the anterior wall and usually seen as a complication of frontal sinusitis or head trauma [3]. It is a rare but serious complication, more common in young adults, although it can be also seen in children. Presenting symptoms of osteomyelitis and Pott's puffy tumor include swelling of the forehead, headache, photophobia, and fever [11].

CT is usually the first imaging modality in the emergency setting. It confirms the presence of ARS, with opacification, mucosal thickening and air-fluid levels in the sinuses, and is the modality of choice to depict cortical bone erosions and/or

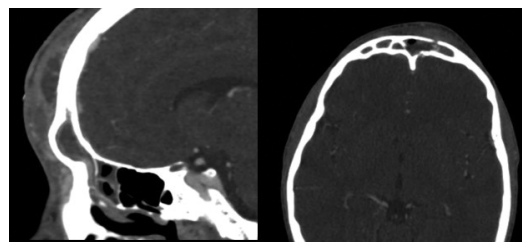


Figure 2. Potts puffy tumor: Sagittal [left] and axial [right] enhanced-CT, soft-tissue [left] and brain [right], shows frontal sinus opacification associated with frontal tumefaction corresponding to a subperiosteal abscess. Erosion of the frontal bone anterior wall can be seen, in keeping with osteomyelitis.

trabecular demineralization, the main signs of osteomyelitis [13].

Due to the high risk of associated intracranial complications, early diagnosis and adequate surgical and antibiotic treatment are mandatory [10,11]. If the patient is clinically stable, medical treatment and simple external drainage of the abscess could be preferred, using a drill hole or even puncture needle to prevent scarring of the acute inflamed frontal recess [10]. According to the literature regarding long bones osteomyelitis, intravenous antibiotic therapy should be maintained for a minimum of 6 weeks [4].

### ORBITAL COMPLICATIONS

Frontal sinusitis alone rarely causes an orbital complication [3]. These are usually due to ethmoidal sinusitis, followed by maxillary, frontal, and, more rarely, sphenoidal sinusitis [1].

Orbital complications occur in 6 %of cases of acute rhinosinusitis [ARS], more commonly in the pediatric population [12,13].

CT is usually diagnostic and shows thickening and densification of the eyelid, with no changes in the postseptal area, namely extraocular muscles, postseptal fat and lacrimal glands [13].

Cases of preseptal and orbital cellulitis are usually treatable with medical therapy alone,

namely intravenous antibiotherapy and corticosteroid. On the other hand, more severe complications usually require surgical drainage [including the affected sinuses] coupled with intravenous antibiotherapy, although medical treatment alone may be successful and initially attempted in selected cases of subperiosteal abscess [14].

With early treatment, orbital complications have a good prognosis, although some symptoms, such as proptosis or orbital edema, could take up two to three months to fully recede [19].

#### CAVERNOUS SINUS THROMBOSIS

It may be considered an orbital or intracranial complication, resulting from retrograde thrombophlebitis of the ophthalmic vein or direct extension of sphenoidal sinusitis, being a rare complication from FS [15].

The main clinical manifestations are from ocular origin and proptosis, chemosis, ptosis or diplopia are common features.

The presence of filling defects representing the occluding thrombus is demonstrated on either CT or contrast-enhanced MRI, although MRI is considered superior [13].

Cavernous sinus thrombosis has a mortality rate of 8 % in children and up to 30 % in adults [4], and may account for important morbidity associated with damage of structures that traverse or are in close relation with the cavernous sinus, including cranial nerves I, III, IV, V1, V2 and VI, internal carotid artery, ophthalmic veins and the optic chiasm [15].

Regarding treatment, aggressive medical therapy and drainage of the affected sinus is indicated [4].

#### INTRACRANIAL COMPLICATIONS

Except for cavernous sinus thrombosis, the frontal sinus is the most frequent origin site of intracranial complications [13].

The sinus infection can extend to the intracranial compartment directly through bony dehiscence or by means of osteitis [4,19].

In contrast to CT, MRI performs better in the detection, localization and characterization of intracranial collections as well as parenchymal changes, allowing for earlier diagnosis of these complications and a more accurate and reliable distinction between them [4].

Intracranial complications can occur at any age, although more frequent in the second and third decades [2]. Clinical manifestations include severe headache, photophobia, seizures, or focal neurologic findings.

Treatment of intracranial complications requires aggressive medical treatment, and almost invariably, endoscopic sinus surgery, that may be allied with neurosurgical intervention in some severe cases [7].

#### EPIDURAL EMPYEMA

Also known as extradural abscess, it results from the accumulation of pus between the skull and the dura-mater, mostly caused by contiguous infection spread from the adjacent bone. It is almost exclusively derived from frontal sinusitis, due to the poor adhesion of the dura onto the frontal bone posterior wall. Although extradural by definition, it should be noted that epidural empyema frequently occurs in association with or immediately previous to the development of a subdural empyema [16].

Clinically, it courses with mild symptoms, headache and fever, with minimal or absent neurological symptoms, as the dura mater is still acting as a barrier between the infection and the brain parenchyma [4].

As epidural empyema is frequently associated with frontal bone osteomyelitis CT and/or MRI should also include careful evaluation of the overlying tissues, for the presence of abscesses, such as Pott's puffy tumor, or cutaneous fistulas. Meticulous evaluation of the underlying meninges is essential to identify signs of meningitis. Although dura mater

functions as a natural barrier, cerebral edema can be present due to mass effect [4].

Treatment generally comprises drainage of the abscess by craniotomy or transfrontal route and intravenous antibiotherapy [20].

#### SUBDURAL EMPYEMA

Subdural empyema consists of purulent content located between the dura and arachnoid. It represents 10 % of intracranial complications of sinonasal origin and is frequently caused by frontal sinusitis, followed by ethmoidal and sphenoidal sinusitis [4]. The progression of infection occurs mainly by thrombophlebitis of the emissary veins [17].

In contrast to epidural empyema, there is no dura acting as a barrier between the infectious process and the brain itself. Moreover, retrograde phlebitis can reach and obstruct the cortical veins, leading to edema and infarction, and originating a direct route for the infection spreading [4]. Thus, subdural empyema is considered a neurosurgical emergency, characterized by rapid progression, that ultimately may result in cerebral abscess formation [17,20].

Clinically, there is a rapid deterioration of the patient's neurologic status, with high fever, headache, neck stiffness, focal neurological deficits, and, more seldomly, seizures [3].

Clinical symptoms overlap with those of meningitis, thus imagiological evaluation is mandatory to detect extra-axial fluid collections [17].

When a subdural empyema is diagnosed, immediate intervention should be performed with drainage of both the empyema and the involved sinuses, in order to prevent or restrict cortical damage as well as neurologic deficits [20].

Antibiotherapy with CSF penetration is the mainstay of treatment and should be promptly started, and subsequently adjusted according to bacterial culture and antibiotic susceptibility test results. Mortality ranges from 20 to 35%, with lower rates in children [19,20].

#### CEREBRAL ABSCESS

In this case, the purulent collection is located within the brain parenchyma and is either caused by contiguous extension from an infected sinus or by hematogenous spread [4]. Between 14 to 34 % of cerebral abscesses in adults have sinonasal origin, most often due to frontal and, to a lesser degree, sphenoidal sinusitis [3]. This complication is rarer in children, probably due to the underdevelopment of both frontal and sphenoid sinuses [5]. The frontal lobe is the most commonly involved, given its proximity to the frontal sinuses [20].

In the first stages of abscess formation, patients may not present with neurologic symptoms [3]. The early stages of cerebral edema and cerebritis usually manifest as headache, lethargy, agitation, and altered mental status, with progressive worsening of the mental status [7].

Diagnosis is attained by CT or MRI (Figure 3). Lumbar puncture should be avoided in the presence of intracranial hypertension [4].

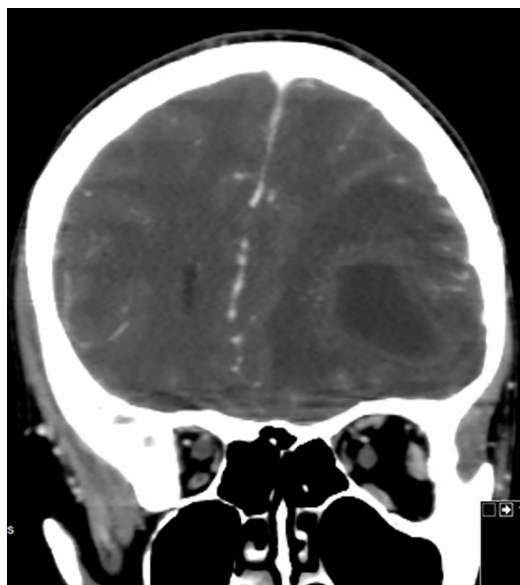


Figure 3. Frontal lobe abscess [green arrow] with perilesional edema, causing mass effect with midline shift.

Treatment varies according to the patient's status as well as the size and location of the abscess. Small abscesses have been reported to resolve with medical therapy alone. Larger abscesses require stereotactic aspiration or craniotomy with complete excision [3,4].

Besides abscess drainage, treatment includes antibiotherapy and drainage of the involved sinuses. Intravenous treatment should be maintained for 2 to 4 weeks [4].

The initial phase of cerebritis can be treated conservatively and medical therapy should include corticosteroids, anti-intracranial hypertension measures and anticonvulsants [18].

The high mortality rate that ensued some years ago has now decreased considerably to 5%, due to advances in diagnosis that allow early recognition. Epilepsy is the most common sequel and occurs in 30 % of cases [4].

#### MENINGITIS

In the pre-antibiotic era, meningitis was considered the most common complication of rhinosinusitis, but its frequency has decreased in relation to other intracranial complications [2].

The most frequently implicated sinuses are the frontal, sphenoid, and posterior ethmoid.

Clinically, the most important symptoms are headache and neck stiffness, with drowsiness and delirium preceding coma. Diagnosis is established by lumbar puncture, which demonstrates high leucocyte and protein counts [4].

Imaging findings of meningitis are usually nonspecific and difficult to recognize on CT. As for other intracranial complications, MRI is the most suitable imaging modality but findings depend on the stage of disease and may be initially normal [13].

Regarding the treatment of sinusitis in the setting of meningitis, clinical judgment determines whether initial treatment is medical or surgical. Systemic antibiotics with good cerebrospinal fluid penetration are critical in either situation and should be started immediately, with a third

generation parenteral cephalosporin and metronidazole in association with intravenous corticosteroid being the most recommended for empiric therapy [3]. If medical therapy fails to improve the patient's condition in 24 to 48 hours, progressive surgical intervention should be considered for the underlying sinusitis [20].

Limitations of this study. This review was limited by the fact that the search was performed in only one database, in only two languages. These factors restrain the scope of this review.

#### CONCLUSIONS

Complications of frontal sinusitis can be severe and life threatening, mainly due to the proximity of the frontal sinus with the intracranial compartment.

Due to its high availability, CT frequently is the first imaging technique performed in the emergency setting. The excellent bone and high-spatial resolution make CT the preferred imaging examination in presurgical planning. However, contrast-enhanced MRI is far superior in soft-tissue evaluation and should be considered whenever an orbital or intracranial complication is suspected.

These complications are mostly treated with intravenous antibiotics and surgical drainage procedures.

Early aggressive intervention has decreased morbidity and shortened hospital stay, although significant morbidity and mortality from complications can still occur.

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APPENDIX 1

Table 1. Table of results.

Authors	Design	Methods	Results
Fokkens <i>et al.</i> [1] [2020]	Clinical Guideline	-	The core objective of this guideline is to provide revised, up-to-date and clear evidence-based recommendations and integrated care pathways in ARS and CRS.
Hansen <i>et al.</i> [2] [2012]	Retrospective Cohort Study	Patients hospitalized in The Netherlands in 2004 with a complication of ARS. Recorded symptoms of ARS and the complication, demographics, medical history, medical treatment preceding hospitalization, diagnostic techniques, therapeutic management, course, and outcome.	47 patients with 48 complications (16 intracranial and 32 orbital). 15 underwent surgery, 8 patients recovered fully after treatment, 3 patients had residual symptoms and 3 patients died. 13 underwent surgery.
Patel <i>et al.</i> [5] [2016]	Systematic Review	Search focused on intracranial complications of sinusitis of pediatric patients (<18 years of age).	Sixteen studies involving 180 patients were included. 70 %of patients were young adolescent males. The most common intracranial complications were subdural empyema (49%), epidural abscess (36%), cerebral abscess (21%), and meningitis (10%). Typical treatment included surgical incision and drainage. The morbidity rate was 27%, and the mortality rate was 3.3%.
Flint <i>et al.</i> [3] [2020]	Clinical Textbook		
Subtil <i>et al.</i> [4] [2019]	Clinical Textbook		
Ruoppi <i>et al.</i> [21] [1993]	Retrospective Cohort Study	A retrospective analysis of patients with acute frontal sinusitis treated at Kuopio University Hospital between 1981 and 1990 was performed to define etiological factors, clinical course and response to treatment.	91 patients, mean age for men of 32 years and for women of 29 years. 47 patients (52%) were hospitalized, the others treated as outpatients. All received medical treatment. Nasal polyps were detected and removed in 18 patients (20%). Anterior ethmoidectomy was made in 12 %of patients and trephination of the diseased frontal sinus in 9 %of patients. No complications occurred. In 5 %of patients acute frontal sinusitis recurred.
Sohal <i>et al.</i> [8] [2016]	Expert opinion		The role of medical management in the treatment of frontal sinusitis cannot be overlooked. Contemporary medical management of frontal sinusitis requires recognition of the unique disease process with implementation of targeted therapies aimed at addressing the specific pathophysiology.
Rosenfelt <i>et al.</i> [6] [2015]	Clinical Guideline		Changes from the prior guideline include a consumer added to the update group, evidence from 42 new systematic reviews, enhanced information on patient education and counseling, a new algorithm to clarify action statement relationships, expanded opportunities for watchful waiting (without antibiotic therapy) as initial therapy of acute bacterial rhinosinusitis (ABRS), and 3 new recommendations for managing chronic rhinosinusitis (CRS).

COMPLICATIONS OF FRONTAL SINUSITIS. BIBLIOGRAPHIC REVIEW

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Authors	Design	Methods	Results
Lang <i>et al.</i> [9] [2001]	Retrospective study	A retrospective review of the hospital database and the patient case notes was performed.	10 patients presented to this department over a 12-month period with subdural empyema secondary to acute frontal sinusitis. 4 patients had a coexisting Pott's puffy tumour and one patient had a periorbital abscess. Each patient was managed using a multidisciplinary approach. A frontal sinus trephine/drain with antiseptic washout was performed at the same time as craniotomy with evacuation of the empyema.
Leong <i>et al.</i> [10] [2017]	Review	Literature PubMed review using a combination of MeSH terms and keywords was undertaken, combined with a single surgeon case series of 3 patients.	29 cases were reviewed. 62 %had acute FS followed by a history of chronic rhinosinusitis (28%). Two patients presented with concomitant preseptal cellulitis and cutaneous fistula, one had pneumocephalus. 59 %had Draf I procedure. 3 cases had Draf III procedure. PostThere were no further complications following ESS. Both fistulas healed without requiring surgical debridement or closure.
Koltsidopoulos <i>et al.</i> [11] [2020]	Review	Search on Web of Science, PubMed and MEDLINE from 1998 to 2018, focused on papers concerning the diagnostic procedure and therapeutic management of PTT. No statistical instruments were used.	53 articles were included that described 92 pediatric and adolescent patients with PPT. Intracranial complications were found in 72%. Of patients. Most authors used computed tomography for the diagnosis of PTT and its complications, either alone or in combination with magnetic resonance imaging. In 50 %of cases, an endoscopic endonasal approach is used for the management of the underlying acute or chronic sinusitis.
Al-Madani <i>et al.</i> [12] [2013]	Retrospective study	Patients attending ENT clinic with sinusitis from January 2010 until January 2012 were included. Two groups: first involved children aged less than 16 and second included adults older than 16 years. Clinical picture, sinus involved, management and outcome were compared.	616 patients included Orbital complications in 5.8 %of patients 72.2 %pediatric patients (21 had preseptal and 5 orbital cellulitis) ten pa27.8%) were adults The most common orbital complication was preseptal cellulitis (72.2%) followed by orbital cellulitis and abscess (22.2 %and 5.6 %respectively). The majority of patients responded to medical treatment.
Dankbaar <i>et al.</i> [13] [2015]	Pictorial Review	Clinical files review	Complications arising from acute bacterial rhinosinusitis can result in life-threatening illness. Knowing the anatomic relationship of the paranasal sinuses to the orbital and intracranial compartment and the mechanisms of infectious spread, is paramount for early diagnosis of these complications. The radiologist needs to be aware of the specific imaging findings of orbital and intracranial complications of acute bacterial rhinosinusitis, including cavernous sinus thrombosis.
Wan <i>et al.</i> [14] [2016]	Retrospective study	Clinical files review	31 pediatric patients with orbital complications secondary to acute rhinosinusitis. In all cases, intensive treatment was initiated with a combination of oral or intravenous antibiotics, glucocorticoid and gelomyrtol forte after admission. ESS was performed if an improvement in the condition of patients did not occur after 48 hours. Patients with orbital SPA, motility disorders of eyeball or decreased vision received ESS immediately within 24 hours.
Barros <i>et al.</i> [19] [2016]	Clinical Textbook		

(continued)

COMPLICATIONS OF FRONTAL SINUSITIS. BIBLIOGRAPHIC REVIEW

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Authors	Design	Methods	Results
Smith <i>et al.</i> [15] [2015]	Review	Clinical data and radiographic studies on 12 cases from our institution were analyzed Retrospectively. A literature search and review were conducted, with additional cases pooled with the new cohort for an aggregate analysis.	Twelve cases of cavernous sinus thrombosis. 25 %experienced neurologic morbidity. Contrast-enhanced MRI and contrast-enhanced head CT were 100 %sensitive for detecting cavernous sinus thrombosis, Literature review produced an additional 40 cases, and the aggregate mortality rate was 4 of 52 (8%) and morbidity rate was 10 of 40 (25%). Outcomes did not vary by treatment or with unilateral vs bilateral cavernous sinus involvement.
Scullen <i>et al.</i> [7] [2019]	Systematic review	Studies reporting surgical management and outcomes of frontal sinus disease with intracranial extension were queried in PubMed. Common internet search engines were also used. Studies regarding sinogenic intracranial suppurative infections treated surgically with ESS and neurosurgical approaches were included.	108 cases were identified with intracranial sinogenic disease were treated via ESS alone, 47 cases via transcranial intervention alone and 43 cases via simultaneous neurosurgical and ESS .Complex sinus disease with posterior table compromise in the absence of intracranial extension treated via ESS alone was reported in 164 cases.
Fountas <i>et al.</i> [16] [2004]	Review of the literature and case report		Frontal sinusitis should be carefully approached because of the severe complications that may develop. The antibiotics and the newer diagnostic modalities such as CT and MRI should be correctly used to prevent such problems.
Lal <i>et al.</i> [20] [2019]	Clinical Textbook		
Foerster <i>et al.</i> [17][2007]	Review		This paper describes and depicts infections within the different compartments of the brain. Pathology-proven infectious cases are presented in both immunocompetent and immunocompromised patients, with a discussion of the characteristic findings of each pathogen. Magnetic resonance characteristics for several infections are also discussed.
Kombogiorgas <i>et al.</i> [18][2007]	Retrospective study	Clinical files of 11 consecutive paediatric patients, who were subjected to surgery for sinusitis-induced suppurative intracranial complications were reviewed.	Children presenting with possible sinusitis induced SIC require: - High index of suspicion in order to establish the diagnosis as soon as possible. Low threshold for performing CT and MRI scanning of the brain and sinuses of children; - Prompt and aggressive medical and surgical intervention in order to minimize the mortality and maximize the outcome for those children.