Journal of Cranio-Maxillo-Facial Surgery 47 (2019) 876–882

Contents lists available at ScienceDirect

Journal of Cranio-Maxillo-Facial Surgery

journal homepage: www.jcmfs.com

Is post orthognathic maxillary sinusitis related to sino-nasal anatomical alterations?☆

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ARTICLE INFO

Article history:
Paper received 17 December 2018
Accepted 5 March 2019
Available online 12 March 2019

Keywords:
Sinusitis
Septal deformities
Endoscopy
Orthognathic surgery
Le Fort complications

ABSTRACT

Le Fort I osteotomies have been used for more than five decades, but their impact on nasal and paranasal cavities physiology, has not been studied deeply. In this paper we want to analyse the possible correlation between post-orthognathic findings and prevalence of sinusitis which require surgical treatment.

A retrospective cohort study was designed in 2017; the study was designed and carried out in the Verona University maxillo-facial department, a referral centre for orthognathic surgery. The study population is made of 64 patients that underwent orthognathic surgery (To treat class II or III malocclusion) between 2010 and 2015. Inclusion criteria were the availability of a Cone Beam Computed Tomography (CBCT) before surgery and one between 12 and 24 months after orthognathic surgery. Exclusion criteria were smoking habit and previous orthognathic procedures.

During follow-up time prevalence of sinusitis was 18.5% and some patients required a secondary surgery to treat sinusitis. Surgery induced anatomic alterations were frequent in patients with sinusitis, sings and symptoms of sinusitis show positive correlation with anatomic alterations.

1. Introduction

Effects of orthognathic surgery on anatomy and physiology of the upper airways have been extensively studied (Mattos et al., 2011). It is demonstrated that maxillo-mandibular advancement is related with an increase of the volume of the upper airways (Lye, 2008; Boyd et al., 2009) and upper pharynx enlargement with a remarkable improvement on airflow (Mattos et al., 2011; Lye, 2008; Boyd et al., 2009; Maurer, 2010; Susarla et al., 2010; Jacobson et al., 2012). Despite these facts (Varghese et al., 2012; Faria et al., 2013), studies that investigate effects of orthognathic surgery on nasal cavities and paranasal sinuses are not so frequent and results are controversial (Bell et al., 1986; Nocini et al., 2016).

Acute sinusitis is a possible complication after Le Fort I osteotomy but is not very common; this is proved by the relatively low rate of early infective complications after surgery (Morris et al., 2007; Steel and Cope, 2012; Panula et al., 2001; Bailey et al., 2004; D'Agostino et al., 2010; Pereira-Filho et al., 2011; Garg and Kaur, 2014; Valstar et al., 2013). Filho and Valstar report 4% incidence of maxillary sinusitis after orthognathic surgery but they show that surgery is not directly related to the onset of chronic or subacute sinusitis (Valstar et al., 2013; Pereira-Filho et al., 2011).

However, most of the studies in current literature do not analyse the anatomical and functional endonasal changes induced by surgical treatment (Perko, 1972), which may play an important role in the pathogenesis of maxillary sinusitis.

Le Fort I osteotomies can have a major impact on health and homeostasis of the paranasal sinuses as well as major preprosthetic surgery (D'Agostino et al., 2016), moreover, a recent study has demonstrated that radiological evidence of inflammation in maxillary sinuses and an increase of rhinosinusitis symptoms could benefit from the routine use of CBCT and SNOT20 to detect early rhino-sinusal complications after orthognathic surgery (Nocini et al., 2016).

The purpose of this study is to analyse the prevalence of sinusitis requiring surgical treatment in patients with history of orthognathic surgery.

☆ This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

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https://doi.org/10.1016/j.jcms.2019.03.006
1010-5182/

The investigators hypothesize that orthognathic surgery could promote sinusitis, by changing sino-nasal anatomy and/or by altering sinus homeostasis.

The specific aims of this study are to follow up patients who underwent orthognathic surgery using LMS and SNOT20 for early detection of patients who required FESS, and to compare LMS and SNOT20 before and after FESS, demonstrate anatomical changes detected by imaging, and correlate those anatomical changes with the incidence of sinusitis that is not responsive to conservative treatment.

2. Materials and methods

Investigators designed a retrospective study to investigate the prevalence of sinusitis that requires surgical treatment in patients with history of orthognathic surgery and the correlation between sinusitis and anatomical alterations induced by surgery.

The population was composed of patients who underwent orthognathic surgery at the Oral and Maxillofacial Surgery Section of the University Hospital of Verona between January 2010 and December 2015.

Inclusion criteria were a history of orthognathic surgery, availability of a preoperative CBCT scan taken one week before surgery, and a postoperative CBCT scan taken between 12 and 24 months after surgery. Exclusion criteria were smoking habit and history of multiple orthognathic surgical procedures.

64 patients were selected, 38 (59%) female and 26 (41%) male. The mean follow-up duration was 40.2 months (range 24–73). None of the patients had history of rhinitis, none of the patients were referred to a specialist for sinusitis symptoms before orthognathic surgery (see Table 1).

CBCT scans were acquired with the patient in natural head position, the dose uptake for each patient was approximately 59 mSv. The type of surgery (Functional Endoscopic Sinus Surgery) was carried out in patients with LMS $\geq$ 2 and SNOT20 score between 40 and 100. All the procedures were performed by the same surgeon (P.P.). Given the retrospective nature of this study it was granted exemption by the Verona university IRB. The patient's gender, age, and follow-up duration were registered. The primary outcome variables are Lund–Mackay CT score (LMS), SNOT20, endoscopic findings and plates infection (see Table 2).

LMS was used to monitor sinusal pathologies. LMS is a widely used score to evaluate the signs of sinusitis using CT scans. The scale analyzes the severity of mucosal thickening or fluid retention of each cavity (maxillary, frontal, sphenoid, anterior ethmoid, and posterior ethmoid) and the ostio–meatal complex (6 sites on each side). The score is 0 (no opacification), 1 (partial opacification), or 2 (total opacification); the ostiomeatal complex score is 0 or 2 (the presence or absence of disease, respectively).

SNOT20, a validated patient-reported measure of sino-nasal conditions, is one of the most widely adopted tools to evaluate a range of health and quality-of-life variables linked to rhinosinusitis issues. Each of its 20 items receive a score ranging from 0 (no limitation) to 5 (extreme limitation). The final overall score ranges from 0 to 100. Higher scores represent worse symptoms and poor quality of life; lower scores represent less symptoms and better quality of life. A score of 0–10 indicates no or little alteration, score of 11–40 indicates mild to moderate issues, a score of 41–69 indicates moderate to severe problems and requires a specialist consult, and a score greater than 70 is considered suggestive of severe or critical conditions necessitating the attention of a specialist for possible surgical intervention.

Table 1
Population data.

Number of patients	64
Male	26 (40.6%)
Female	38 (59.4%)
Mean age (y)	27.06
Range age (y)	17–47
Mean follow up (mo)	40.2
Range follow up (mo)	24–63

Table 2
Pre- and post-orthognathic primary outcome variables (number of patients).

	Pre-orthognathic	Post-orthognathic
SNOT20		
0–10	62 (97%)	52 (81%)
11–40	2 (3%)	8 (13%)
>40	0 (0%)	4 (6%)
LMS		
0	58 (91%)	32 (50%)
1	4 (6%)	20 (31%)
≥2	2 (3%)	12 (19%)
Nasal alterations		
Deviated septa	2 (3%)	5 (8%)
Perforated septa	0 (0%)	6 (9%)
Nasal wall discontinuities	0 (0%)	13 (20%)
Hardware infection	–	8 (12.5%)

Each patient's pre- and postoperative CBCT scans were analyzed to detect any anatomical defects or surgery-induced alterations that could lead to paranasal homeostasis disruption. The analysis focused on any interruption or deviation of the septum, discontinuities in the sinus walls, and presence of hardware in the sinuses. Radiologic and clinical analyses were performed by 2 of us (L.L., F.L.).

Study variables were analyzed pre and post orthognathic surgery with t-student paired test, P value fixed $\leq$0.005.

Potential confounders in association between primary predictor variable and primary outcome variables was tested by one-tail Pearson' correlation, P value fixed $\leq$0.005.

Comparison between study population and sub-populations with sino-nasal morphologic deformities was carried out using Chi–Square test (P value < 0.05).

All statistical analyses were performed using Statistical Package for Social Sciences Version 22.0 (SPSS Inc., Chicago, IL).

2.1. Orthognathic treatment

All patients underwent orthognathic surgery following FAB guidelines: improvement of face's profile (Bertossi et al., 2018a), preservation or augmentation of the volume of the upper airways, adequate dental occlusion.

Piriform and nasal ceiling were always separated from mucosa by using Obwegeser periosteal to preserve the integrity of the mucosal walls.

Le Fort I Osteotomy was performed on all patients by means of saw and scalpel. Osteoplasty was performed on maxillary crest and medial wall of maxillary sinuses to avoid interference during maxillary repositioning.

In case of damage to nasal mucosa it was repaired using resorbable suture. Osteosynthesis was performed by means of titanium plates and screws.

3. Results

3.1. Radiologic analysis

During pre-orthognathic evaluation, 4 patients had mucosal thickening in the maxillary sinuses (LMS = 1), 2 presented with

bilateral maxillary sinus opacification (LMS = 2); interestingly both showed radiological improvement after orthognathic surgery.

Overall 20 of the 64 patients (31.25%) showed post-orthognathic mucosal thickening (LMS = 1) and 12 (18.75%) showed evidence of sinus opacification (3 bilateral and 9 monolateral) (LMS ≥ 2) (See Graph 1).

The post-operative LMS scores were higher, and the difference with respect to the preoperative scores was statistically significant ($P = 0.00001$).

Confounders do not significantly affect the outcome variables: variation in LMS post-orthognathic surgery is not related with sex: $P = 0.091$ neither with age $P = 0.305$.

3.2. Clinical analysis

Clinical analysis demonstrated that 62 had pre-orthognathic SNOT20 score between 0 and 10 and 2 had a score between 11 and 20.

After Le Fort I osteotomy, 52 of the 64 patients (81.25%) had a SNOT20 between 0 and 10, 8 patients (12.5%) had a score between 11 and 40 (i.e. moderate rhinosinusitis) and 4 patients (6.25%) had a score between 40 and 100 (See Graph 2).

The increase in the SNOT-20 scores after surgery was statistically significant ($P = 0.0040$).

Confounders do not significantly affect the outcome variables: variation in SNOT20 post-orthognathic surgery is not correlated with sex: $P = 0.235$ nor with age: $P = 0.317$.

3.3. Morphologic analysis

Several alterations of nasal cavities and paranasal sinuses were evidenced in the examined population.

An analysis of post-orthognathic CBCT scans uncovered abnormal sinus anatomy in 16 patients. Loss of continuity of lateral nasal wall was present in 13 patients (20.3%); 6 patients (9.4%) had incomplete healing of the nasal septum with osteo-cartilaginous defects and 5 patients (7.8%) showed a markedly deviated nasal septum not present before surgery. Multiple abnormalities coexisted.

3.4. Secondary surgery

Patients with LMS ≥2 and SNOT20 score between 40 and 100 underwent FESS. Details about the 4 surgically treated patients (6.25%) are outlined in Table 3.

During FESS, loss of continuity of the lateral nasal wall was evidenced in 3 patients (See Figs. 1–3). In addition, three patients had incomplete healing of the nasal septum with osteo-cartilaginous deficits while one patient showed a markedly deviated nasal septum not present before orthognathic surgery.

Giant mucocele was found in two patients (See Fig. 4). In addition, one patient showed an unusual anatomic alteration that led to a newly formed sinus cavity inside the maxillary sinus (See Figs. 5 and 6).

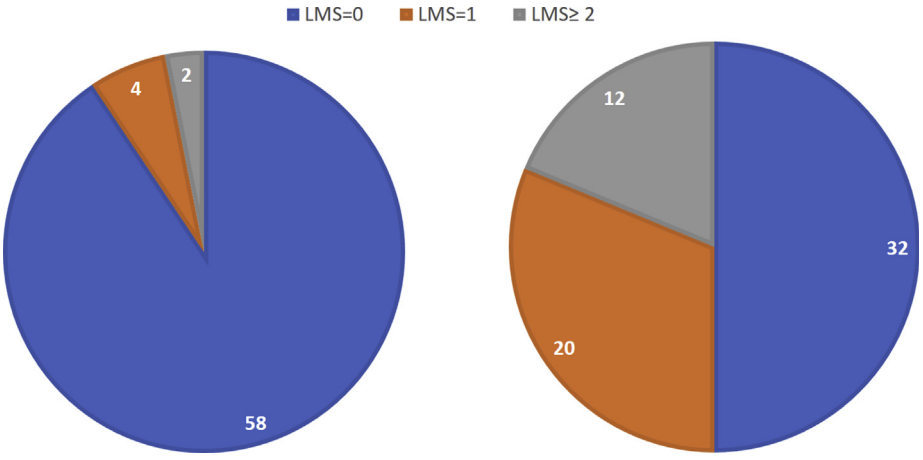
Overall 9 out of 64 patients needed plates removal but only 8 of them (12.5%) showed signs and/or symptoms of hardware infection. Six of them (LMS < 2 and SNOT20 < 40) had plates and screw removal without major surgery: screws loosening and/or granulation tissue were evidenced. The remaining 3 patients (LMS ≥ 2 and SNOT20 > 40) had plates removal during FESS: 2 of them presented with an intraoral fistula, pus drainage, and bone reabsorption, the latter only reported plates discomfort and it was covered by healthy reactive cortical bone.

Comparison between study population and sub-populations with sino-nasal morphological changes carried out that patients with specific deformities have a positive correlation with sinusitis requiring FESS (LMS > 2 and SNOT20 > 40): nasal wall defect ($P = 0.004$), perforated septa ($P = 0.000003$) and plates removal ($P = 0.019$) are statistically significant. Patients with deviated septa have a positive association with FESS, but it is not statistically relevant ($P > 0.5$) (See Graph 3).

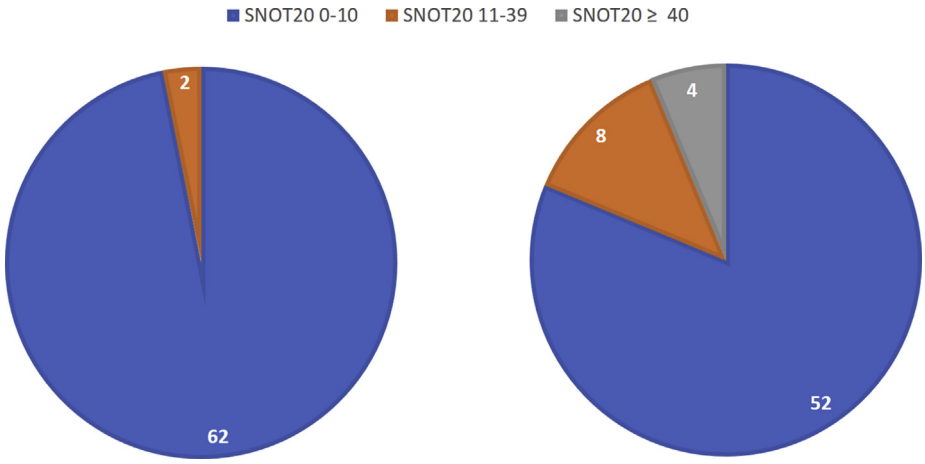
4. Discussion

The purpose of this study was to analyse sino-nasal complications and anatomical alterations in people who underwent orthognathic surgery. Our hypothesis is that orthognathic surgery may cause anatomical alterations of the nasal and paranasal cavities and promote sinusitis due to the alteration of sinus homeostasis. There are many studies that show that complications in orthognathic surgery may arise in the medium to long term after the procedure, however it is impossible to say the same about the literature that study the anatomical and functional alterations of the nasal cavity and paranasal sinuses after surgery (Valstar et al., 2013; Williams et al., 2013).

The estimated prevalence of sinusitis ranges from 2 to 16%, however, definitive diagnostic criteria for sinusitis remain controversial. Some authors suggest that chronic rhinosinusitis should be defined as a group of disorders characterized by inflammation of the mucosal lining of nasal passages and paranasal sinuses lasting



Graph 1. Comparison between pre and post orthognathic Lund MacKay score (number of patients).



Graph 2. Comparison between pre and post orthognathic SNOT20 score (number of patients).

Table 3
Patient evidence and treatment.

Patients	1	2	3	4
Age	27	40	29	31
Gender	F	M	F	M
Pre-orthognathic SNOT20	0	14	4	0
Pre-orthognathic Lund MacKay score	0	1	1	0
Type of orthognathic surgery	Le Fort I BSSO Bone inlay	Le Fort I BSSO Bone inlay	Segmented Le Fort I BSSO	Segmented Le Fort I BSSO
Complications	None	None	None	None
Post-orthognathic SNOT20	75	78	68	71
Post-orthognathic Lund MacKay score	2	6	3	2
Signs	Cheek oedema Intraoral fistula Rubor	Rubor Intraoral fistula	None	None
Symptoms	Pain Nasal dripping Pain on hardwire/s palpation, intraoral fistula	Pain Nasal dripping Pain on hardwire/s palpation, intraoral fistula	Pain Discomfort on hardwire/s palpation	Pain Nasal dripping
Endoscopic surgery	Maxillary antrostomy	Maxillary antrostomy Anterior ethmoidectomy Mucocele removal	Bilateral maxillary antrostomy	Pus drainage Mucocele removal
Hardwire removal	Yes	Yes	Yes	No
Post-FESS SNOT20	5	5	25	10
Post-FESS Lund MacKay score	0	0	0	0
Deformities	LNW, OS	LNW, SP	SP, SD	LNW, SP

LNW: Loss of continuity of nasal wall, OS: Occluded sinus, SP: Septum perforation, SD: Septum deviation.

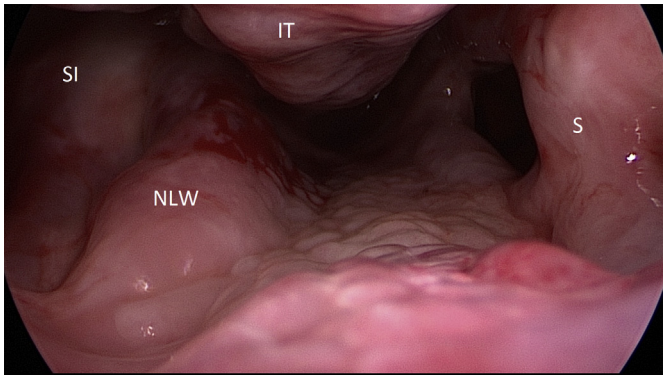


Fig. 1. P 4, 31 years old, several alterations of the nasal cavity: the discontinuity of the nasal lateral wall caused a destructive communication between nose and maxillary sinus. IT: right inferior turbinate, S: septum, NLW nasal lateral wall, SI: right maxillary sinus.

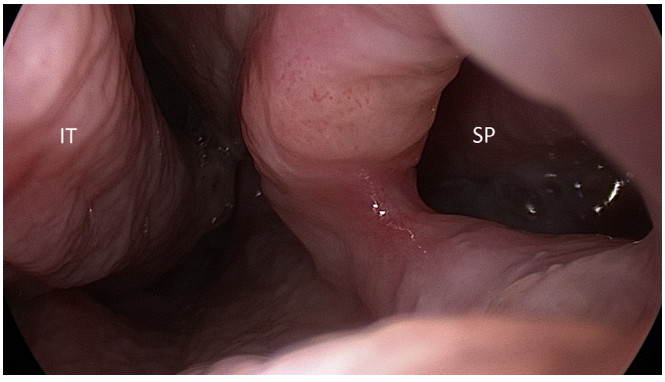


Fig. 2. P 4, IT: right inferior turbinate, SP: septum perforation.

Fig. 3. P 4, bilateral sinusitis. Loss of continuity of the lateral nasal wall, septum perforation and deviation.

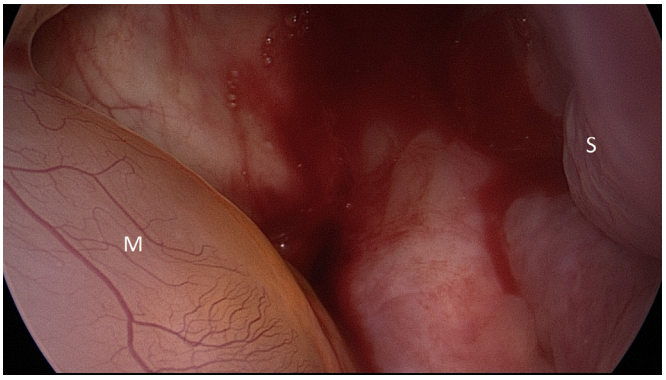


Fig. 4. P 4, S: septum, M: mucocele.

at least 12 consecutive weeks (Benninger et al., 2003). Other authors suggest that symptoms consistent with rhinosinusitis such as those outlined in the SNOT20 questionnaire should also be considered to classify the disease as symptomatic or asymptomatic (Lachanas et al., 2012; Moses et al., 2000; Bertossi et al., 2018b).

In the studied group, 32 (50%) showed evidence of post-orthognathic inflammatory processes affecting the paranasal sinuses (LMS $\geq$ 1), while only 6 (9.38%) showed signs of inflammation at pre-orthognathic CT.

12 patients (18.75%) developed radiological evidence of sinusitis (LMS $\geq$ 2) after orthognathic surgery; 8 of them (12.5%) had a SNOT20 score between 11 and 40 while 4 patients (6.25%) had a score greater than 40 which required secondary surgery (FESS).

Interestingly 2 patients showed radiological improvement after orthognathic surgery (LMS 2 preop − 1 postop): none of them demonstrated nasal alteration or plates infection after Le Fort I osteotomy. Even if we cannot explain the reason of this radiological improvement, it is possible to assume that these are occasional findings. Signs of chronic subclinical rhinosinusitis were more frequent in the postoperative CT scan than in the preoperative one. Symptoms (SNOT20) are positively related with signs (LMS).

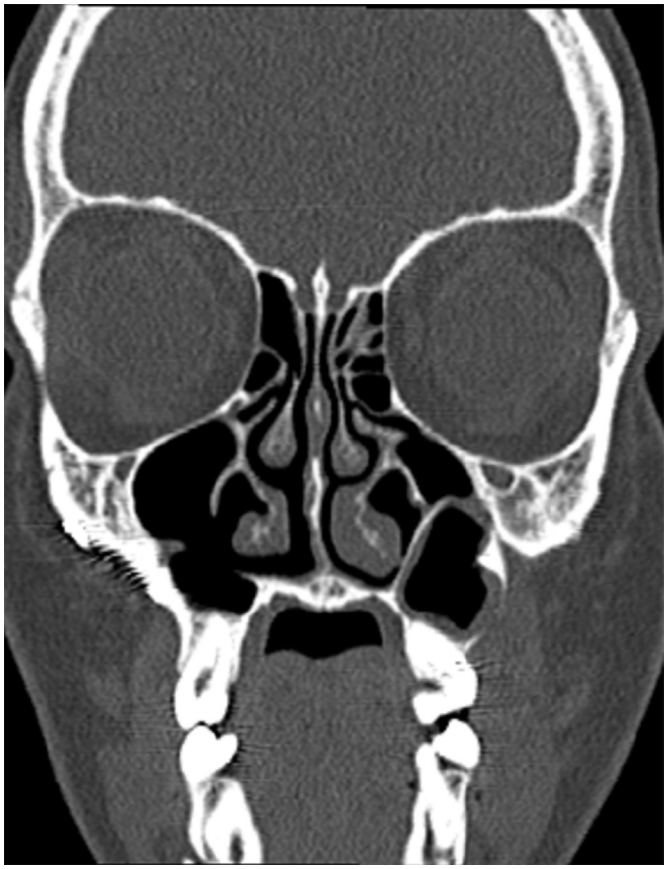


Fig. 5. P 1, 27 years old. Loss of continuity of right nasal wall, newly formed sinus cavity inside maxillary sinus isolated from the airways.

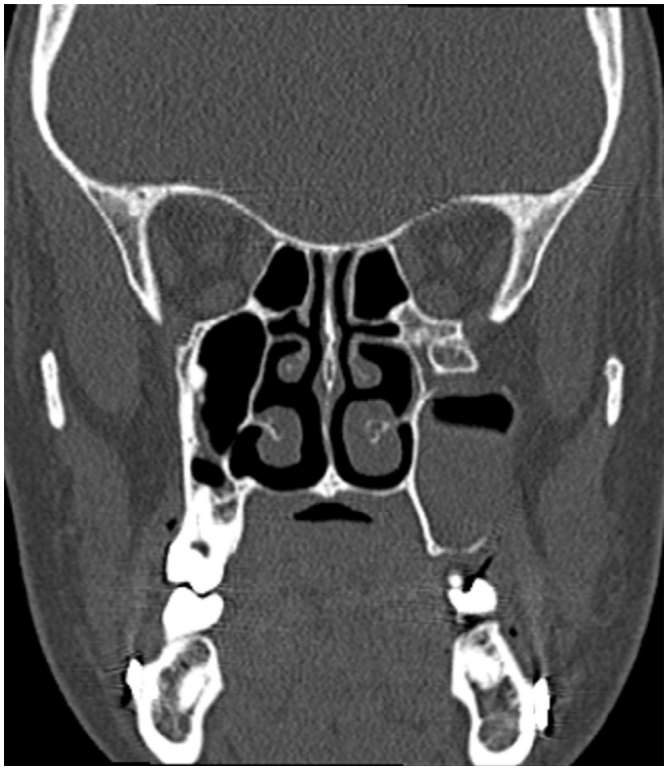
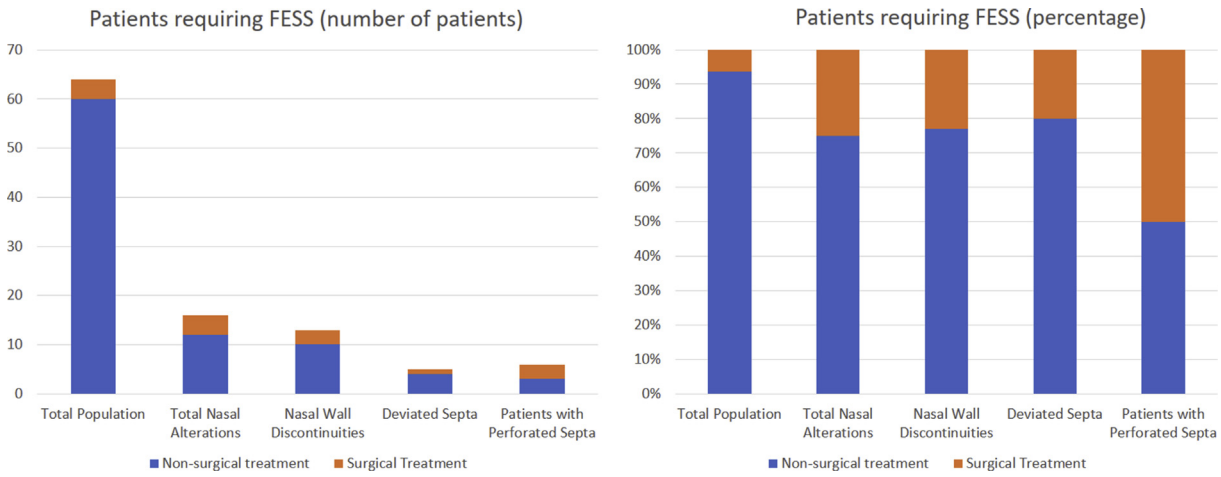


Fig. 6. P 1, 27 years old. Loss of continuity of right nasal wall, isolation of left maxillary sinus, different cut: pus level is appreciable.



Graph 3. Frequency of FESS treatment: comparison between study population and sub-populations with nasal alterations; FESS is positively linked to nasal deformities.

The morphologic evaluation detected changes in sino-nasal anatomy in a relevant percentage of patients; these alterations could play a key role in the pathogenesis of sinusitis. In the population in the exam, deformities are positively linked with rhino-sinusal problems and more frequent in patients that required surgical treatment (FESS).

Although these alterations have often been undervalued by clinicians, when associated with reduced mucociliary clearance and debridement of healthy inferior sinus mucosa, they may play a role in the onset of rhinosinusitis; in fact, 4 patients that needed FESS presented multiple abnormalities (see Table 3).

Among patients with post-orthognathic deformities there is a high incidence of sinusitis that required FESS (6.25% with $P < 0.1$), in addition, nasal deformities can influence the necessity of sinus surgery (See Graph 3).

Among 9 patients requiring hardware removal, only 2 presented both sinusitis and plates infection. Although hardware infection may contribute to the development of the sinusitis, only patients with plates infection, nasal alterations, SNOT20 >40 and LMS >2 required surgery. Perhaps the association between hardware infection and nasal alterations can disrupt sinus homeostasis and contributes to the pathogenesis of severe sinusitis that requires surgical treatment.

The strength of this study is the strict selection of population: rigid inclusion and exclusion criteria have narrowed the study group to avoid any interference with other risk factors that may increase the prevalence of the sinusitis.

Out of these 64 patients only 4 had secondary surgery (6.25%). Among these there is a high prevalence of sino-nasal anatomical changes that may promote their condition.

The main weakness is the design of the study, it was not possible to determine whether plates infection was a cause or a consequence of maxillary sinusitis.

The anatomy of nose and paranasal sinuses is complex. The nasal septum and the medial nasal walls represent the cornerstone of the airflow through the nasal cavity. The loss of continuity in the nasal septum as well as in the medial nasal walls leads to a defective nasal airflow that is strictly associated to unsatisfactory breathing function and finally to a higher risk of sinusitis. Although the anatomical alterations are not avoidable, they seem to be related to flow alterations and to sinusitis itself. It is recommended to identify before surgery patients prone to sinusitis. In these patients the unavoidable anatomical modifications could represent a contributing factor to symptomatic sinus inflammation not responsive to conservative therapy.

Further studies on larger populations are required to confirm our results.

5. Conclusion

Sinusitis has a relatively higher prevalence in patients with history of Le Fort I osteotomy than in the general population (2–16% in general population vs 18.75% in this study).

CBCT and SNOT20 questionnaire after orthognathic surgery are useful to evaluate signs and symptoms of sinusitis.

Some patients may require a specialist for evaluation, medical therapy and eventually surgery to treat sinusitis. FESS might be an effective treatment option in those patients.

Anatomic defects or surgery-induced alterations of the upper airways are relatively frequent in patients with sinusitis after orthognathic surgery. Patients should be clearly informed about these eventual side effects preoperatively.

Conflict of interest statement

All authors have no conflict of interest to declare.

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