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Original Article

THE IMPACT OF COVID-19 ON THE PERI-OPERATIVE COMPLICATIONS RATE OF MAXILLARY SINUS FLOOR AUGMENTATION

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ABSTRACT

Aim: The objective of this comparative study was to correlate the effect of previous infection with human coronavirus (HCOV) on the incidence of Schneiderian membrane perforation (SMP) and postoperative complications of maxillary sinus augmentation. **Patients and methods:** Twenty-four eligible patients with atrophic posterior pneumatized maxilla (assessed radiographically) were enrolled to the current study to undergo sinus floor augmentation. The patients were divided into two equal groups: positive history of COVID 19 infection/ study group and negative history of COVID-19 infection/control group. All patients were imaged by cone beam computed tomography (CBCT) three times; before surgery (for inclusion), immediately after surgery (1 week), and at the end of follow-up (4 months). Clinical and radiographic assessment were performed to monitor the incidence of SMP and Postoperative complications. **Results:** The mean patient's age was 48.75±6.69 & 52.42±5.82 for the study and the control group respectively. There was no statistically significant difference (p=0.059) regarding SMP among the studied groups. Regarding the post-operative complications, the incidence of facial pressure was significantly higher in the study group than the control group (p=0.035). However, there was no significant difference among groups in terms of the other postoperative complications. **Conclusion:** COVID-19 induced sinusitis could be a potential risk factor for postoperative complications of sinus augmentation surgery.

KEYWORDS: COVID-19, sinus membrane perforation, sinus augmentation, sinus lift, complications

I. INTRODUCTION

The primary obstacle of the insertion of endosseous dental implants in the posterior maxilla is limited bone quantity (height/volume) [1]. Various strategies, including tilted implants, short implants, and grafting of the maxillary sinus floor, have been reported in the literature to address these anatomical challenges [2]. The most frequently utilized surgical technique to enhance deficient bone quality and quantity in the posterior maxilla is maxillary sinus floor augmentation [3].

It's performed as a standard approach to add a sufficient amount of bone height to the posterior maxilla in order to accommodate simultaneous placement for dental implants. However, when sufficient primary implant stability cannot be achieved due to extensive maxillary atrophy, sinus floor augmentation can be done as an initial stage with performing the implant placement on a second stage surgery [4].

Through the literature, different grafting materials have been assessed for sinus lifting. For many reasons, including their osteogenic, osteoinductive, osteoconductive characteristics and the lack of an immunogenic reaction, autografts represent the gold standard for all grafting materials [5,6].

Open sinus floor elevation (SFE) could result in certain complications and related comorbidities. There are general complications such as swelling or hematoma and specific risks [7]. These specific risks occur less frequently and include sinus membrane perforation (SMP), chronic rhinosinusitis, hemorrhage or even overfilling with subsequent ostium blockage or even membrane necrosis [1]. These complications may compromise the viability of the graft and/or the implants and cause the patient a great deal of discomfort. When there is a sufficient remaining bone height, closed sinus lifting may be performed as it is a less invasive procedure that enables simultaneous trans- crestal implant installation [8]. However, the most frequent complication of open SFE is SMP and bleeding following osteotomy window creation.

SMP has an incidence ranging from 20% to 44% with subsequent risk of compromised augmentation and implant survival [9, 10]. However, perforations that resulted from closed sinus lift and an implant protruding 3mm beyond the sinus floor following its installation doesn't result in implant failure but rather postoperive sinusitis or epistaxis [11].

The perforation risk may be affected by anatomical as well as patient's related factors [12, 13]. Anatomical factors include thin membrane, acute angle (<30°) between buccal and palatal shelves, presence of septa, previous surgery, irregular sinus floor, protruding roots or residual alveolar Hight<3.5 mm [14]. Hence**,** preoperative cone beam computed tomography (CBCT) is an effective tool for analyzing anatomical sinus structures and planning the SFE procedure [10]. Patient related factors include patient's age, medical status, occupation, local infection and smoking which affect the structural integrity of the respiratory epithelium [15].

Average thickness of healthy sinus membrane on CBCT ranges from 0.8-1.99 mm. reviewing literature, it was found the risk of SMP increases when the thickness of sinus membrane is less than 0.8 or more than 2 mm. [16,17]

In terms of the sequalae of the sinus membrane perforation and how that impacts the prognosis of dental implants in the augmented sinus, few studies were encountered. [18-20] Sequalae of SMP on implant survival on the long run (8.9 years) has been evaluated with a resulting incidence of one failure for 25 perforations. [7]

Despite SMP doesn't necessarily predispose to implant failure, it may result in postoperative complications. [13] They include dispersion of graft material throughout the sinus, superimposed infection, sinusitis and ostium blockage. [4,20]

Diagnosis of SMP if not made by direct inspection, it can be made by Valsalva maneuver or more accurately with endoscopic inspection. [21] Management of such perforations is greatly affected by its size and varies from no intervention, suturing to utilization of barrier membrane (collagen or platelet rich fibrin (PRF)) or combinations. However, the most widely utilized technique for repair is the use of collagen membrane. [22] On the other hand, small size perforation can heal by membrane being folded on itself. [23]

The severe acute respiratory syndrome, Coronavirus 2 (SARS-CoV-2)-caused Coronavirus disease pandemic of 2019 (COVID-19) has rapidly spread around the entire world since its initial outbreak in China. Health care individuals, social workers and older individuals have the highest risk of getting infected. [24] There have been reports of upper airway symptoms, such as nasal congestion and rhinorrhea with an obviously direct impact on the respiratory epithelium. Studies have proved that the viral load is higher in the upper respiratory tract. [25] This subsequently led to more damaging effects on the nasal and sinus epithelium than on the lungs.

Due to COVID-19's direct impact on the anatomical structure of the respiratory epithelium, it seriously affects the outflow of the maxillary sinus, increasing the risk of infection without even existence of a simultaneous sinus surgery. [26,27]

According to a study that focused on the impact of coronavirus on the respiratory epithelium, the virus damages the epithelium on the third day after enucleation, causes structural damage and mucociliary dysfunction even if though there's no symptoms of common cold. [28] This fact alone might cause the sinus membrane to be of questionable quality and undergo tears during its elevation in patients with recent COVID-19 infection.

To the best of our knowledge, no previous study has addressed the consequences of SARS-CoV-2

infection on the maxillary sinuses membrane and subsequent risk of its perforation clinically or radiographically via cone beam computed tomography (CBCT) scans. CBCT is considered a valuable tool for analyzing the sinus anatomy as well as for preoperative planning of sinus floor augmentation surgeries. CBCT imaging modality has many advantages that make it a better choice when compared to traditional two-dimensional radiographs. It provides distortion free image, high resolution, accurate measurements and three-dimensional evaluation to the surgical site. Moreover, it overcomes some of the limitations in computed tomography CT such as the high dose required, and the higher cost. **[29]** So, the aim of the present study was to correlate the history of COVID-19 infection with the occurrence of SMP or Postoperative complications related to SFE surgery.

II. PATIENTS AND METHODS

The present study was approved by the ethical committee of the faculty of dentistry, Cairo University that follows the declarations of Helsinki regulations (ethical approval number: 25 3 23). Patients that have missing upper posterior teeth with atrophic posterior maxilla were recruited from the outpatient clinic of the same institution to evaluate if they meet the inclusion criteria. The eligible subjects have signed the informed consent after full understanding of the possible surgical complications as well as the need for multiple CBCT scans. The present study was approved by the ethical committee of the faculty of dentistry, Cairo University that follows the declarations of Helsinki regulations.

Eligibility criteria:

To be included in the current study, patients with missing upper posterior teeth and atrophic posterior maxilla should have 4 mm or less residual bone height, age more than 18 years and highly motivated. Patients who suffered from any systemic disease, sinus pathosis other than sinusitis induced covid 19 or those under any medication that may affect the normal bone healing were excluded from the current study. Patients were assigned to groups according to a positive or negative PCR for the study and control group respectively.

Target population:

Twenty-four eligible patients were enrolled to the current study to undergo SFE surgery with bovine graft augmentation as a first stage surgery. A second stage surgery for delayed implant placement after 4 months was scheduled. Patients were divided into two equal groups: study group who had a positive history of COVID-19 infection and control group who had a negative history.

Preoperative radiographic assessment was performed to all included patients using CBCT imaging modality. On the coronal cuts, the residual alveolar bone height and Schneiderian membrane thickness were measured (Fig.1). Moreover, the required graft volume was provisionally assessed on the planned surgical site. The radiographic assessment was performed by a single experienced maxillofacial radiologist with 15+ years of experience. The measurements were recorded and included in the statistical analysis.

Surgical procedure:

Prophylactic antibiotic (Clindamycin 300mg) was prescribed for all patients the night before and one hour before the surgery. Under local anesthesia, buccal full thickness flap was raised following crestal and anterior vertical releasing incision. A rose head bur was used to create the osteotomy window under copious irrigation. The sinus membrane which became clear through the bony window was gently elevated all around the osteotomy. Elevation began with the alveolar portion followed by the remainder required parts of the membrane.

The sinus was inspected for any perforation (primary outcome) then grafted with bovine graft as necessary. If SMP was encountered, it was handled before grafting based on the perforation size. For perforation less than 4 mm, an extended membrane elevation was performed to allow for suturing or folding of the membrane over itself. Larger perforations are handled with collagen or PRF application before grafting. The flap was then repositioned and sutured in interrupted fashion.

Patients were instructed to follow strict oral hygiene measures and the prescribed antibiotic regimen for one week postoperative. Patients were followed up on regular follow up intervals (weekly for the first month then monthly for the additional

three months to assess soft tissue healing and presence of any complication. Patients were asked and examined at the follow up intervals also for facial pressure, congestion, stuffy nose, headache, prolonged low-grade fever, nasal or oral discharge and maxillary posterior teeth pain (secondary outcomes).

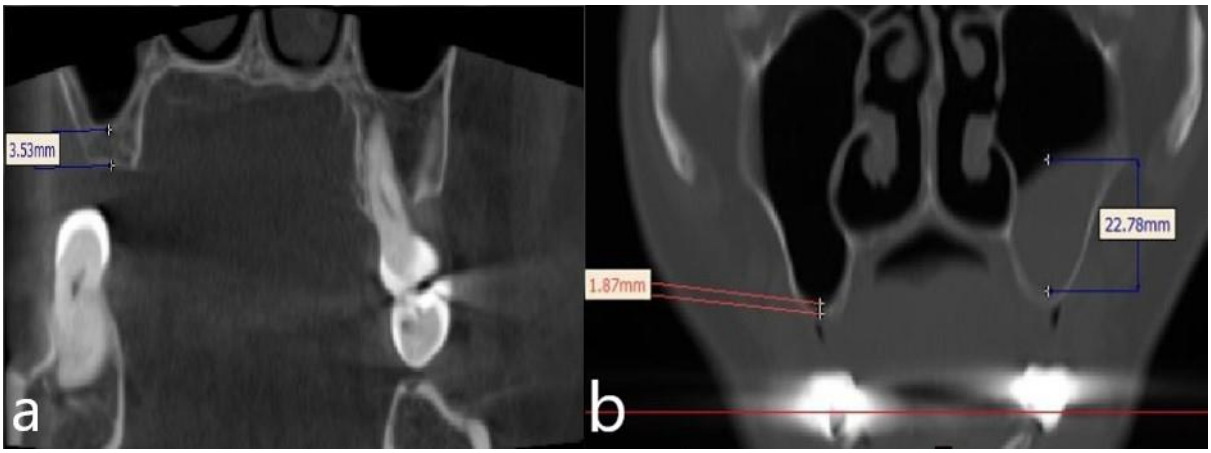

Figure 1: CBCT radiograph, coronal cut showing preoperative measurement of: a) The residual alveolar bone height and b) Schneiderian membrane thickness

Radiographic assessment:

CBCT radiographic assessment was performed, all the patients underwent an immediate scanning after surgery (1week) and another postoperative scanning after 4 months. Dicom files were then imported in mimics software (version 21, Materialise, Leuven, Belgium) for secondary reconstruction and image analysis. Assessment included evaluation of the presence of graft dispersion into the sinus cavity (indicating peri-operative complication) versus the integrity of the sinus membrane around the graft and the absence of any radiographic signs of infection (indicating no peri-operative complications) (Fig.2)

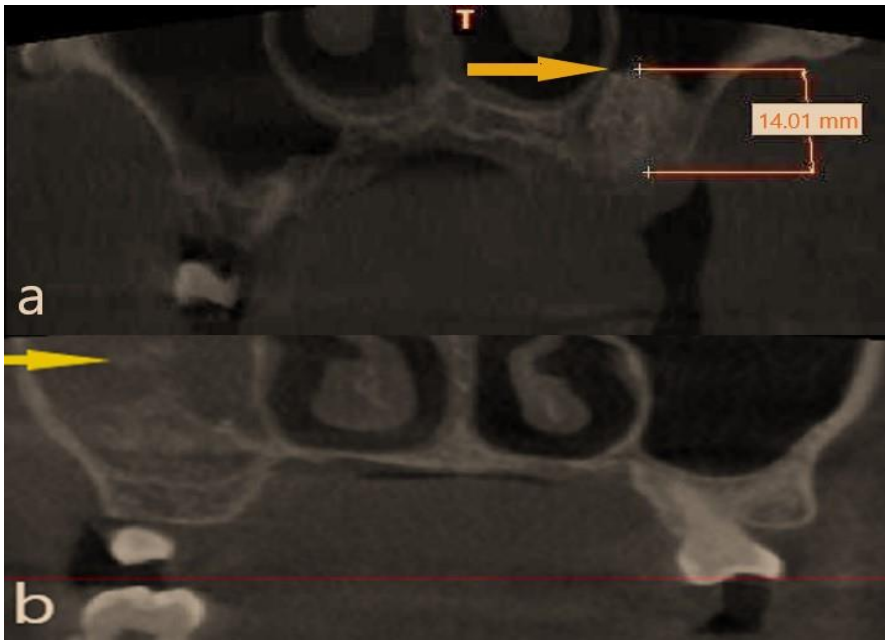

Figure 2: CBCT radiograph, coronal cut showing immediate (1week) postoperative: a) Uniform contour of the graft beneath the intact sinus membrane and b) Dispersion of the graft material through the sinus following infection.

Statistical analysis

Categorical data were presented as frequency and percentage values and were analyzed using Fisher's exact test. Numerical data were presented as mean and standard deviation values. They were analyzed for normality using Shapiro-Wilk's test. Age data were normally distributed and were analyzed using independent t-test. Membrane thickness data were found to be non-parametric and were analyzed using

Mann-Whitney U test. The significance level was set at $p<0.05$ within all tests. Statistical analysis was performed with statistical analysis software version 4.3.1 for Windows.

III. RESULTS

The study was conducted on 24 cases that were randomly and equally allocated to each of the studied groups (i.e., 12 patients each). There were 6 males and females in the study group, while in the control group there were 5 males and 7 females. The mean age of the cases in the study group was (48.75±6.69) years and in the control group it was (52.42±5.82) years. There was no significant difference between tested groups regarding sex (p=0.682) and age (p=0.166). Demographic data are presented in (Table 1). There was no significant association between sinus membrane thickness and intra-operative perforation (p=0.871) as presented in (Table 2). There was a significant difference between both groups regarding the incidence of facial pressure with the study group having a significantly higher percentage of affected cases (p=0.035, OR=7.00) For the incidence of other outcomes, the difference was not statistically significant (p>0.05). Incidence of different outcomes is presented in (Table 3& Fig.3). Of all the reported cases of the study group, one patient experienced fever, infection, highly elevated levels of D- dimer ten days postoperative. Investigations revealed postoperative positive covid -19 infection. There was a graft dispersion through the whole sinus cavity. Clinical soft tissue healing went uneventful in most of the cases except for the patient with postoperative covid infection who revealed clinical signs of infection and pus extrusion.

Table (1): Intergroup comparisons and summary statistics of demographic data

Parameter		Study	Control	Test statistic	p-value
Sex [n (%)]	**Male**	6 (50.0%)	5 (41.7%)	**0.17**	**0.682**
	Female	6 (50.0%)	7 (58.3%)		
Age (Mean± SD) (years)		48.75±6.69	52.42±5.82	**1.43**	**0.166**

Table (2): Association between sinus membrane thickness and intra-operative perforation for the study group.

Sinus membrane thickness (mm)		u-value	p-value
Intraoperative perforation (no)	**Intraoperative perforation (yes)**		
1.88±2.17	4.22±5.08	**19.00**	**0.871**

Table (3): Intergroup comparisons of the incidence of different outcomes.

Outcome	Status	Study	Control	χ^2	p-value	Odds ratio (96% CI)
SMP	**No**	7 (58.3%)	11 (91.7%)	**3.56**	**0.059**	**7.86 (0.75:82.13)**
	Yes	5 (41.7%)	1 (8.3%)			
Facial pressure	**No**	5 (41.7%)	10 (83.3%)	**4.44**	**0.035***	**7.00 (1.04:46.95)***
	Yes	7 (58.3%)	2 (16.7%)			
Facial congestion /swelling	**No**	7 (58.3%)	10 (83.3%)	**1.82**	**0.178**	**3.57 (0.53:23.95)**
	Yes	5 (41.7%)	2 (16.7%)			
Stuffy nose	**No**	11 (91.7%)	12 (100.0%)	**1.04**	**0.307**	**3.26 (0.12:88.35)**
	Yes	1 (8.3%)	0 (0.0%)			
Headache	**No**	9 (75.0%)	10 (83.3%)	**0.25**	**0.615**	**1.67 (0.22:12.35)**
	Yes	3 (25.0%)	2 (16.7%)			
Prolonged low-grade fever	**No**	11 (91.7%)	12 (100.0%)	**1.04**	**0.307**	**3.26 (0.12:88.35)**
	Yes	1 (8.3%)	0 (0.0%)			
Nasal discharge	**No**	12 (100.0%)	12 (100.0%)	**NA**	**NA**	**NA**
	Yes	0 (0.0%)	0 (0.0%)			
Oral discharge/pus	**No**	11 (91.7%)	12 (100.0%)	**1.04**	**0.307**	**3.26 (0.12:88.35)**
	Yes	1 (8.3%)	0 (0.0%)			
Maxillary posterior region pain	**No**	10 (83.3%)	11 (91.7%)	**0.38**	**0.537**	**2.20 (0.17:28.14)**
	Yes	2 (16.7%)	1 (8.3%)			
Acute sinusitis	**No**	11 (91.7%)	12 (100.0%)	**1.04**	**0.307**	**3.26 (0.12:88.35)**
	Yes	1 (8.3%)	0 (0.0%)			

*; significant ($p<0.05$), SMP: sinus membrane perforation

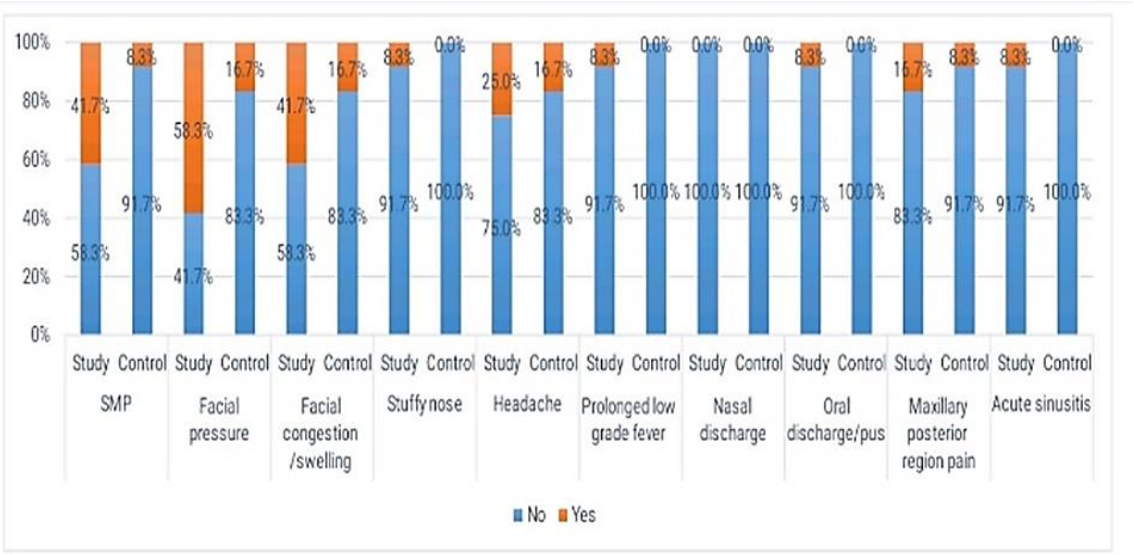

Figure 3: Stacked bar chart showing the incidence of different outcomes

IV. DISCUSSION

Maxillary sinus floor augmentation is one of the predictable reconstructive options for rehabilitation of the atrophic posterior maxilla. The procedure involves elevation of Schneiderian membrane which represents a respiratory epithelium. [30,31] Integrity of that epithelium is essential for graft preservation and implant long term survival. COVID-19 is known to attack the respiratory epithelium and exert its pathological effects on it. [32] The information regarding the duration and extent of its effect on the respiratory epithelium is still lacking in literature.

On the other hand, acute sinusitis may follow SFE as an adverse reaction to non-autogenous grafting materials. Adverse reactions to a xenogeneic graft material have been reported in literature in the form of foreign body reaction, graft dispersion, sinus or maxillary bone pathology, oroantral communication, chronic inflammation or cyst formation. [33] A foreign body reaction to the non- degradable particles of the graft has been encountered also long-time following grafting in one study. [34]

For patient number 3 of the study group of the present study, the patient experienced severe infection one week following SFE surgery. This resulted in graft dispersion and subsequent sinus infection which necessitated graft removal, sinus curettage and planning for future grafting with alternative material. Despite the condition could be attributed to a graft sensitivity, patient's infection with COVID-19 postoperatively might have played a role in worsening of the condition. Non optimal sinus membrane condition (from previous infection) has been correlated to SMP during its elevation in several studies. [16, 17] Hence this complication is to be considered as an expected sequalae of previous COVID -19 infection. The results of the present study showed similar incidence of SMP in the Studied groups during SFE. The size of the encountered perforations was variable, and collagen membrane was utilized as a barrier before grafting.

That management was in accordance with Meleo D et al., 2012 who utilized a pouch technique where the graft material was encased within a large size collagen membrane to avoid sparsity of the graft within the sinus. [35] The postoperative complications encountered in the study group were only high in terms of facial pressure compared to the control group. The other postoperative complications were minimal and nearly equal among the studied groups. Facial pressure might result from acute exacerbation of chronic sinusitis (of whatever cause) which was encountered in the patient (number 3 of the study group) with the radiographic graft dispersion.

Some authors documented that 6-9 mm sinus lining thickness is contraindicated for sinus lifting. [4, 36] Therefore, chronic sinusitis (presented as a thickening of sinus membrane) from whatever cause (COVID/ else) can lead to intraoperative SMP. In the present study, SMP infection risk without even intervention for performing a sinus surgery. [39] Upper airway symptoms, such as nasal congestion

and rhinorrhea have been reported with obvious direct effect on the respiratory epithelium. [28]

Few studies have addressed the devastating effects of SARS-CoV-2 infection on the maxillary sinuses clinically and radiographically. The evidence supporting the resultant damage of the sinus membrane and how that affect the prognosis of dental implants in the augmented sinus is still lacking. The ordinary COVID- 19 testing is performed from a nasopharyngeal sample. However, a single study that performed COVID-19 testing from maxillary sinus lining swap (rather than nasopharyngeal) before correction of orbital blow out fracture was encountered. [40]

On the other hand, sinus epithelium which is in direct and closer communication with the nose; it carries high risk of infection transmission to maxillofacial surgeon because of the use of burs and aerosols during sinus lifting. Maeba T et al, 2023 & Jian L et al., 2020 reported that the infection risk from the maxillary sinus is minimal in case of concomitant negative nasopharyngeal swab test. [40, 41]

A study that investigated the effect of coronavirus on the respiratory epithelium reported that the virus results in disruption of the respiratory epithelium on the third day of inoculation even if the patient appears asymptomatic. [26, 28] This must be considered during planning of SFE surgery and appropriate investigations to be performed.

Moreover, taking that COVID-19 infection is strongly associated with increased postoperative complications, there's no guarantee that SARS COV-19 virus doesn't remain dormant in the respiratory epithelium and may get activated by sinus surgical intervention as Varicella-zoster virus. Aguila .et al, 2020 has detected SARS COV-19 virus from the intestinal lining of some patients several months after their infection recovery. [42] This should apply to all epithelial linings of patients with previous COVID-19 encountered with membrane thickness of 4.22±5.08 mm.

Regarding other postoperative complications of SFE, the postoperative headache has been correlated with acute rhino sinusitis in Covid positive patients and there was no significant difference among groups in a previous study. [37] Smoking is another risk of developing, non-optimal sinus epithelial condition that frequently results in membrane perforation as the membrane is thinner than normal. [4]

The biological mechanism of infection, intracellular entry, spread all over the body and their effect on the variation of symptoms from mild, asymptomatic, to fatal is still not fully explained. Moreover, it's been reported in literature that viral load in the nose was greater than that in the throat. [38]

Response of Respiratory epithelium which was previously infected with COVID 19 infection to surgical intervention is still a point of investigation. Due to the direct effect of COVID-19 on the anatomical structure of the respiratory epithelium, it may have a significant effect on the drainage of maxillary sinus with subsequent infections with more prevalence in the respiratory one that exists in intimate contact to the virus. The viral genome was also detected in patients with negative nasopharyngeal swab and symptoms. [43]

The results of the current study revealed that patients with history of symptomatic COVID-19 infection had as same incidence SMP risk as non-COVID-19 patients. However, postoperative facial pressure prevailed in the COVID -19 group. Moreover, the impact of the fear of catching COVID-19 infection from the dental treatment, made individuals postpone their restorative treatment of their maxillary dentition with their subsequent loss or extraction and further postponing of the prosthodontic treatment. The risk of the spread of dental infection to the sinus from delayed treatment or sinus pneumatization secondary to the delayed tooth replacement have resulted through the last few years.

V. CONCLUSION

Sinusitis induced COVID-19 infection is a potential risk factor for SMP and postoperative complications. Authors recommend further randomized controlled trials with larger sample size investigating various sinus surgeries in patients with or without history COVID-19 infection with an extended follow up period. An endoscopic swap from sinus lining before surgical intervention in patients with familial history of COVID-19 would be beneficial also.

Conflict of interest:
Authors declare no conflicts of interest.

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Ethical approval:
This study was approved by the ethical committee of Faculty of Dentistry, Cairo University that follows the declarations of Helsinki regulations. Approval ID: 25323.

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