

## Clinical and Radiographic Evaluation of Dental implants Penetrating the Maxillary Sinus

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### Abstract

The objective of this retrospective contemplate was to clinically and radiographically appraise the penetration of dental implants into the maxillary sinus cavity during the osteotome-mediated sinus floor elevation procedures and its consequence on the success of osseointegration and sinus health.

35 patients with 50 dental implants protruding into the sinus cavity after membrane perforation were assessed.

The results reported limited sinus complications with 96% success and survival rates for all implants. Cone Beam Computed Tomography (CBCT) revealed sinus membrane mucosal thickening in half of the penetrated implants. Mean marginal bone resorption was within the acceptable recordings ( $1.04 \pm 0.12$  mm) and mean mobility results (-2.4) confirmed osseointegration along the follow up period.

It can be concluded that maxillary sinus penetration during implant placement procedures is considered an action with fair prognosis.

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### Introduction

Oral rehabilitation using osseointegrated dental implants has become a predictable and trustworthy treatment preference in patients with partial or total loss of teeth<sup>1-2</sup>. Posterior maxilla usually offers a limited amount of bone as a consequence of pneumatization of the sinus or resorption of the alveolar ridge or a blend of both together. For compensation of the deficiency of bone, numerous bone augmentation processes and trials were recommended and incessantly refined<sup>3-7</sup>. The technique of osteotome mediated sinus floor elevation has been implemented and introduced in 1994 by Summers<sup>8</sup> to overcome this deficiency. This technique involves elevation of the Schneiderian membrane using sinus osteotomes through crestal approach

accompanied with simultaneous implant placement. Throughout the years, other techniques have been suggested providing crestal bone and sinus floor implant anchorage<sup>9</sup>. Since these approaches have been regarded as conventional treatment options accompanied with implant placement the jeopardy and possibility of implants penetrating into the maxillary sinus cavity have increased. The incidence discussing the occurrence of maxillary sinus perforation was unclearly revealed and as an end result the sinus lift process was deserted in a number of contemplates because of the reported complications. Generally, the sinus membrane perforation is regarded as a probable risk indicator for implant failure and sinus infection. Acute or chronic sinusitis and further different maxillary sinus problems were interrelated to dental implants position with the incidence and clinical relevance remaining controversial<sup>10-13</sup>. Conversely, various investigators have documented that minor membrane perforation during implant insertion does not have a considerable part in the clinical outcome on implant success and survival. However, the

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existing literature has not decisively resolved so far the consequence of implant penetration into the sinus cavity and its effect on implant condition. Most reported results revealing sinus membrane perforation are clinical observations discussing the complications and still lacking well defined outcome criteria and follow-up<sup>14-16</sup>.

The endeavor of this long-term retrospective contemplate was to clinically and radiographically assess the penetration of dental implants into the maxillary sinus cavity and its effect on the success of osseointegration and sinus health.

### Materials and methods

Between January 2011 and December 2016, 175 patients were treated with maxillary sinus floor elevation with immediate placement of dental implants using the osteotome technique at two private clinics. 110 patients were partially edentulous and 65 patients were completely edentulous. A total of 320 Biomax™ (Irvine, California, USA) dental implants were placed in those patients. Only patients with clinical and radiographic evidence of maxillary sinus membrane perforation and implant penetration into the sinus accompanying the osteotome technique procedures were included in this contemplate. A five years retrospective review of these patients was done.

A total of 35 adult patients (13 females and 22 males) were assessed in this study. The patients' age ranged between 35 to 55 years displaying an average of 49 years. A total of 50 Biomax™ flat-end dental implants were placed penetrating the maxillary sinus. The participation of the patients in this study was based upon the availability of the pre and post operative panoramic radiographs in addition to CBCT data, clinical measurements through the follow up periods and evidence of dental implants penetration 2-6 mm into the maxillary sinus. The dentists reported that all the patients underwent implant placement through crestal approach. This technique was carried out under local anesthesia and starts with a crestal incision after which a full-thickness flap was raised in order to expose the alveolar ridge. Next, an osteotomy was done, preparatory with an osteotome of the smallest size followed by its gradual increase of size to expand the alveolus and compress the bone. An implant larger in diameter than the osteotomy

was then placed. The study protocol was approved by the Medical Ethical Committee at the National Research Centre, Cairo, Egypt.

### Inclusion Criteria

All patients included in this study had one or more missing teeth in the maxillary posterior region with alveolar bone deficiency as a result of sinus pneumatization or alveolar bone resorption or combination of both. All participants were systemically healthy and had no condition that might alter the treatment outcome. All the included subjects had  $\geq 5$  mm residual bone height (RBH) measured from the crest of the alveolar ridge to the maxillary sinus floor and  $\geq 6$  mm bone width with the recipient site of the implant free from any pathological conditions.

### Exclusion Criteria

Patients treated with lateral sinus lift elevation techniques with or without filling materials were not included in this study. Patients with history of systemic illness, drug abuse, catabolic drug or psychiatric disorder were not allowed to participate in the study. Patients having insufficient bone quantity and vertical inter-arch space upon centric occlusion were excluded. Participants in the growth stage with partially erupted teeth did not take part. Patients with parafunctional habits such as bruxism or clenching that might produce overload on the placed implants were not accepted. Alcoholics were also excluded. All patients who participated in the study were thoroughly informed about the surgical protocol and all the risks associated with the procedures and signed an informed consent form documenting their approval.

### Implants Selection

Out of 320 correctly placed Biomax™ dental implants 50 implants accidentally penetrated the sinus. These penetrated implants are tapered in shape with flat-end providing good primary stability with a platform switch having a smooth surface to decrease plaque accumulation and crestal bone resorption. It has a sharp buttress shaped threads to provide bone cutting not fracturing with improvement of load distribution to enhance the healing process. A standardized 2.45 mm hex connection is also provided.

### Pre-surgical Evaluation

Local visual examination and palpation to examine the entire oral and para-oral tissues were carried out. The width of the bone at the future implant site was measured using a graduated bone caliper. Maxillary and mandibular

impressions were done and poured into stone casts to check the occlusion and direction of forces with respect to future implant site. Presurgical radiographic evaluation with panoramic and CBCT radiographs in order to measure the residual bone height and to detect presence of any clinically undetectable pathology was performed.

Pre-surgical medications include a single dose of IV antibiotic (ampicillin/sulbactam 1500 mg) in the form of Unasyn 1500 mg vial, Pfizer, USA) and IV corticosteroids injection was given (Dexamethasone sodium phosphate 8mg/2ml, Organium laboratories, UK) half an hour before the operation as prophylactic measures.

### **Surgical Protocol**

After administration of local anesthesia, a crestal incision was done followed by elevation of full thickness mucoperiosteal flap in order to expose the alveolar ridge. All the drills were mounted on an implant handpiece and drilling was done under copious normal saline cooling irrigation. Sequential drilling started with the 1.6 mm drill, then the 2.3 & 2.8 and 3.4 mm drills when placing a 4.2 mm implant in soft bone; in case of hard bone, the 3.8 mm drill was used. When placing a 4.7 mm implant, the sequential drilling ended with the 3.8 mm drill in soft bone or the 4.4 mm drill in hard bone. For placing a 5.2 mm implant, the sequential drilling ended with the 4.4 mm drill in soft bone or the 4.8 mm drill in hard bone. Meanwhile in placing a 5.7 mm implant, the sequential drilling ended with the 4.8 mm drill in soft bone and the 5.4 mm drill in hard bone. Osteotomy preparation was done up to 1 mm below the sinus floor. Sinus floor infracture was then accomplished using the direct sinus floor infracture technique by using the osteotome with the mallet. The corresponding osteotome was used to punch-out the cortical plate of the sinus floor with the adherent membrane to the working length. Immediately after infracture, the implant site was tested for perforation of the sinus membrane by direct visual inspection and by using a gauge or by observing the appearance of bubbles of blood coming out through the osteotomy when the patient tries to exhale gently through his nose while his nostrils are pinched. Diagnosis of sinus penetration was established during implant bed preparation or implant insertion.

After sinus floor infracture the implant was applied to the prepared osteotomy site by its

implant mount and turned in a clockwise direction till resistance was encountered. This was followed by the use of the 2.45 mm hex driver and the adjustable torque wrench, until the implant body was seated within the bone and the platform is flush with the crestal bone. Primary stability was confirmed reaching  $\geq 30$  N. The cover screw was then placed and tightened to seal the internal hex of the implant. The flap was then returned to its original position and sutured with 3-0 black silk (Assut<sup>®</sup>, Switzerland). After the implant placement the sinus floor penetration was calculated as the difference between the length of the implant and the residual bone height. Amount of implant penetration was measured from the CBCT. Oral hygiene instructions were given to the patients. Postoperative medications included antibiotics (Augmentin 1 gram, twice daily for 5 days) and analgesics (Ibuprofen 200 mg tablets) were prescribed to prevent postsurgical pain and avoid the possibility of infection. Chlorhexidine gluconate 0.1 % mouthwash was prescribed twice daily for 5 days. Soft toothbrush was recommended to be used. Sutures were removed after 7-10 days following the surgery. No other complications appeared during the implant placement procedures.

### **Prosthetic Phase**

After a healing period of 6 months, dental implants were exposed and healing collars were then attached to the implants. The tissues were left to heal for a period of 3-5 days. Impressions were taken using polyvinylsiloxane material (Cavex, Silcon A, Cavex, Holland) for construction of the final ceramo-metal restorations. The final restorations were checked for shade matching, marginal fitness and occlusion, then permanently cemented using zinc polycarboxylate cement (Adhesor Carbofine, Spofa Dental, Czech Republic).

### **Postoperative Follow up Evaluation**

#### **Clinical evaluation:**

Each patient was evaluated through the follow up periods (6-60 months) average 2.45 years postoperatively. Discomfort, pain and tenderness were evaluated according to the signs and symptoms of the patients.

Marginal bone loss was calculated throughout the follow-up period mesially and distally. The first crestal thread was the reference point for recordings. Mobility was attested using the Periotest M (Medizintechnik Gulden, Bensheim,

Germany) to evaluate the clinical stability. Periotest M values (PTMV) of (-8 to 0) were considered the ideal values that denote successful osseointegration.

Patients were asked about any signs of maxillary sinusitis related symptoms, and they were informed about the sinus membrane perforation occurred during implant placement procedures. At postoperative follow up periods after implant placement all patients were specifically asked about signs and symptoms consistent with a diagnosis of acute or chronic rhinosinusitis<sup>17</sup>, including nasal bleeding, congestion or obstruction and presence of nasal secretions, pain, fullness or tenderness in the infraorbital or sinus regions. Other complications such as headache, dental pain, halitosis, fatigue, cough, ear pain and fever were also taken into consideration.

#### Radiographic evaluation:

Radiographs were taken immediately after implant insertion, at 6 and at the end of the follow up period postoperatively to detect amount of sinus floor penetration, marginal bone level and any changes in bone around the implants at the area of sinus penetration. All available radiographs were analyzed.

#### Data Collection

Clinical and radiographic preoperative and follow up records were investigated. Recorded information including patient's age, gender, implant diameter and length were also collected.

#### Statistical Analysis

Data were presented as mean and standard deviation (SD) values. The t-test was used to record the change in marginal bone around the penetrated implants. Wilcoxon signed-rank test was used to study the changes by time. The significance level was set at  $p \leq 0.05$ . Statistical analysis was performed with SPSS 16.0® (Statistical Package for Scientific Studies) for Windows.

#### Results

50 placed implants with sinus membrane perforation in 35 patients (13 females and 22 males) were within the study's inclusion criterion. Average patient's age was 49 years ranging from 35 to 55 years. Implants were placed in the premolar or molar sites in partially edentulous patients. Each patient has one or more missing

tooth. Calculated average implant penetration was 4 mm range between 2-6 mm. The average clinical and radiographic follow-up period was 2.45 years (range 6-60 months). 20 patients received one implant, 12 patients received two implants and two patients received three implants. Four implant diameters were utilized, 4.2 mm (8 implants), 4.7 mm (27 implants), 5.2 mm (12 implants) and 5.7 mm (3 implants). The lengths of the implants were 11.5 mm (22 implants), 13 mm (21 implants) and 16 mm (7 implants). The depth of sinus penetration was 2 mm (10 implants), 3 mm (15 implants), 4 mm (24 implants) and only one implant penetrated for 6 mm. At the report on period, no apparent clinical or radiological signs of sinusitis were recorded. Only one patient reported a sensation of nasal fullness and obstruction persisting for two months after implant placement.

Two patients reported biannual recurrence of maxillary fullness and distress correlated to flu, with no change in the frequency after implant insertion. Soft tissue healing was in general not complicated and normal in all the participating patients in this contemplate. All patients felt only slight discomfort in the first week, which was explained as a result of the pressure from bone expansion. Patients also reported slight postoperative swelling and pain with very little requirements for medications and analgesics which subsided after 5-7 days postoperatively.



Figure 1. Panoramic view of CBCT showing two penetrated implants into the sinus cavity with mucosal thickening around the implants.

Out of the 50 implants, four implants were recorded having peri-implantitis and were managed therefore without reported reappearance of this problem.

Four patients were smokers only smoking 2-3 cigarettes per day with successfully placed implants. Radiographic follow-up verified an ordinary bone healing progression in every participating subject. Only a couple of implants failed to osseointegrate. Preoperatively, no one of the patients had a history of maxillary sinusitis. At the clinical report on periods, no unusual clinical evidence of sinusitis in any patient was reported. Nevertheless, the CBCT data revealed that some of the cases showed mucosal thickening near and around the penetrated implants in the sinus cavity (Figure 1, 2). The resultant swelling of the mucosal lining was restricted to the floor of the sinus and did not involve the osteomeatal complex. In all the successfully inserted implants, there were no indicators of abnormal mucosal reactions. There were no radiographic evident signs of pathologic bone reactions or abnormal loss of anchoring bone. The baseline data of assessment was placed at the records obtained after six months of implant insertion, compared to the evaluation done at the end of the entire follow-up period.



**Figure 2.** Panoramic view of CBCT showing penetrated implant into the sinus cavity with mucosal thickening near the implant.

The mean marginal bone resorption recorded was  $1.04 \pm 0.12$  mm at the end of the follow-up period; which was statistically insignificant and within the acceptable range ( $p$ -value: 1.03).

Attested average mobility confirmed the successful osseointegration at the end of the follow up period which was - 2.4 with insignificant statistical results ( $p$ -value: 1.88). The total success and survival rates of the penetrated implants were 96% with only two lost implants.

## Discussion

Deficient bone summit in the maxilla posteriorly is one of the main problems that hinder the treatment with dental implants<sup>18</sup>. Many authors recommended various techniques to overcome this obstacle including sinus membrane elevation procedures. Sinus membrane perforation can happen during the dental implantation process all through the instrumentation process (drilling or utilizing the sinus osteotome) or while inserting the implant<sup>19-22</sup>. In the current contemplate, 50 dental implants perforated the maxillary sinus membrane unintentionally during the implantation process. When perforation was confirmed through accurate diagnosis the appropriate implant was selected according to the remaining bone height and placed penetrating into the maxillary sinus. Researches documenting implant-associated sinus complications are limited<sup>23</sup>. The recorded complications are typically linked with the presence of a distant body in the maxillary sinus as dislocated dental implants or bone augmenting materials. Moreover, complications can be associated with failure of osseointegration of implants, resulting in maintained oroantral fistula that allows a spreading path of infection from the oral cavity. Other reported complications include acute or chronic sinusitis, cyst or mucocele formation, delayed wound healing, hematoma, loss or sequestration of bone<sup>24</sup>. Slight discomfort and edema in addition to feeling of fullness and sinusitis related symptoms were reported by very few patients in the present study. On the other hand many animal and human studies reported that implant penetration into the maxillary sinus cavity is not always associated with the establishment of sinus complications<sup>22-23</sup> which is line with the current contemplate that revealed that most of the patients did not have any complications with the penetrated implants in place.

It is documented in previous research that minor sinus membrane perforation during implant placement usually heals impulsively. It was also noticed that the parts of the implants projecting through the mucosa of the sinus floor into the cavity were not completely covered with a recently created sinus membrane when implant penetration is more than 4 mm<sup>24</sup>. In our current contemplate implant insertion was done through a crestal incision without lifting the sinus mucous

membranes with no bone augmentation used accompanying the sinus elevation techniques and all the implants were successfully osseointegrated except for two which might be as a result of lack of initial stability, small sized implant diameter used or the type D4 soft bone presence as previously explained<sup>25-27</sup>.

Studying the response of the sinus mucosa surrounding the dental implants penetrating the sinus cavity by endoscopic methods in previous studies revealed ordinary mucosa. There is lack of signs denoting increased secretions or presence of infection related to the inserted implants<sup>19-20</sup>. In the current contemplate, exceeding half of the implants revealed increase in mucosal thickness surrounding the portions of the implants bare to the sinus cavity. Amusingly, no symptoms of maxillary sinusitis were revealed along the study period. This was possibly due to the verity that the bulge of the mucosal lining was restricted to the floor of the sinus and did not affect the osteomeatal complex as described<sup>20-24</sup>.

In a former contemplate unwanted side effects have been reported when parts of implants that might be enclosed by ordinary mucoperiosteum are projecting into the nasal or sinus cavity. Length of implant protrusion might reduce the impulsive revival of membrane perforation following implant positioning. It was also confirmed that implants penetrated less than 2 mm was enclosed by the mucosa of the sinus in mongrel dogs. Computerized tomography (CT) scans revealed that penetration of > 4 mm in the maxillary sinus can result in increased thickness of the sinus mucosa surrounding the implants which was the same in our study. Still these sinuses showed no signs or symptoms. In this current contemplate, projection of the implants was between 2-6 mm and no signs of sinus problems were reported as formerly explained<sup>28-31</sup>.

Patients integrated in this contemplate were chosen having at least 5 mm remaining bone height calculated from the crest of the ridge up to the maxillary sinus floor. It was accepted that early stabilization of the implant is derivative from the remaining alveolar bone; thus, a minimum of 5 mm of preoperative bone height has been recommended. A remaining bone height (RBH) of less than 5 mm can be coupled with decreased initial implant stability<sup>9</sup>.

Soft tissue healing was normal in all the included subjects. All patients felt only slight discomfort in the first week, which was explained as a result of the pressure from bone expansion. Patients also reported nominal postoperative swelling and pain with very little requirements for medications and analgesics. This is in line with reported results that utilized the flapless approach for implant placement<sup>9</sup>. The use of the current technique also yielded similar results as regarding the amount of marginal bone resorption and mobility records as mentioned<sup>9</sup>.

The use of radiographic imaging is one method of screening inflammatory surroundings of the paranasal sinuses. Standardized periapical and panoramic radiographs are helpful in discovering hidden pathological conditions. These methods are commonly not useful in confirming the presence of sinus inflammation, and they are with less specificity and sensitivity as compared to CBCT for analyzing the extent of sinus abnormality. As a result, utilizing these techniques has decreased and they have been replaced by CBCT scanning as used in our contemplate<sup>1</sup>.

## Conclusions

This retrospective long-term contemplate, documented that no sinus complications were revealed after implant protrusion into the maxillary sinus. Moreover, lack of such complications is associated with the presence of triumphant osseointegration. Under strict aseptic conditions, proper diagnosis, patient selection and treatment planning providing that good primary stability was achieved, maxillary sinus penetration during implant placement procedures is considered an action with fair prognosis.

## Declaration of Interest

The authors report no conflict of interest and the article is not funded or supported by any research grant.

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