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Evaluating the effect of intentional perforation of dental implants into the maxillary sinus in different depths (Stability andRadiographicalstudy)

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ABSTRACT: ***The sinus membrane perforationcombined withexposing dental implant into the maxillary sinus is considered as a potential risk factor for implant failure and sinus complication.The present study****investigated the incidence of intentional sinus membrane perforation by dental implant in different depths and the possible risk factors associated with membrane perforations and* ***assessed the implant osseointegratin and the survival rate of implants placed in the posterior maxillain a dog model. A total of 32 titanium implants were placed in the bilateral maxillary first molar areas of 16 adult mongrel dogs with different penetrating depths of implants into the maxillary sinus cavities (group A: 0 mm; group B: 1 mm; group C: 2mm; group D: 3 mm). The sample, block biopsies were harvested six months after surgery and evaluated by Biomechanical analysisandradiographic observation.After six months healing period, no signs of inflammatory reactions or complications were observed in any maxillary sinus of the sixteen doges. The results showed that the posterior maxillary edentulous areas with reduced bone height may be successfully rehabilitated with implants that penetrate the Schneiderian membrane and extended into the maxillary antrum. During the 6-monthes observational period in canines, despite the different protrusion extent, penetration of dental implant into the maxillary sinus with membrane perforation did not compromise the dental implant osseointegation processes and the sinus health. It was also found out when penetrating depth into the sinus is less than 2 mm, the apical portion of implant could be re-covered by regenerating membrane.No significant differences were found among groups regarding implant stability, bone-to-implant contact (BIG) and bone area in the implant threads (BA). In conclusion, invading the maxillary sinus by dental implant is not necessarily associated with significant complications as was generally expected, and stable osseointegrated dental implant that perforate the sinus without apparent immediate complication cannot be considered a harmful factors that necessitate its immediate removal, so could be left provided that they were initially stable.***

Key words: Maxillary sinus;Perforation; Dental implants;Biomechanical analysis; Radiographic observation.

1. Introduction

Missing teeth can be replaced by endosseous dental implants placed in the alveolar bone. Osseointegrated implants have become the therapy of choice to rehabilitate fully and partially edentulous ridges (Buser *et al* 1997). The posterior maxilla often provides limited bone height secondary to pneumatization of the maxillary sinus and/or the resorption of the alveolar ridge. To compensate the lack of bone height,several bone augmentation techniques are continuously refined, in which dental implant are inserted marginally to the bony sinus floor with a localized augmentation procedure (Tatum *et al* 1986).

Sinus left and maxillary sinus augmentation are the procedures that aim to increase the vertical bone height of the alveolar bone to allow placement of dental implants for more than 30 years, the maxillary sinus augmentation procedure has been performed for implant-directed maxillary reconstruction. Since these approaches have become conventional treatments in Implant Dentistry, the risk of exposing the implant to the maxillary sinus increased. (Smiler*et al* 1992)

In 1994, Summers introduced the osteotome sinus floor elevation. In this technique, the Schneiderian membrane is elevated using sinus osteotomes through a crestal approach, and implants are simultaneously placed. (*Bahat et al* 1993). As a consequence, implants placed in the posterior maxilla may penetrate the maxillary sinus. Acute or chronic sinusitis and other maxillary sinus complications related to endosseous implant placement have been described (Hunter *et al* 2009*)*, but the incidence and clinical relevance of such complications remain controversial.(Jung *et al* 2006)

The sinus lift is generally considered to be a safe surgical procedure with a low prevalence of complications (Ziccardi *et al* 1999*)*.However, all surgical procedures have the potential to develop complications, leading to additional surgry, prolong hospital recovery, fatigue and nutritional disorders, which markedly compromise quality of life. *(*Cunningham *et al* 2004*)*

The occurrence of complications with maxillary sinus augmentation procedures may in fact jeopardize the final outcomes of bone grafting and implant placement. The most common intraoperative complication seems to be schneiderian membrane perforation,the incidence of the sinus membrane perforation was reported as 7% to 35%, and the sinus lifting procedure was abandoned in some studies because of the large perforation of the sinus membrane (Schwartz *et al* 2004)

The exposing of dental implant into the maxillary sinus combined with membrane perforation might increase risk of implant failure and sinus complications .In general, the sinus membrane perforation is considered as a potential risk factor for implant failure and sinus infection. Some investigators claimed that the membrane perforation was strongly associated with the occurrence of postoperative sinus infection , while others assumed that there was a correlation between implant failure and sinus membrane perforation (Hernandez *et al* 2008).

However, clinicians have generally reported that slight membrane perforation after implant placement does not play a significant role in the clinical outcome, (Branemark *et al* 1984*)*. Nevertheless, the available literature has not conclusively determined so far the significance of

implant exposure to the sinus cavity, on implant survival and maxillary sinus complication, particularly with respect to the histological evidence.

Because most reported results of the sinus membrane perforation are clinical observations, they lack well defined outcome criteria or control. In order to help clinicians to make proper surgical decisions, data on a more controlled scientific level is necessary to be provided . (Timmenga *et al* 1997*)*

Disintegration or perforation of the sinus membrane is an unwelcome incident because of the need for additional surgeries. In the instance of chronic oroantral fistula occurrence, the established fistula enables the passage between the oral cavity and the maxillary sinus. Consequently, the microbial flora can exchange and inflammation may occur with various possible consequences. This simple complication might lead to major problems, be handled easily, or recover spontaneously. Therefore, oral and maxillofacial surgeons are always careful about complications associated with the maxillary sinus.

The aim of this study was to evaluate the effects of dental implant exposure to maxillary sinus cavity with penetrating depth of 1 mm, 2 mm, 3 mm on the osseointegration. To evaluate the nature and incidence of maxillary sinus adverse events related to endosseous implant placement with protrusion into the maxillary sinus in a dog model after a 6-months healing period.

2. Materials and Methods

2.1 Implant system

In the present study, Dentium-SuperLinefixture tapered type,endosseous dental implat (Dentium Co., Ltd, Sangpil Yoon, 150, Eondong-ro,Giheung-gu,Gyeonggi-do 443-270 KOREA), made of Pure Titanium grade 4; 4 mm diameter and 10 -12 mm length is selected to be used in this study (Fig 1).

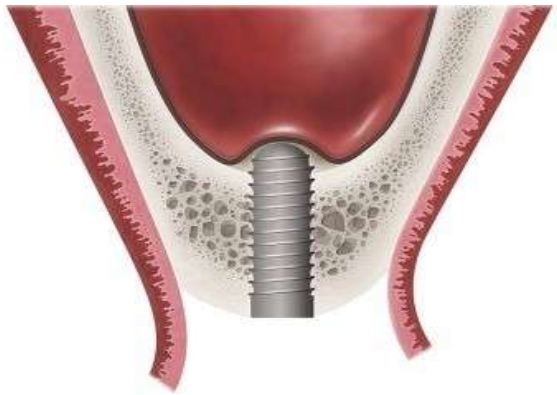
Figure (1)Dentium-SuperLine fixture

2.2 Study sample

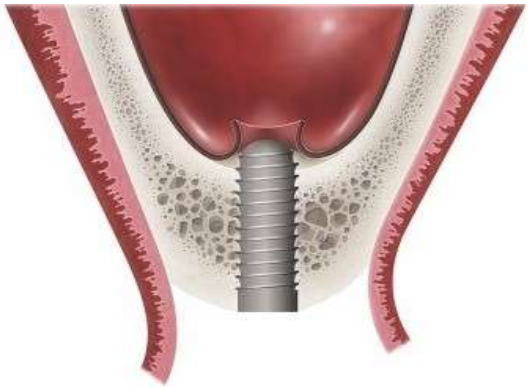
The experimental animals used in the current study are sixteen healthy adult male mongrel dogs, with a weight range between 15.5-18.5 Kg and a range of age between 20-24 months-old. (Sicwaten and Stahl, 1982), under observation and supervision of the veterinarian for two weeks before the experiment to ensure acclimatization. A standard protocol of eating regarding (quantity and quality), behavior, weight monitoring and activity was planned by the veterinarian.

A split-mouth randomized design, using four treatment protocols on the positions of bilateral maxillary first molars, was employed. At total of (32) dental implant were used in this study. Each implant recipient site was randomly assigned to one of the four treatment protocols, and immediate implant placement was applied accordingly as follow and as illustrated in figure (2; A-D)

1-) group A (n=8) was control group without sinus floor penetration;
2-) group B (n=8) with penetrating depth of 1 mm;
3-) group C (n=8) with penetrating depth of 2 mm;
4-) group D (n=8) with penetrating depth of 3 mm

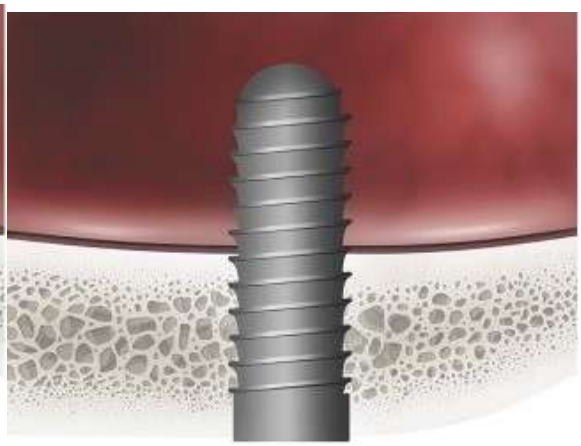


Group (A) no perforation



Group (B) 1 mm perforation

Group (C) 2 mm perforation



Group (D) 3 mm perforation

Figure (2) Graphic representation of experimental groups A-D

2.3 Surgical procedure

The surgical procedure including the dental extraction and implant insertion, was done in the Animal Care Center in the College of veterinary of Duhok University.The surgical procedure was carried out according to the standard practice, including intense disinfection for the operating room, autoclaved surgical instruments and the use of disposable surgical kits.

2.4 Anesthesia

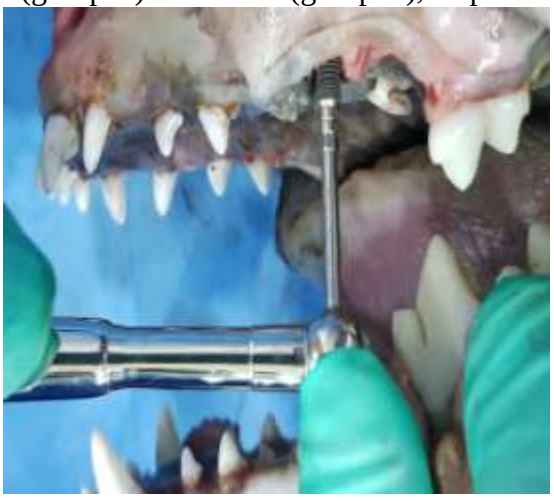
The experimental animal was anesthetized with an intramuscular injection of 5 ml/kg B.W. of Ketamine hydrochloride “anesthetic solution” and 0.5ml/kg B.W. of Xylazine “muscle relaxant solution; this dose of anesthetic solution kept the animal anesthetized for about 2 hours.

2.5 Dental extraction

The whole surgical procedure was performed under sterile conditions by only one surgeon with a clinical experience in implant dentistry. The maxillary first molars were extracted bilaterally with special care, thin elevators were used to luxate the teeth and then extracted using forceps with rotary movements to avoid trauma of the alveolar ridges. A plain periapicalradiograph is taken to measure the height of residual ridge and to detect the level of the sinus floor.

2.6 Dental implant insertion

The surgical insertion of the dental implants was carried out immediately after teeth extraction. Thirty two sterile threaded cylindrical implants of grade 5 pure titanium were placed (Fig 3). Except the control group, (group A (n=8) without sinus floor penetration), eight implants were placed within the alveolar bone without protruding into the sinus cavity. The other twenty four implants were placed bilaterally in the sinus cavity in such a manner that they penetrated the bone and mucous membrane of the maxillary sinus floor to the extent of 1 mm (group B), 2 mm (group C) and 3 mm (group D), respectively (Fig 4).



Figur(3) Implant insertion

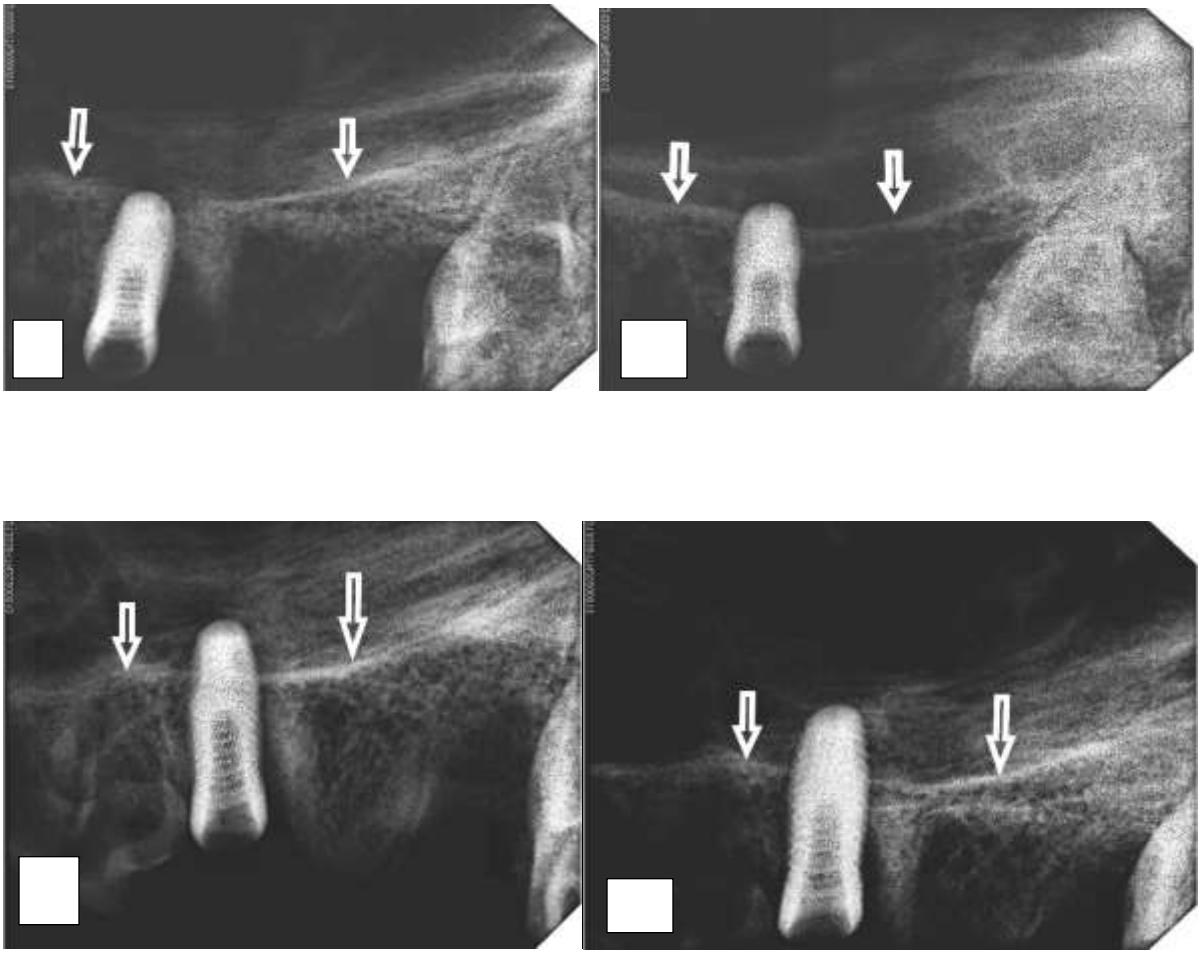


Figure (4) Plain periapical radiographs for inserted implants in four different depths

(A= 0 mm; B= 1mm; C= 2mm; D= 3mm)

2.7 Primary Stability Reading

After the insertion of the dental implants, the first biomechanical reading (primary stability) was measured using a PeriotestMdevice (Medizintechnik Gulden – Germany).

During the measurements, the Periotest M device was held horizontally with the starting botton up. The tip of the hand piece was kept at a distance of about 2-3 mm from the dental implant abutment head. The handpiece also was perpendicular to the dental implant abutment head. Three readings for each dental implant were measured , and the mean for such readings was considered the final reading (Mortensen, 2007). The stability of the implants was assessed at the time of implant placement and 6 months later.

2.8 Post-operative care

To prevent postoperative infections, the animals received a post-surgical medication included a daily penicillin intramuscular injection (2 doses of 100,000 unit /kg, penincillin G sodium) one week , and plaque control was ensured three times per week using a 0.2% chlorhexidine gel on implant placement sites with soft tooth brush. A soft diet was given to the animals during the healing period.

2.9 Secondary stability reading

At the end of the experimental six months healing period, the animals were sacrificed by administration of an over does of ketamine hydrochloride (Jimbo*et al*., 2013). The surgical site was reopened by a small incision and the dental implants were exposed carefully then, implant abutment were adapted to the implant fixtures, then the secondary stability reading was measured with the same technique as that followed in the primary one (Fig 5).

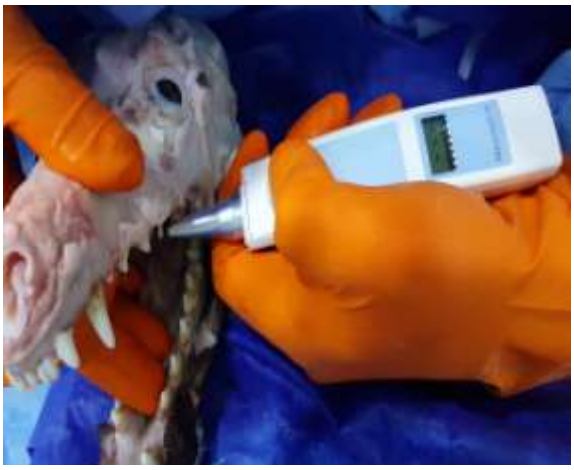


Figure (5)Secondary stability measurement

2.10 Sacrifice and samples preparation

After dissection of the jawbones, each implant with a preserved 5-mm thickness of peri-implant bone was removed as one piece of sample. The membrane adjacent to the implant was separated and removed.

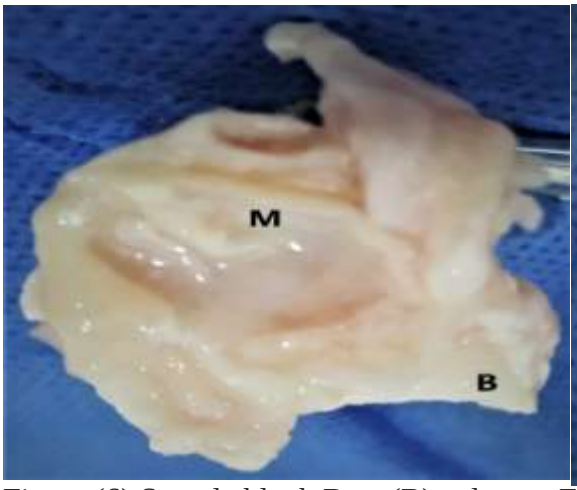


Figure (6) Sample block.Bone(B)and Sinus membrane(M)

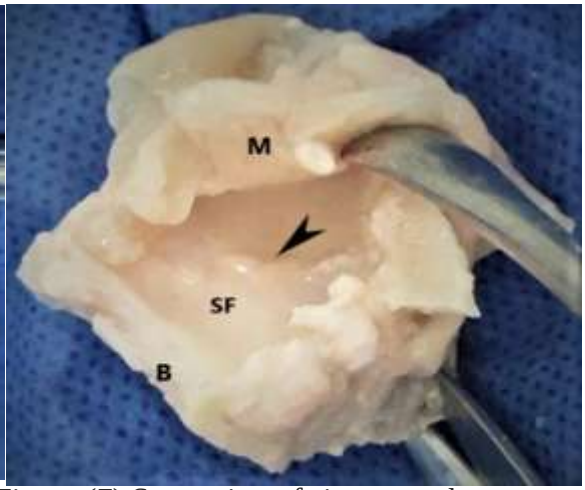


Figure (7) Separation of sinus membrane (M) from bone (B) and sinus floor (SF)

The bone specimen with dental implant was sectioned to an approximate size of 5 mm thickness of peri-implant bone using a low-speed water-cooled diamond disc, and immersed in 10% neutralized buffered formalin for four days.

2.11Radiographical examination

After post healing period, another radiographic examination was performed with periapical radiograph using paralleling technique, and the X-ray beam was perpendicular to the long axis of the implant and film. All samples were shot using the following exposure conditions: 70 Kv tube voltage 10mA tube current and 0.4-second exposing time.

An analysis CBCT images were obtained by using a CBCT scanner for all the experimental animals (FONA CBCT / Italy).

The examinations were performed using FONAXPan 3D CBCT cone beam computed tomography (Imaging Sciences International,Italy). The images were obtained after standard positioning of the subjects according to the manufacturer's recommendations. Image analysis was performed on the software, on a multiplanar reconstruction window in which the axial, coronal, and sagittal planes could be visualized in 0.5 mm intervals. CBCT datasets of experimental animals were selected to include and show a complete maxillary sinus, including the osteomeatal complex and entire maxillary floor.

In the present study the images were taken for the purpose of searching for abnormalities in jaw bones, for examination and assessment the peri-implant status , healing process and the surrounding bone quality and quantity, as well as evaluation of the maxillary sinus status and health, and assessment sinus ventilation, sinus septa, the sinus totally compartmentalized, the hypoplastic sinus, sinus aplasia, the prolapsed sinus, , mucosa thickening, sinus opacity,and other pathologic findings in sinus such as polyps and cysts.

2.12 Statistical Analysis

In the present study, Data were analyzed using statistical package for the social sciences (SPSS) version 22.0. The penetration means differences in the cases of Bone Implant Contact percentage BIC %, Bone Area percentage BA%, Cortical Bone Thickness CBT, Membrane Thickness MT, Primary stability and Secondary stability were analyzed using Analysis of variance (ANOVA). The comparison between Primary stability and Secondary stability in different depths were analyzed Paired Samples T-test.

3. Results

The results of the clinical and radiographical examinations for the operated experimental animals were collected throughout and after 6 months of healing and of follow up periods. At the time of surgical procedure, the animals showed no clinical signs of any sinus disorder. The postoperative healing was uneventful in all of the cases. All animals recovered rapidly from surgeries and were healthy throughout the follow-up period.

There was not any sign of wound infection or other complications such as implant loosening or falling except four cover screws were exposed two in the control group, one in group B and one in group C.

All the dental implants (32) were stable andhad a high percussion sound and showed no signs of loosening during the 6 months post-operative follow-up period as verified by clinical, radio graphical examinations and biomechanical analysis (periotest reading values). The soft tissue surrounding the implants looked healthy without signs of inflammation.

3.1. Clinical results:

3.1.1 Gross Examination Results

The bone at osteotomy site and membrane of sinus floor remained intact healthy without sings of inflammation in the control group (**A**) (Figure 8). In group (**B**) and group (**C**), the protruding parts of implants that had been introduced into the sinus cavity for 1mm and 2 mm were fully re-covered with a thin layer of newly formed membrane with a healthy appearance and no inflammatory reaction was observed in the surrounding sinus membrane. Regenerated bone tissue was discovered on the upper most part of some implants (Figures 9 and 10). In group (**D**), the parts of implants that had been penetrated into the sinus cavity for 3 mm were totally exposed in the sinus cavity with the membrane surrounding the base of protruding parts, circular epithelium structure similar to gingival cuff formed around the base of the protruding parts and did not show any signs of inflammation (Figure 11).

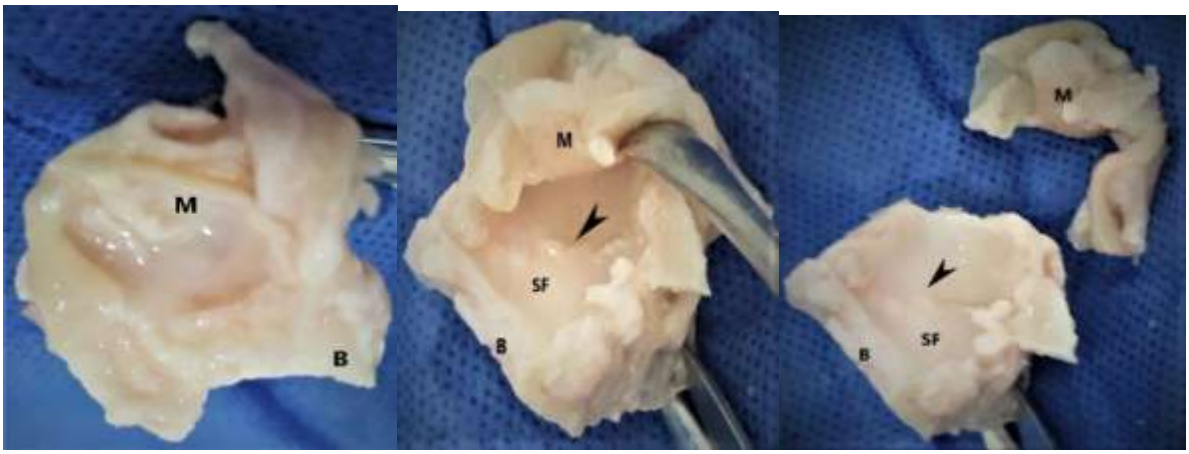


Figure (8) Gross observation of the apical portion of the implant in the sinus cavity.The bony sinus floor in the control Group (**A**) remain intact without implant exposure (arrow). SF: sinus floor; M: membrane; B: bone of the lateral sinus wall

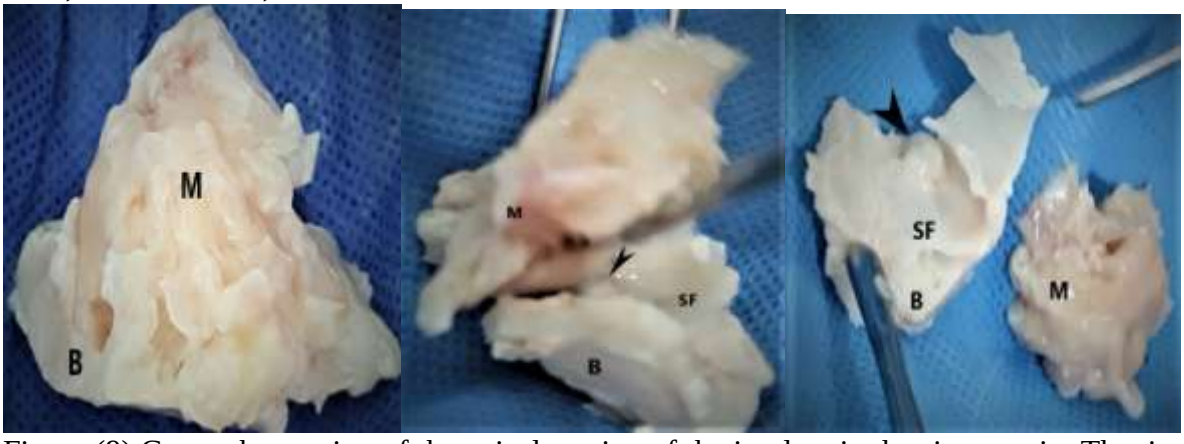


Figure (9) Gross observation of the apical portion of the implant in the sinus cavity.The tips with protruding depth of 1mm Group (**B**) were partially covered with new bone and scars were left at

the penetrating spots on the membrane (arrow). SF: sinus floor; M: membrane; B: bone of the lateral sinus wall.

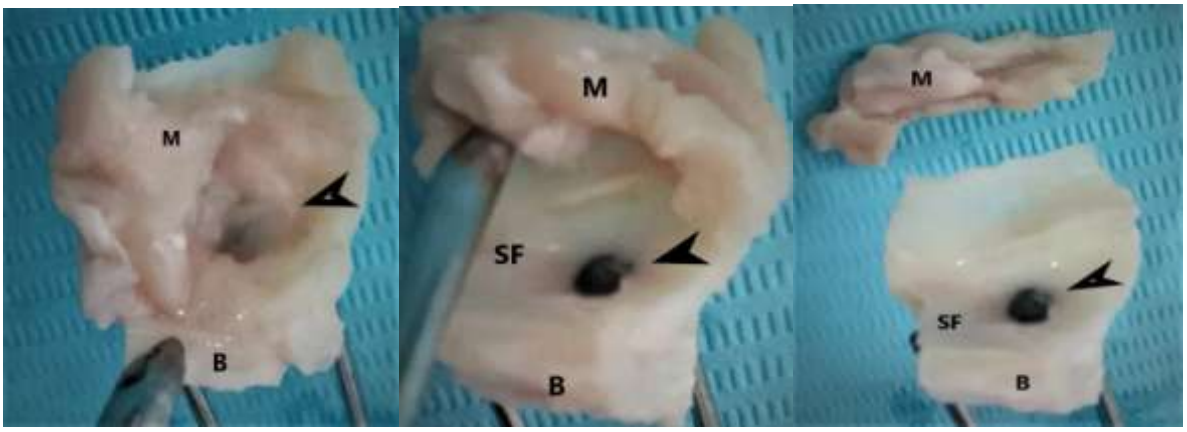


Figure (10) Gross observation of the apical portion of the implant in the sinus cavity.The tips with protruding depth of 2mm Group (**C**) were partially covered with new bone and scars were left at the penetrating spots on the membrane (arrow). SF: sinus floor; M: membrane; B: bone of the lateral sinus wall.

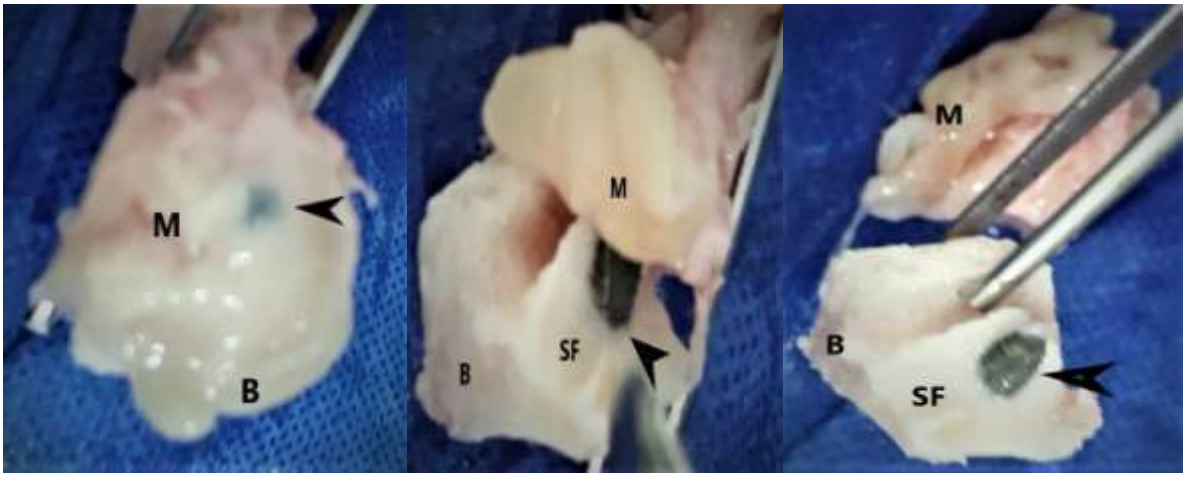


Figure (11) Gross observation of the apical portion of the implant in the sinus cavity.The implant tip with protruding depth of 3mm group (**D**) was totally exposed in the sinus cavity with no bony coverage and the penetrating hole was left on the sinus membrane (arrow). SF: sinus floor; M: membrane; B: bone of the lateral sinus wall.

3.1.2 Biomechanical Results (Periotest Values)

In all groups the values from implant stability measurements were recorded at the moment of implants placement and animal sacrifice . A high level of repeatability between different Periotest units had been shown as well. Successfully integrated dental implants have yielded a wide range of stability readings with the Periotest.This range in values is believed to reflect bone density at the implant interface. No apparent differences were found among groups.

3.1.2.1 Periotest Values of the Primary Stability

The descriptive statistics including mean, standard deviation, standard error, minimum and maximum values of the primary stability (Pr.) for all groups are shown in table (1).

Table 1.Descriptive analysis oftheprimary stability for the four groups.

Treatment	No.	Mean*	Std. Err.	Minimum	Maximum
A	8	-2.64	0.18	-3.40	-1.90
B	8	-2.55	0.24	-3.80	-1.80
C	8	-2.71	0.15	-3.20	-1.90
D	8	-2.78	0.14	-3.40	-2.20

*The Measurements in Periotest Value

The results of the ANOVA statistical analysis showed non-significant differences (P = 0.832) between the values of Primary stability for the four groups, as shown in figures (3.7 and 3.8).

Figure (12) Chart diagram for the primary stability of the four groups.

3.1.2.2 Periotest Values of the Secondary Stability

The descriptive statistics regarding mean, standard error, minimum and maximum values of the secondary stability (Sc.) for all groups are shown in the table(2).

Table 2.Descriptive statistics of the secondary stability for the four groups.

Treatment	No.	Mean*	Std. Err.	Minimum	Maximum
A	8	-3.23	0.27	- 4.20	-2.20
B	8	-2.79	0.18	- 3.40	-1.80
C	8	-2.89	0.24	- 4.20	-2.20
D	8	-3.16	0.20	- 3.80	-2.20

*The Measurements in Periotest Value

The results of the ANOVA statistical analysis showed non-significant differences (P = 0.463) between the values of secondary stability for the four groups, as shown in figures (3.9 and 3.10).

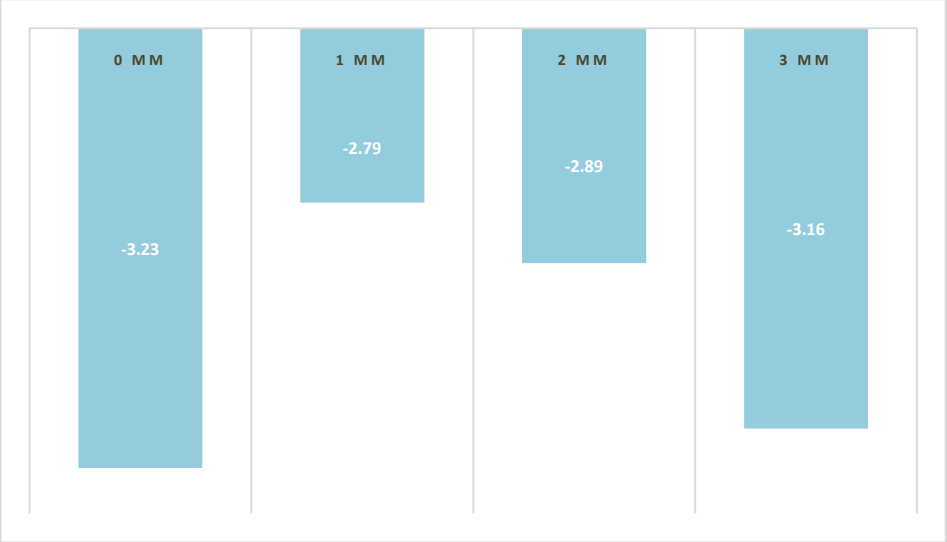


Figure (13) Chart diagram for the secondary stability of the four groups.

3.1.2.3 Comparison between Primary and Secondary Stability

In the current study, the Paired Samples t-test results showed non-significant differences (P-value) in the Periotest values between the Primary stability and the Secondary stability measures of all the groups, as shown in table (3),and figures(14 and 15).

Table 3.Comparson between Primary and Secondary stability (P-values)

	Group A	Group B	Group C	Group
Depth	**0 mm**	**1 mm**	**2 mm**	**3 mm**
P-value	**0.078**	**0.382**	**0.368**	**0.104**

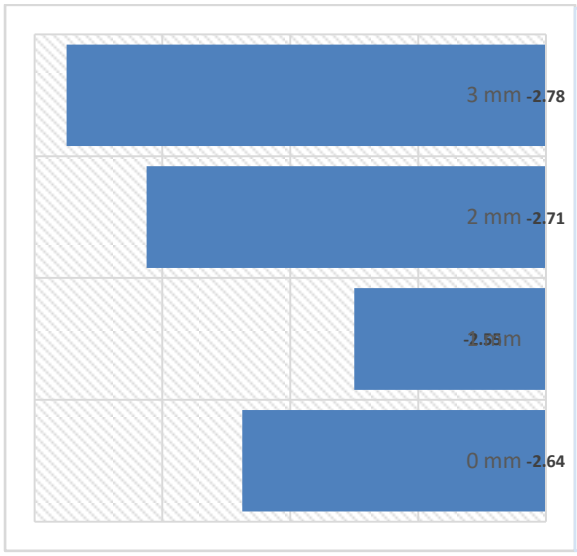


Figure (14) Chart diagram for the primary stability of the four groups

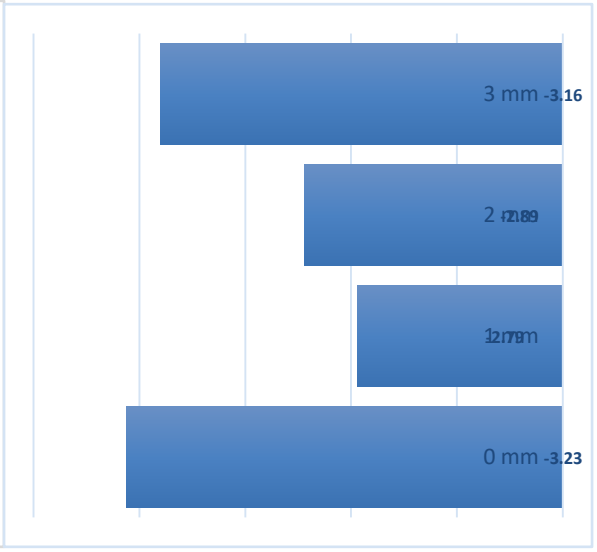


Figure (15) Chart diagram for the secondary stability of the four groups.

3.2 Radiographic examination results

3.2.1 Intraoral radiograph

Radiographic examination of the sites of implantation demonstrated a close contact of bone and implant without radiolucent areas. The tips of implants in the control group (**Group A**) were completely embedded in the alveolar bone and no signs of inflammation had been seen at pri-implant area (Figures 16).

The tips of implants with the penetrating depth of 1 mm (**Group B**) and 2 mm **(Group C**) were surrounded by bone tissue with close contact near the tips of some of implants without any significant sigs of inflammatory reaction. (Figures 17 – 18).While the tips of implant with the penetrating depth of

3 mm (**Group D**) were found to protrude inside the sinus cavity without bone coverage without radiolucent areas around the implant (Figures 19).

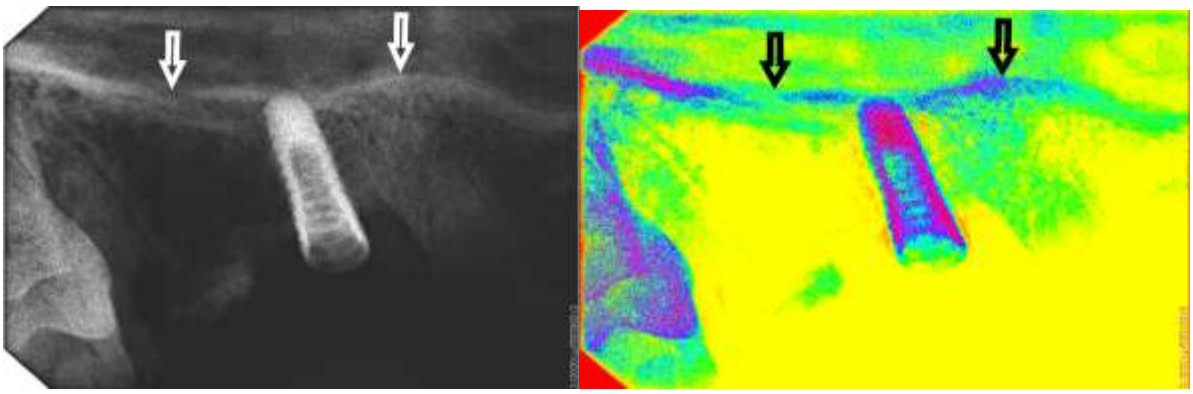


Figure (16) Radio graphic examination pictures of the sites of implantation .The tips of implants in the control group (A= 0 mm) were completely embedded in the alveolar bone. Arrows indicate the bony sinus floor.

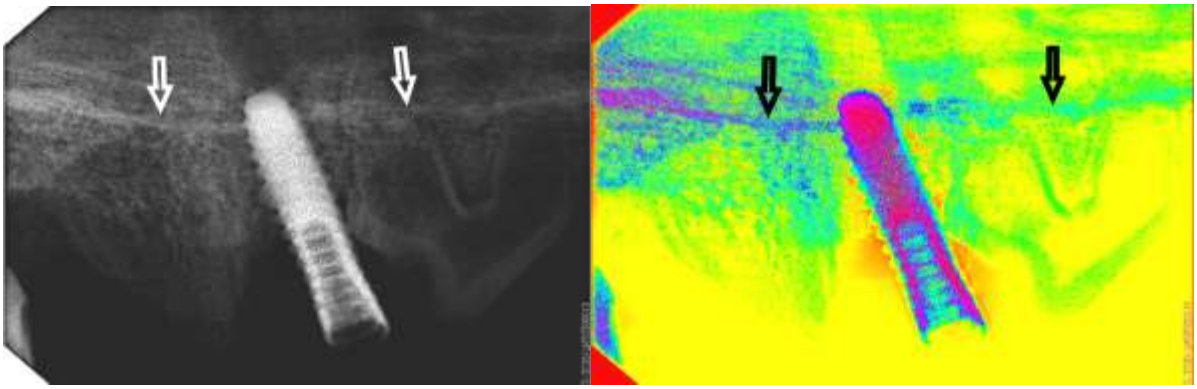


Figure (17) Radio graphic examination pictures of the sites of implantation . The tips of implants with penetrating depth of (B=1 mm) were surrounded by bone tissue . Arrows indicate the bony sinus floor.

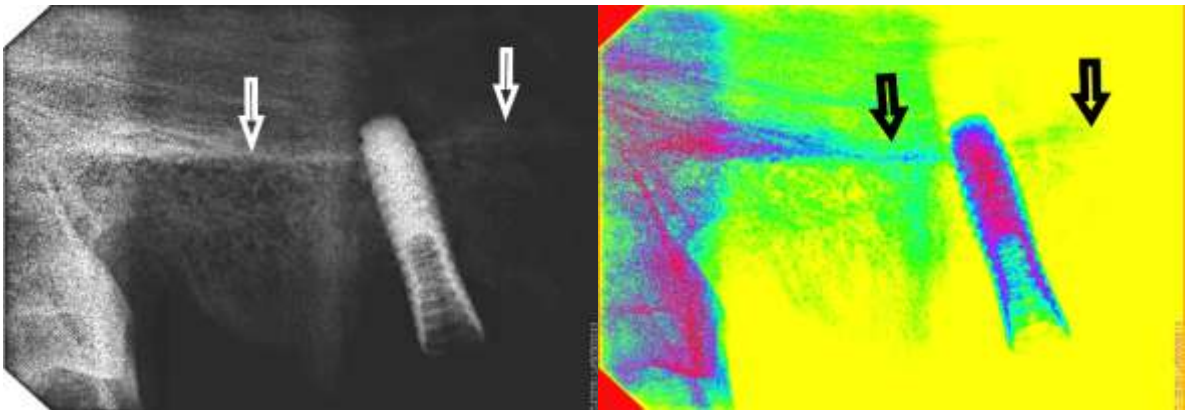


Figure (18). Radio graphic examination pictures of the sites of implantation . The tips of implants with penetrating depth of (C=2 mm) . Arrows indicate the bony sinus floor.

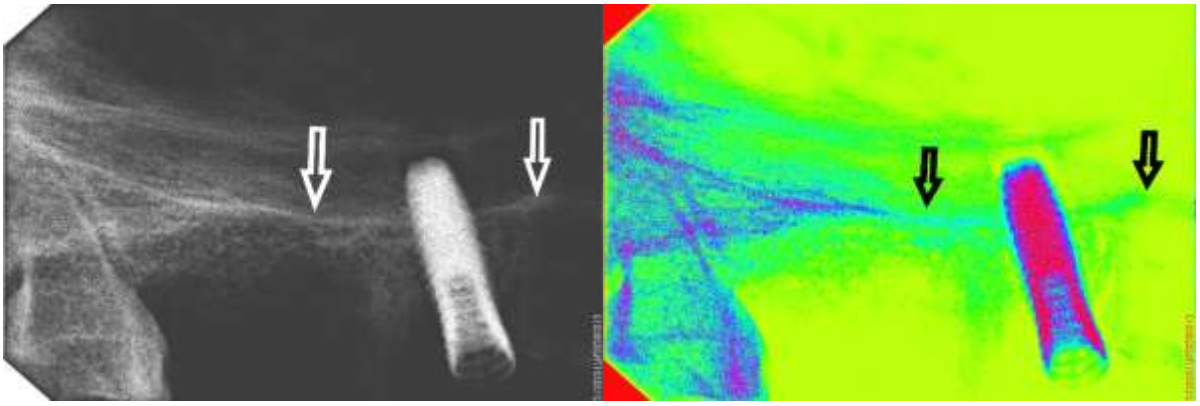


Figure (19). Radio graphic examination pictures of the sites of implantation. The tip of implant with the penetrating depth of (D=3 mm) was found to protrude inside the sinus cavity with no bone coverage . Arrows indicate the bony sinus floor.

3.2.2 CBCT results

A CBCT for all the experimental animals were taken (FONA CBCT / Italy), for examination and assessment the peri-implant status , healing process and the surrounding bone quality and quantity, as well as evaluation of the maxillary sinus status and health, including, mucosa thickening, sinus opacity, and other pathologic findings in the sinus such as polyps and cysts etc.

A DICOM viewing software program was used to analyze the images. The images were reconstructed with a slice thickness of 0.5 mm and a slice interval of 1.5 mm.The CBCT images were evaluated by a certified oral and maxillofacial radiologist. There was a calibration session prior to initiation of image evaluation to understand the purpose of the study and a training session was conducted to understand the various functions of the reconstruction software.

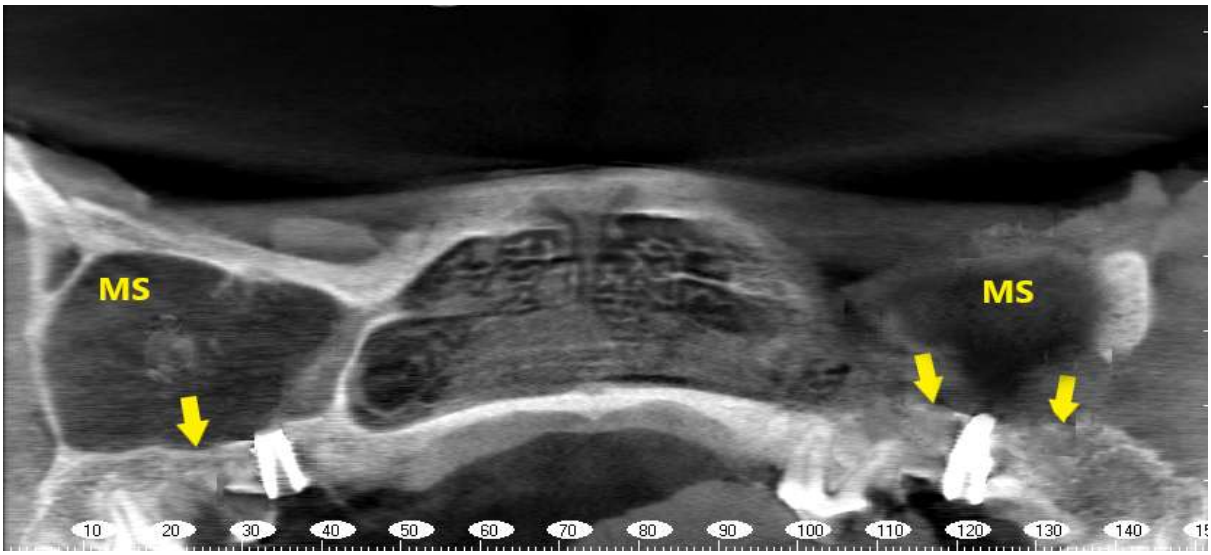


Figure (20).Panoremic view of CBCT shows implant with 0 mm perforation at right side and 1mm perforation at left side of the maxillary sinus. Arrows indicate the bony sinus floor.
MS: Maxillary sinus

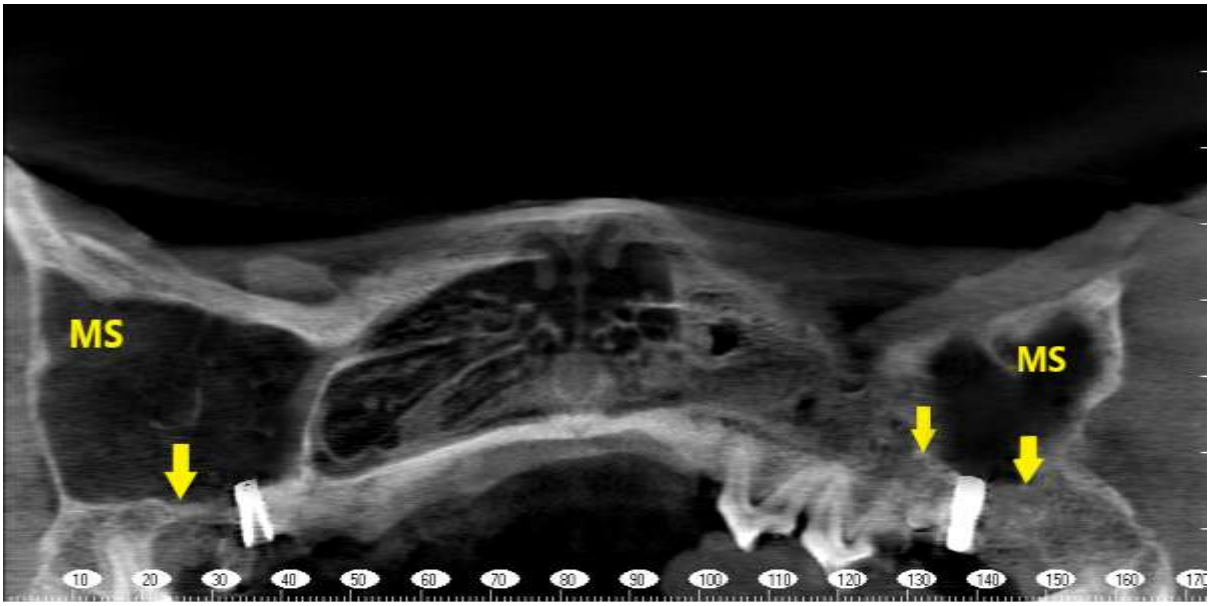


Figure (21).Panoremic view of CBCT shows implant with 1 mm perforation at right side and 0 mm perforation at left side of the maxillary sinus. Arrows indicate the bony sinus floor. MS: Maxillary sinus

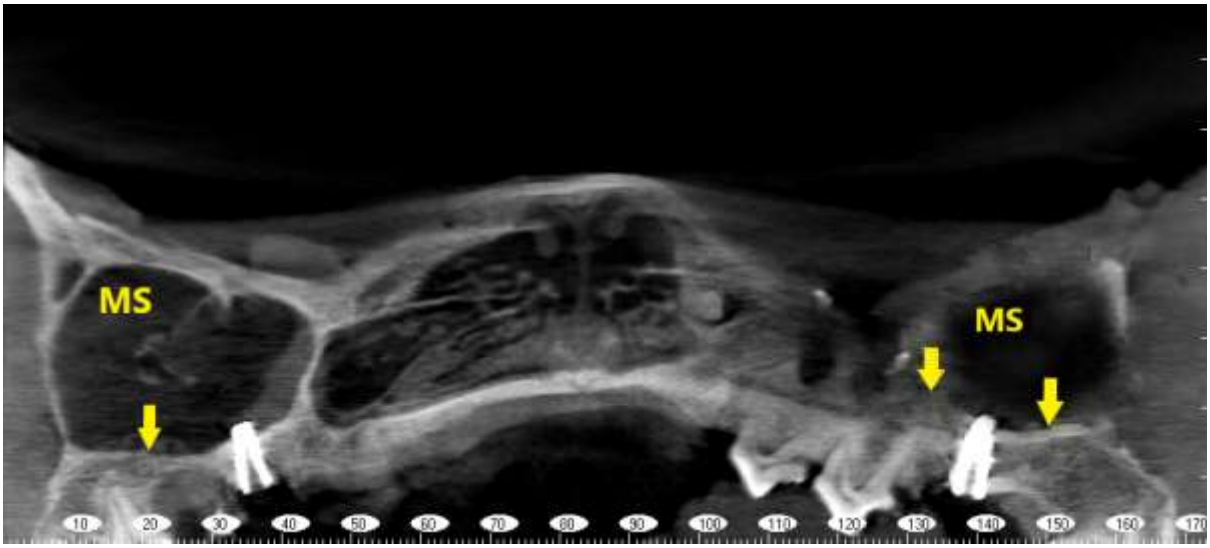


Figure (22).Panoremic view of CBCT shows implant with 2 mm perforation at right side and 1mm perforation at left side of the maxillary sinus. Arrows indicate the bony sinus floor. MS: Maxillary sinus

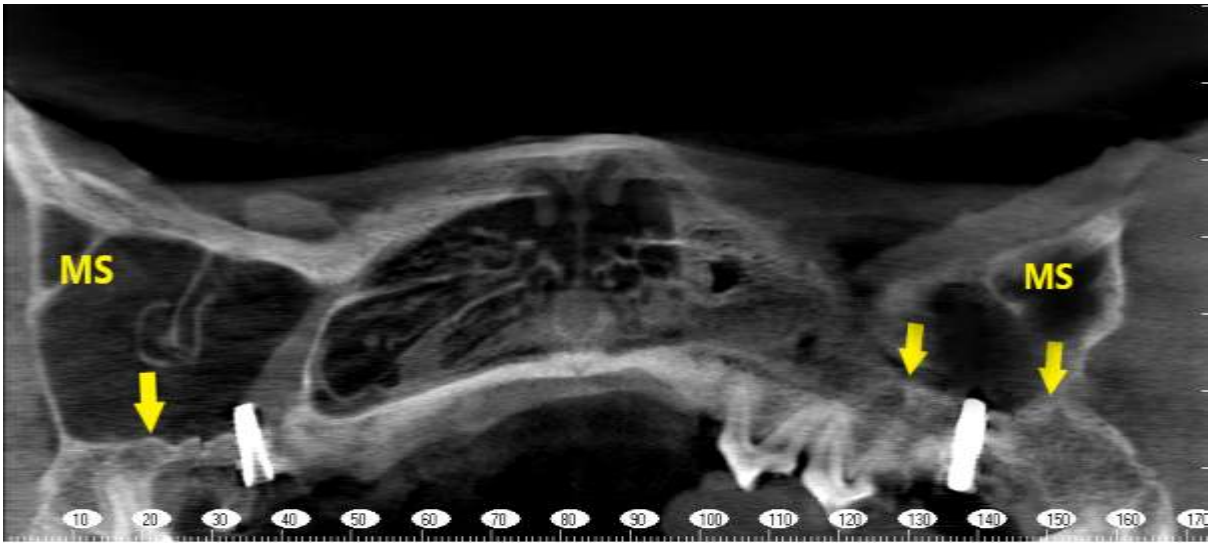


Figure (23).Panoremic view of CBCT shows implant with 3 mm perforation at right side and 1mm perforation at left side of the maxillary sinus. Arrows indicate the bony sinus floor. MS: Maxillary sinus

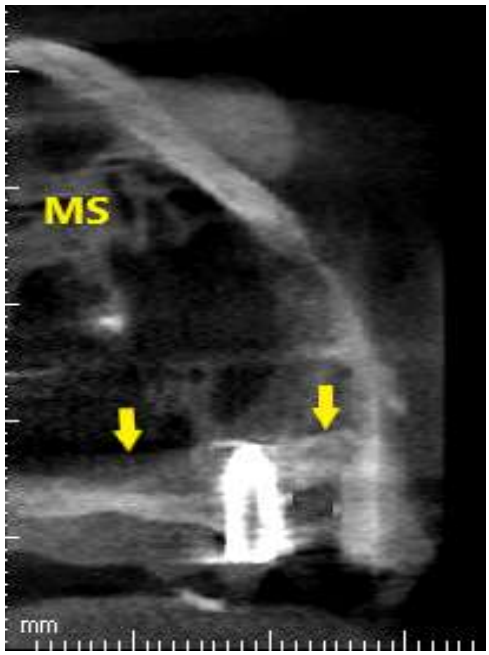
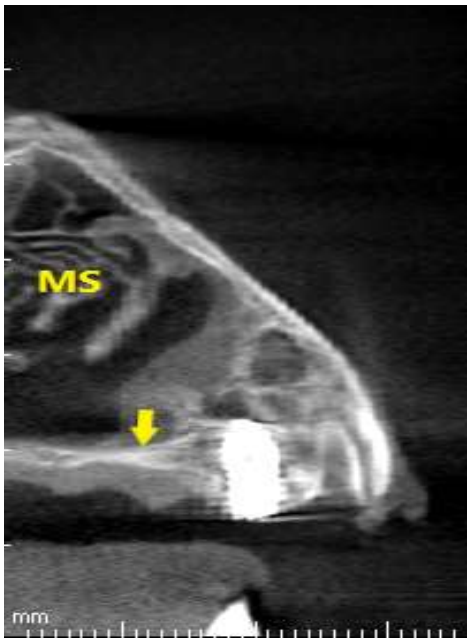
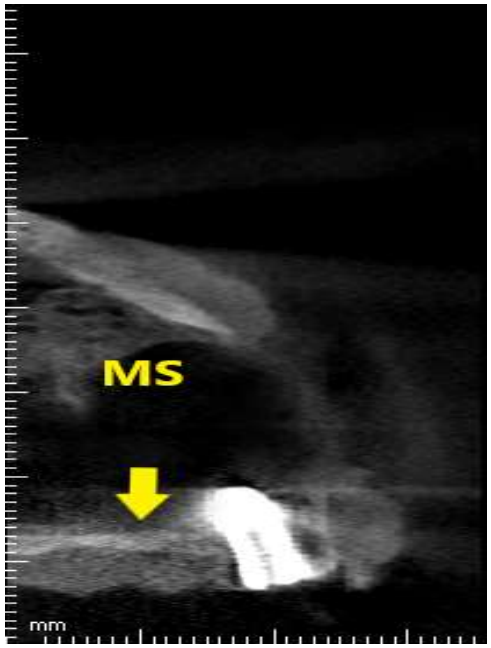


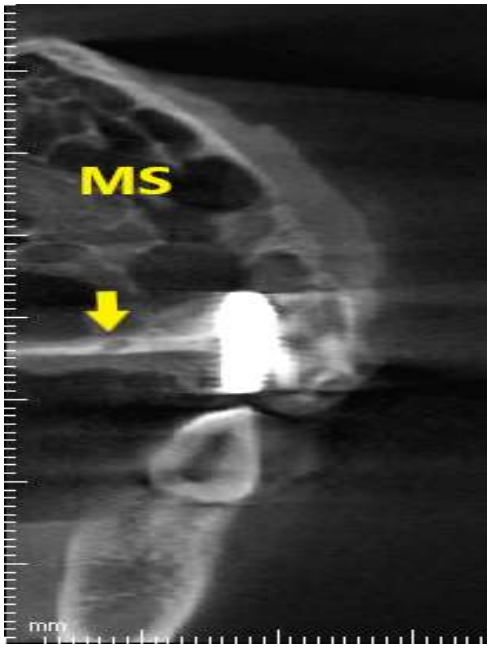
Figure (24) a) Cross view of CBCT shows 0 mm perforation into the maxillary sinus



b) Cross view of CBCT shows 1 mm perforation into the maxillary sinus



c) Cross view of CBCT shows 2 mm perforation into the maxillary sinus



d) Cross view of CBCT shows 3 mm perforation into the maxillary sinus

4. DISCUSSION

The present animal experiment was designed to evaluate whether there are difference between minor and major penetration of implant into maxillary sinus, with respect to their effect on implant osseointegration and maxillary sinus complication.

4.1 Clinical results

In this experimental study, there was not any sign of wound infection or other complications such as implant loosening or failure and no any adverse inflammatory reaction in the sinus, and high success rates were achieved. Similar findings were reported by other investigators (AbiNajm et al 2013),,(Nooh et al 2013). Different perforation sizes and depths didn't affect the sinus health, implant osseointegration and success rates.

In the current study all the dental implants (32) were stable and had a high percussion sound and showed no signs of loosening during the 6 months post-operative follow-up period as verified by clinical, radio graphical examinations and biomechanical analysis (periotest reading values). The soft tissue surrounding the implants looked healthy without signs of inflammation.

Radiographic imaging is one way of showing inflammation of the paranasalsinuses,standardperiapical and panoramic radiographs are useful in searching for dental pathology. These radiographs are generally not helpful in documenting the presence of sinus inflammation, and they are less specific and sensitive than computerized tomography (CT) scanning for analyzing the degree of sinus abnormalities (Brook 2009),(Longhini et al 2012). As a result, their use has declined and they have been replaced by CT scanning

In this current study, clinical examination of the sinuses at the time of implant control no signs of pathology. Plain films for implant control purposes seemed sufficient in addition to CBCT analysis for the sinus health .Despite the different penetrating depths, the osseointegration

in the interface between implant and bony sinus floor was observed in the surrounding sinus membrane, suggesting that the exposed implants do not make the maxillary sinus membrane vulnerable to complication. The present study revealed that disruptive membrane around the apical portion of implant healed again and re-covered the tips of implants provide the protruding depths were less than 2 mm. regenerated bone tissue was discovered on the uppermost part of some implants which indicated the self-regenerating and new bone-inducing abilities of sinus membrane. Based on the present result, it seems that under the circumstance of everyday practice, it is relatively safe to control the implant protrusion depth to the extent of less than 2 mm in case a healthy maxillary sinus was accidentally perforated. Whereas, when the protruding depth was deeper than 3 mm, membrane coverage of the exposed potion could not be achieved. Circular epithelium structure similar to gingival cuff formed around the base of the protruding parts and did not show any sign of inflammation. This observation may be explained by the direct attachment of the membrane to the implants, forming a barrier to the sinus cavity. As for the parts that were not covered with the sinus membrane, debris might accumulate on the surface of the exposed apical over time and become a potential predisposition to sinusitis.

4.2 Radiological results

In the current study, a standardized intraoral periapical radiograph was taken on the day of implant placement (baseline) and after 6 months postoperatively to evaluate the bone formation around the implant apex.Radiographic examination of the sites of implantation demonstrated a close contact of bone and implant without radiolucent areas. The tips of implants in the control group were completely embedded in the alveolar bone and no signs of inflammation had been seen at pri-implant area. The tips of implants with the penetrating depth of 1 mm and 2 mm were surrounded by bone tissue with close contact near the tips of some of implants without any significant sigs of inflammatory reaction. While the tips of implant with the penetrating depth of 3 mm, were found to protrude inside the sinus cavity without bone coverage as well as without radiolucent areas around the implant.

The introduction of CBCT has changed the imaging paradigm in preoperative treatment planning for implants (Kennedy et al 1985; Wen et al 2013).

In the current study, CBCT views in the previousmentioned postoperative follow up periods showed good adaptation of bone around the implant with an absence of any peri-implant radiolucency and showed a healthy mucosal thickening around the intruded part of the implant in all cases. Integrated bone around the implant appeared with intimate contact to the implant fixture surfaces in all cases. There was no observantly significant difference between area of bone/implant interface and the adjacent alveolar bone. The newly formed bone around the implants installed with this technique is repeatedly seen on radiographs and resembles the bone seen around natural teeth in the maxillary sinus region. . This result is in accordance with the previous studies in humans (Lundgren *et al* , 2003; 2004; 2008; Hatano*et al* , 2007 ;Nedir*et al*, 2009; Balleri*et al*,2012) and animals (Palma *et al*, 2006; Cricchio*et al*, 2009) that all obtained, in a varied range, new bone formation in the maxillary sinus augmentation without bone grafts.

In this present study, clinical examination of the sinuses at the time of implant control no signs of pathology. Plain films for implant control purposes seemed sufficient and no further radiological investigation was deemed necessary. Thus, no Lund- Mackay scores for head and neck CT were calculated .Length on implant penetrating could inhibit the spontaneous recovery of membrane perforation after implant placement. Jung et al. reported that penetrated implants

into the sinus floor less than 2 mm was covered by the sinus mucosa in mongrel dogs. CT scans showed that implant protrusion of>4 mm in the maxillary sinus can cause thickening of the sinus mucosa around the implants. However these sinuse remained asymptomatic(Jung et al 2006),(Jung et al 2007). In our study, estimated implant penetration was 3 mm in all cases and no signs of sinus problem were seen, the minor post-operative complications of sinusitis and epistaxis reported in the study did not contribute to long-term problems.

This study revealed that the maxillary sinus membrane thickness with CBCT analysis range from 1 mm to 2 mm normal healthy thickness without any pathological abnormalities. Many studies have measured the thickness of the Schneiderian membrane using different methods such as cadaver examinations, CTs, and CBCTs. Normally, the thickness of the Schneiderian membrane is approximately 1 mm (Borgonovo et al 2015). However, in every day clinical practice, mucosal thickening of the maxillary sinus is a common radiographic finding in asymptomatic patients; therefore, mucosal lining of more than 4 mm is considered to be pathological.

When planning any surgical treatment for the maxilla that includes the posterior region, not only the dimensions and abilities of the Schneiderian membrane, but also the anatomical variations of the maxillary sinus are very significant for every clinician. Cone-beam computed tomography provides essential three-dimensional information regarding the inner part of the maxillary sinus in order to increase the success rate of every surgical procedure and, simultaneously, in order to limit the intra- and post-operative complications.

4.3 Biomechanical evaluation results

The success of a dental implant depends on its ability to osseointegrate with surrounding bone(Lekholm et al 1985). Within the clinical perspective, successful osseointegration is quantified on the basis of implant stability(Linkow et al 1991). Implant stability can be categorized as primary implant stability and secondary implant stability. Osseointegration is defined as the direct and functional connection between the implant and the bone surface (Mall et al 2011).

The clinical definition of implant osseointegration considers the level of stable marginal bone and absence of mobility in the bone. Therefore, the diagnosis is based on radiographic and mechanical stability criteria. Periimplant radiolucent areas and marginal bone height can be identified on X-ray, although only mesiodistal changes are detected. Sundén et al stated that high-quality radiography is necessary to optimise the irradiation geometry, density and contrast.

Clinical assessment is based on mechanical rather than histological criteria of stability (Meredith 1998).In the current study, the primary and secondary stability were measured using Periotest M device, a lot of methods and devices were used for implant stability measurement by different researchers.

4.3.1 Primary stability evaluation results

In the present study, the lowest and highest Periotest Values PTV for the primary stability of the dental implants were -3.80 and -1.80 respectively, all the other values fell in-between.The above-mentioned range denotes substantial stability of the of the dental implants, which agrees with Sachdeva*et al*. in (2016) who mentioned that PTV marked from -8 to 0 is considered good stability.

The mean PTV of the primary stability for the Control group and experimental groups were -2.64, -2.55, -2.71 and -2.78 respectively, such initial high stability is possibly attributed to the implant-cortical bone firm contact. Data suggest that primary stability leads to more efficient achievement of secondary stability. However, data are inconclusive concerning the effect of the degree of primary stability on implant survival and marginal bone loss. Furthermore, while insertion torque seems to influence positively on implant survival, high thresholds of insertion torque have demonstrated to have a detrimental effect on peri-implant marginal bone stability. The immediate implant placement approach has been studied extensively since being introduced. Evidence available indicates that it is a successful procedure that may benefit patients. However, careful planning and case selection are needed to ensure implant success (Koh et al 2010). There is a significant biological response by the hard and soft tissues to immediate loading of dental implants . (Javedand Romanos 2010). It is believed that threaded implants provide the highest mechanical stability after placement. The application of tapered implants and progressive lateral bone compression during drilling are thought to improve the implant to bonecontact, implant stability, and osseointegration.

4.3.2 Secondary stability evaluation results

In the present study, the lowest and highest Periotest Values PTV for the secondary stability of the dental implants were -4.20 and -1.80 respectively, all the other values fell in-between.The above-mentioned range denotes substantial stability of the of the dental implants, which agrees with Sachdeva*et al*. in (2016) who mentioned that PTV marked from -8 to 0 is considered good stability. The mean PTV of the secondary stability for the Control group and experimental groups were -3.23, -2.79, -2.89 and -3.16 respectively. The secondary stability of the control group and experimental group showed statistically no significant differences after six month healing period, and no significant difference between primary and secondary stability reading values with P-values; 0.078, 0.382, 0.368, 0.104 respectively.

Secondary stability involves initial healing process around the dental implant, and it's determined by primary stability process of osseointegration who developed from regeneration and remodeling of the bone and tissue around the inserted dental implants (Rozé et al 2009)and is influenced by the implant surface and the wound-healing time. Bone healing is activated at the bone-implant interface after the surgical injury produced during preparation of the implant site (Sjöström et al 2005).

From a different perspective, the achievement of "high" mechanical stability with the term "high" signifying the use of a "larger-than-normal" insertion torque involves the risk of causing a deleterious effect upon peri-implant tissue stability. For example, recent studies in animal models have focused on the interplay between biology and mechanics in osseointegration. (Cha et al 2015),(Wang et al 2017),(Yuan et al 2018), (Duyck et al 2010). Based on these findings, the insertion of dental implants under "high" torque triggers an increased spatial extent of interfacial microfractures and related bone resorption, which in turn can compromise osseointegration. On the other hand, implants placed with "low" insertion torque (ie, lower than typically used) showed significantly smaller compressive strains in peri-implant bone and minimal cell death, which, in turn, may blunt the oft-reported "dip" in plots of implant stability over time (West and Oates 2007),(Zhou et al 2009). Measurements thereof, a search for a quantitative metric that would enable clinicians to predict successful performance of dental implants regardless of their

placement and/or loading protocols has represented an active thrust in dental research within the last two decades.

Careful planning and case selections are needed to ensure implant success and final aesthetic outcomes, because bone quality and bone resorption followed by remodeling of the maxillary ridges after tooth loss, oftenresults with residual ridge process where primary stability can't be obtained. Successful osseointegration (primary and secondary stability) process of placed dental implants depends and related to their stability.

4.5. Success rate

Success was defined as the implant remaining in situ during the entire observation period. In this study no implant (0 %) had been failed. All the implants achieved osseointegration after 6 months of loading yielding an implant success rate of (100 %) This percentage is similar or higher than the survival rates reported in previous studies for implants placed in maxilla without grafting materials (Hatano*et al*,2007;Sohn*et al*, 2008;Borges *et al*, 2011) those found survival rates in their studies between 92.9%-100% .

In spite of short period of follow up, the results showed the validity of the procedure. The high rate of implant success might be due to several factors including implants length, the amount of the remaining bone height, implants primary stability, good quality of bone. Finally good and highly experienced team, proper selection of the experimental animals and good cooperation with veterinarian specialists make this procedure successful.

The low implant failure rate found during this studywas consistent with the data from previous studies (Lundgren *et al*, 2004; Hatano*et al*, 2007;Cricchio*et al*, 2011). The exact cause of implant failure is unknown but may be due to one of the following factors including undue pressure from the provisional denture that was used by the patient. Where the mucosa of the failed implant was damaged and the cover screw was exposed during the healing period.

5. Conclusion

In this study, the incidence of intentional sinus membrane perforation by dental implant in different depths and the possible risk factors associated with membrane perforations were investigated and the implant osseointegratin and the survival rate of implants placed in the posterior maxillain a dog model were assessed by Biomechanical evaluation andRadiologicalimaging. The results showed that the posterior maxillary edentulous areas with reduced bone height may be successfully rehabilitated with implants that penetrate the Schneiderian membrane and extended into the maxillary antrum. During the 6-monthes observational period in canines, despite the different protrusion extent, penetration of dental implant into the maxillary sinus with membrane perforation did not compromise the dental implant osseointegation processes and the sinus health. It was also found out when penetrating depth into the sinus is less than 2mm, the apical portion of implant could be re-covered by regenerating membrane.

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