Republic of Iraq

Ministry of Higher Education & Scientific Research

University of Baghdad

College of Dentistry

The Effectiveness of Platelet Rich Fibrin as a Graft Material in Sinus Augmentation Procedures through Lateral Approach

A thesis submitted to the Council of the College of Dentistry at the University of Baghdad, in partial fulfillment of requirements for the Degree of Master of Science in Oral and Maxillofacial Surgery

Submitted by

Dunia Saad Muhammed Fathy

B.D.S.

Supervised by

Assist. Prof. Dr. Thair A. Lateef

B.D.S., H.D.D., F.I.B.M.S.

2018 A.D. **1439 A.H.**

Abstract

Background: Rehabilitation of posterior maxilla is compromised by deficient residual bone height with inherent poor bone quality that inversely affects the primary dental implant stability. Sinus augmentation is a predictable surgery to provide additional required bone volume for adequate implant placement. Natural bone regeneration that fills the subsinus space can be improved with the use of platelet rich fibrin that serves as a scaffold for new bone regeneration taking into account the osteogenic potential of periosteal-like layer of sinus membrane.

Aim: The objective of this study was to evaluate the effectiveness of platelet rich fibrin as the sole graft material with immediate or delayed implant placement utilizing radiographical analysis for the final submembraneous bone height and density.

Materials and methods: Presurgical examination with orthopantomography and cone beam computed tomography for initial assessment of the residual bone height. Ten males and 6 females with mean age of 48.88 years (range: 29-65) were enrolled in this study. Simultaneous 17 implants placement with sinus augmentation (one-stage surgery) were done for 14 cases while augmentation with delayed implant placement (two-stage surgery) was performed for 5 cases with PRF as the sole filling biomaterial. Twenty four weeks postsurgical examination with cone beam computed tomography was done to assess the final height and density of submembraneous bone. Statistical analysis was presented as frequency, percentage, mean, and standard deviation. Two independent samples T-test, paired sample T test, and Pearson Correlation. Level of significance at: P: 0.05.

Results: Sixteen consecutive patients (19 sinus augmentation procedures) 14 of them received 17 sinusal implants. All implants were inserted in residual bone height between 3-6 mm (mean±SD 4.46±1.25 mm), and

two-stage surgery was performed for residual bone height ranged from 0.5 to 2.9 mm (mean 1.92±1.08 mm). The submembraneous (residual bone height+neoformed bone) bone height for one-stage surgery in each implant site ranged between 10.7 and 13.9 (mean 12.44±0.99 mm) and for two-stage surgery ranged between 1.2-7.2 mm (mean 4.93±1.61 mm) in proposed implant site, which was highly significant for both protocols. In one-stage surgery cases, the mean density of gained bone was 408.28±169.89 Hounsfield unit which falls in category 3 of bone density according to Misch scale, while for two-stage surgery the mean gained bone density was 183.60±97.67 Hounsfield unit which falls in category 4. Postoperative period was uneventful and all implants were stable after 24 weeks. Radiographic analysis revealed that final submembraneous bone height was very significant with long implant. There were no statistically significant changes in *schneiderian membrane* thickness although (26.32%) of patients who revealed radiographic preoperative membranous thickening >2 mm were found to resolve completely when cone beam computed tomography examination performed after 24 weeks.

Conclusion: Platelet rich fibrin as optimized blood clot is an easily obtained and cost effective biomaterial uptrend natural bone regeneration around implant. From a clinical and radiographical point of view 24 weeks after sinus augmentation procedure, platelet rich fibrin clot as the sole graft material during sinus lift with immediate implant placement provides stable, high level of natural bone which is comparable to normal bone density of posterior maxilla, and the neoformed bone in the submembraneous cavity is in continuity with the tip of the implants. However, despite platelet rich fibrin clot is able to form new bone in two-stage protocol but its capacity to maintain space is unclear and need further studies.

List of contents

List of tables

List of figures

List of abbreviations

Abbreviation	word
%	Percentage
1st	First
2nd	Second
3rd	Third
2D	2 Dimensional
3D	3 Dimensional
AAA	Alveolar antral artery
ALP	Alkaline phosphatase
ASAA	Anterior superior alveolar artery
BD	Becton, Dickinson
BMP	Bone morphogenic protein
BV	Basilic
◦C	Degree centigrade
CI	Confidence interval
CBCT	Cone beam CT
Cm	Centimeter
Co.	Company
cPRP	Concentrated platelet rich plasma
CT	Computed tomography
CV	Cephalic vein
d.f	Degree of freedom
DI	Dental implant
EGF	Epidermal growth factor
ENT	Ear, nose, throat
FGF	Fibroblast growth factor

Fig	Figure
G	Gauge
GBR	Guided bone regeneration
GF	Growth factor/s
HU	Hounsfield units
HS	Highly significant
i.e.	id est.: a Latin phrase means "that is"
IGF	Insulin-like growth factor
IL	Interleukin
IOA	Infraorbital artery
kV	Kilovolt
L-PRF	Leukocyte-and Platelet -Rich Fibrin
L-PRP	Leukocyte- and Platelet-Rich Plasma
mA	Milliampere
µm	Micrometer
MABV	Median antebrachial vein
Max	Maximum
MCV	Median cubital vein
Mg	Milligram
Min	Minute
Min	Minimum
mL	Millileter
Mm	Millimeter
mRNA	Messenger ribonucleic acid
MS	Maxillary sinus
µSv	Microsievert
MT	Membrane thickness
N/cm	Newton/centimeter

NS	Non significant
No.	Number
OPG	Orthopantomography
ORC	Oxidized regenerated cellulose
P	Probability
PDGF	Platelet derived growth factor
PRF	Platelet rich fibrin
P-PRF/ PRF	Pure Platelet-Rich Fibrin
P-PRP / PRP	Pure-platelet rich plasma
PPP	Platelet poor plasma
Psi	Pound per square inch
PSAA	Posterior superior alveolar artery
r	Pearson correlation
RBC	Red blood corpuscles
RBH	Residual bone height
Rpm	Revolution per minute
SA	Sinus augmentation
SBH	Submembraneous bone height
S.D	Standard deviation
Sig	Significant
S.L.A.	Sand blasted. Large grit. Acid etched
SM	Schneiderian membrane
SP	Sinus pneumatization
Tab	Tablet
TGF	transforming growth factors
TNF-α	Tumor necrosis factor-alpha
VEGF	Vascular endothelial growth factor
VV	Voxel value

Introduction

Edentulism of posterior maxilla results in deficient bone volume and vertical height between the floor of the sinus and the edentulous ridge, compromising the placement of dental implant with the necessary primary stability for long-term success. Sinus floor elevation to augment the maxillary sinus can be achieved by two main approaches: the external lateral window approach and the internal transalveolar approach **(Kao, 2014)**.

The lateral window approach was first developed by Tatum in the mid-seventies and was published by Boyne and James in 1980. Recently it is the most popular method to increase the residual bone height of the posterior maxilla with simultaneous or delayed implant placement **(Starch-Jensen *et al*., 2017)**.

The other approach, established by **Summers** is the crestal technique. It is more conservative, less time consuming; but provides only limited augmentation. With both techniques a variety of augmentation material are used with successful results such as autogenous bone grafts, allografts, xenografts, and alloplastic materials **(Batal and Norris, 2013)**.

Nowadays, platelet rich fibrin (PRF) has been used as sinus augmentation material. It was first prepared by **Choukroun *et al***. in 2001 by simple collection of venous blood and centrifugation without any additives. It is characterized by its fibrin mesh that is enriched with platelets and growth factors, so accelerates physiologic wound healing and new bone formation **(Zhao *et al*., 2015)**.

For pre and postoperative assessment of sinus augmentation procedures cone beam CT (CBCT) is potential and reliable diagnostic modality as reported in many literatures **(Benavides *et al*., 2012)**.

Aim of study

The objective of this clinical study was to assess the effectiveness of PRF clots as the sole filling material during lateral sinus lift with immediate or delayed implant placement depending on CBCT for radiographical analysis of height and density of neoformed bone.

Chapter One

Review of Literature

1.1 Relevant anatomy and physiology of the maxillary sinus

1.1.1 Historical background

The maxillary sinus MS was first mentioned by ancient Egyptians followed by many Greek physicians. The word antrum comes from Latin word that means hollow in land or cave. The first who described the maxillary sinus was the anatomist *Nathaniel Highmore* and hence the name *"Highmore's antrum"* **(Mavrodi and Paraskevas, 2013)**.

1.1.2 Embryology and development

During seventh to eighth week of embryonic life, ridges known as ethmoturbinals develop which are extensions from lateral wall of nasal capsule. There are furrows between ethmoturbinals, the first furrow form the ethmoid infundibulum, hiatus semilunaris, and middle meatus. The MS arises from the lower portion of the ethmoidal infundibulum at 16 weeks. At birth MS is about 7 mm length, 4 mm height, and 2.7 mm width then progress to pneumatize to reach the level of nasal floor at the period of permanent teeth eruption. The adult MS is reached at age 16 years **(Duncavage and Becker, 2011)**.

1.1.3 Surgical anatomy

The maxillary sinus is the largest one among the paranasal sinuses of the skull. It is located in the body of maxilla and is pyramidal in shape. In adult it may reach canine area anteriorly to tuberosity area posteriorly and filled with about 12-15 mL of air. The dimensions are about 40×26×28 mm. The floor which is the thickest wall is formed by the alveolar and palatine processes, the medial wall (lateral nasal wall) is the base of sinus and the floor of orbit forms its roof. The sinus floor is about the same

level with nasal floor in dentate individual while about 10 mm below the nasal floor in edentulous patient. The ostium opens into the semilunar hiatus of the nasal cavity on antero-medial wall, figure (Fig. 1-1) and located in superior position 25.6 mm away from nasal floor that makes drainage independent on gravity **(Kao, 2014; Danesh-Sani *et al*., 2016)**.

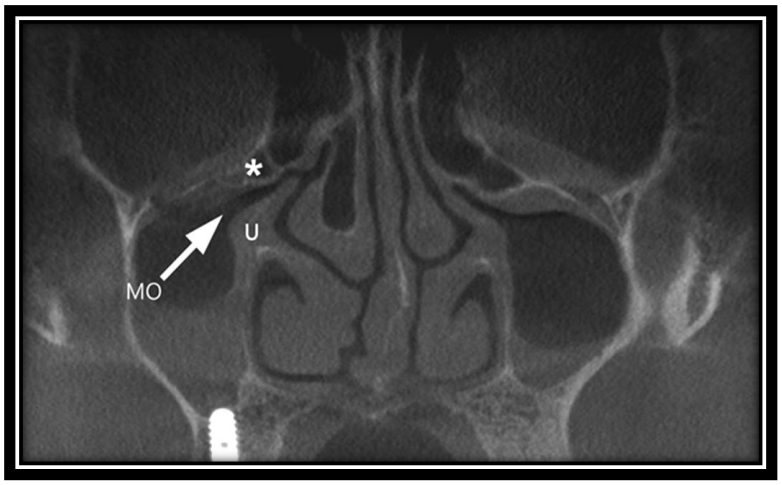


Fig. (1-1): The maxillary ostium (MO) enters the infundibulum, which is the space between the uncinate process (U) and the ethmoid bulla (*) **(Kao, 2014)**.

1.1.4 Innervations and vasculature

Maxillary sinus receives sensory innervations from branches of maxillary division of trigeminal nerve: the posterior superior alveolar, anterior superior alveolar, infraorbital, and greater palatine nerves. The mucous membrane receives the parasympathetic innervations from facial nerve via greater petrosal nerve. The blood supply is by infraorbital (IOA), greater palatine, posterior superior alveolar (PSAA) and anterior superior alveolar arteries (ASAA) which are branches of maxillary artery **(Kao, 2014)**.

There is an extraosseous and intraosseous anastamosis between PSAA and IOA. The intraosseous anastamosis known as alveolar antral artery (AAA) was first reported in 1934, the area of lateral osteotomy is the most common location of it, and it is always present while extraosseous

anastamosis is found in 44% of cases. Bleeding from intraosseous anastamosis is directly proportional to AAA diameter and is more significant as it can obscure the surgical field that may result in higher risk of membrane perforation and subsequent complications. Alveolar antral artery supplies sinus membrane and epiperiosteal vestibular tissue as well as it is of particular importance for vascularization of graft material in sinus augmentation (SA) surgery. According to many studies the diameter of AAA that is measured with computed tomography (CT) scan ranges from 0.8-1.59 mm and the distance from alveolar ridge to AAA ranges from 16.88-23.56 mm **(Valente *et al*., 2015)**. Extraosseous anastamosis is about 23 mm from alveolar ridge **(Hong *et al*., 2017)**.

1.1.5 Functions of maxillary sinus

1. Trauma reduction to the brain as it acts as buffer and lightens the skull.
2. Humidification and warming of inspired air.
3. Voice resonance.
4. Mechanical clearance of mucous.
5. Regulation of intranasal gas pressure (**Kao, 2014)**.

1.1.6 Sinus pneumatization (SP)

According to Wolf's law, bone resorption caused by loss of the posterior teeth and loss of load, eventually will result in loss of remodeling of alveolar bone and this is associated with pneumatization of sinus that explain the inverse relation between pneumatization and residual alveolar bone. It is also reported that the increased osteoclastic potential of sinus periosteal-like layer after maxillary posterior teeth loss and the increased sinus pressure contribute to feature of pneumatization **(Rossi *et al.* ,2012; Tolstunov *et al*. ,2012)**, Fig. (1-2).

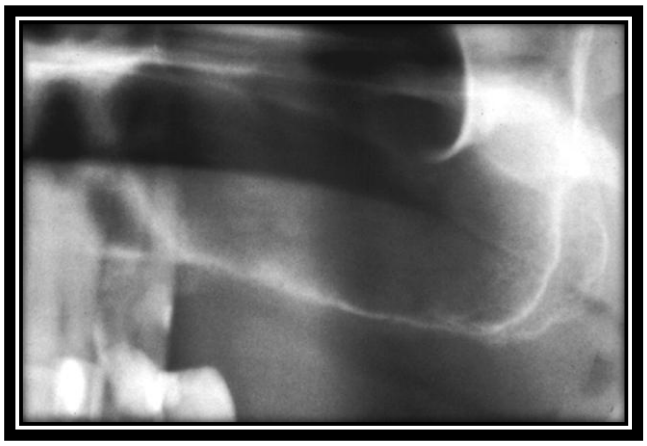


Fig. (1-2): Pneumatization of MS after tooth loss probably caused by reinforcement of osteoclastic activity of the *Schneiderian membrane* **(Zijderveld *et al.* , 2008).**

Depending on distance from anterior border of maxillary sinus to the midline of maxilla measured by cone beam CT (CBCT), **Tolstunov *et al*. (2012)** classified SP into 5 classes:

1. Clear SP0: >30 mm.
2. Mild SP1: >25 mm.
3. Moderate SP2: 21-25 mm.
4. Severe SP3: 16-20 mm.
5. Extreme SP4: ≤15 mm.

In case of augmented sinus repneumatization may occur due to resorption of graft material **(Kao, 2014)**.

1.1.7 Sinus septa

Septa can be defined as one or more cortical bony ridges of at least 4 mm **(Ella *et al*., 2008)**. Septum was first described in 1910 by the anatomist **Arthur S. Underwood** and so called *Underwood septa*. Its incidence is about 24.3-32.5% and is classified into primary and secondary, Fig. (1-3). Primary septa are developed from the embryologic out-pouching of the ethmoid infundibulum, while secondary septa are found over edentulous area of the ridge and developed due to irregular pneumatization of the

sinus. It can be complete or incomplete and can be found at any sinus wall (i.e. coronal, sagittal, and transverse). Septa can be located in premolar region (anterior), molar region (middle), or wisdom tooth region (posterior). Septa should be adequately investigated by CT or CBCT in sagittal, coronal, axial views as they are associated with difficult reflection of membrane as well as difficult adaptation of graft material **(Gülsən *et al*., 2015; Shahidi, *et al*., 2016; Hong *et al*., 2017)**.

Hong *et al.* (2017) reported that *"the function of septa is largely unknown. Van den Bergh et al. postulated that septa act as struts to withstand masticatory forces during the dentate stage of life"*.

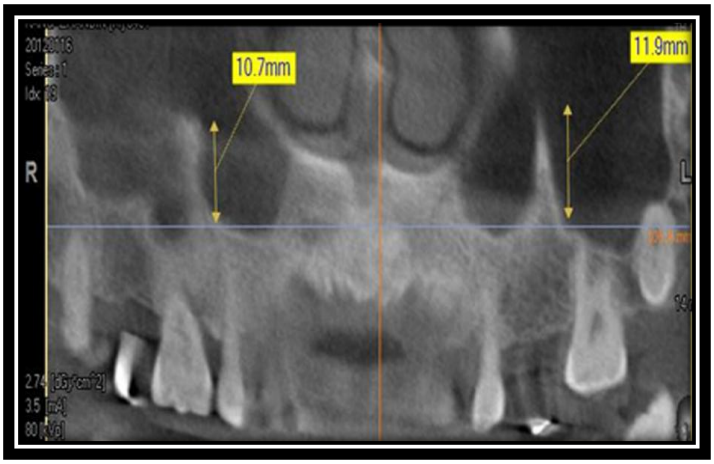


Fig. (1-3): Cone beam CT illustration of a primary septum (right) and secondary septum (left) **(Hong *et al.*, 2017)**.

Modifications of osteotomy window may be necessary in presence of septum, including double window technique or w-shaped window design **(Abramovitch and Rice, 2014).**

1.1.8 Maxillary sinus membrane

The bilaminar structure which is composed of periosteal like deep layer and epithelial layer is called *schneiderian membrane* (SM).There are four cell types in the epithelium, pseudostratified ciliated columnar

epithelium, nonciliated columnar, goblet, and basal cells. The function of cilia is to sweep the mucous against gravity to the ostium. Normal mucociliary clearance is crucial for normal physiology of sinus; therefore sinus lift surgery may interfere with normal mucociliary clearance as it affects the cilia either by direct trauma or loss results in decreasing its function. While the microvilli that are scattered along the non ciliated cells act to increase surface area, air warming and humidification **(Anduze-Acher *et al*., 2013; Kao, 2014)**.

According to several studies the deep layer that interfaces the maxillary sinus bone (periostium- like) is rich in osteoprogenitor cells. It was found that there is positive alkaline phosphatase (ALP) activity and mRNA expression of classical osteogenic markers. This finding supports the osteogenic potential of this layer, that's why elevation of membrane during sinus lift procedure results in formation of bone **(Srouji *et al.*, 2010)**.

Pommer *et al*. (2009) studied the mechanical properties of SM on human cadavers and found that thicker membrane can withstand higher load and therefore less susceptible to perforation during sinus lift surgeries.

Shahidi *et al.* (2016) advocated 0.13-0.5 mm as normal thickness, while some studies give a mean thickness of 0.8 mm **(Makary *et al.*, 2016)**. However in the majority of studies 1-2 mm is reported as normal thickness and it can be localized, generalized, or presented as complete opacification **(Nascimento *et al.*, 2016)**.

1.1.9 Lateral wall thickness

It can be evaluated by CBCT which is normally <1 mm and is considered as thick wall when measured >2 mm. Lateral wall can be very thin and adheres to sinus membrane, in this situation difficult preparation

of window and difficult access will be encountered **(Alessandro Geminiani, 2015)**. The thick wall also makes the open sinus lift surgery more difficult and complete removal of lateral window may be preferable to trap door technique **(Abramovitch and Rice, 2014)**.

1.2 Cone Beam Computed Tomography (CBCT)

Preoperative radiographical assessment of maxillary sinus is essential to adequately verify different anatomical and pathological features so the complications can be avoided **(Alessandro Geminiani, 2015)**. Cone beam CT was used in dentistry for the first time in 1995. **Tacconi and Mozzo**, introduced a CBCT system for the maxillofacial field as a valuable diagnostic modality with its peculiarity of lower radiation dose, cost, exposure time and higher spatial resolution when compared with CT **(Jaju and Jaju, 2014)**.

1.2.1 Clinical applications

1. Preoperative evaluation of the sinus with CBCT is essential for success of sinus lift procedures. The following features can be evaluated with CBCT:

A. Sinus pneumatization.

B. Sinus width and angulation.

C. Sinus septum.

D. Intraosseous artery.

E. Schneiderian membrane thickness and its relation to teeth apices.

F. Lateral wall thickness.

G. Antral pathology.

H. Volume of biomaterial needed for augmentation **(Rahpeyma and Khajehahmadi, 2015; Wolff *et al.*, 2016)**.

2. Gray scale for density estimation, in CBCT the degree of x-ray attenuation by tissue is represented by gray scale (voxel value VV) **(Razi *et al*., 2014)**. Each voxel has numerical value (CT number) and this number is compared with water attenuation value in arbitrary scale called Hounsfield units (HU) which gives a qualitative estimation of tissue density in medical CT **(Rodrigues *et al*., 2015)**. Hounsfield units range from −1000 (air), 0 (water), to +3000 (enamel/dental materials). Misch classified bone density based on HU of CT images as follow: D1: >1250 HU, D2: 850 to 1250 HU, D3: 350 to 850 HU, D4: 150 to 350 HU and D5: <150 HU **(Misch, 2008)**.

Razi *et al*. (2014) studied the relation between HU in CT scan and gray scale in CBCT and concluded that CBCT is valuable in determining bone density considering it as the standard for assessment particularly for its dose and cost sparing.

3. It provides 3D reconstruction using panoramic, transverse, sagittal and axial sections that allows determination of height, width, and volume of bone at implant site in sub millimeters **(Güngör and Doğan, 2017)**.

4. Assessment of bone quality at implant site**:** the bone quality as defined by **Lindh *et al.* (2004)** is a term represented by bone structure such as architecture, 3D orientation of trabecula, and matrix in addition to bone mineral density.

5. Assessment of alveolar ridge morphology (narrow, irregular, or knife ridge).

6. Cone beam CT guided implant surgery; the reconstruction of surgical guide from virtual treatment plan offers more predictable and precise relation between implant and surrounding anatomical structures **(Jaju and Jaju, 2014)**.

1.2.2 Limitations of CBCT

1. Artifact.
2. Noise (irregular granular pattern in the image).
3. Low quality soft tissue contrast **(Rodrigues *et al.*, 2015)**.

1.2.3 Postoperative assessment of augmentation material

Kim *et al*. (2013) stated that 3D evaluation of volumetric changes of graft material after SA procedure by CBCT is more accurate than the 2D images such as orthopantomography (OPG) that can determine length changes of graft material. These volumetric changes are obtained by detecting HU differences between bony area and interior part of maxillary sinus.

Bone density is measured at the most apical part of the graft is significant as healing and maturation depends on neovascularization that mainly occurs from the sinus floor **(Liversedge and Wong, 2002)**.

The presence of normal bone surrounding the implant and its apposition to the surface of the implant body refers to success of an implant **(Gulsahi, 2011)**. For delayed placement of implant following SA, this procedure is considered successful if implant with minimally 10 mm length will be placed **(Fugazzotto *et al.*, 2015)**.

1.3 Subantral bone loss

Davarpanah *et al* (2001) classified subantral bone loss into 4 classes:

1. Intrasinus vertical bone loss: pneumatization is the causative factor, interarch distance is not affected. Here in SA is recommended.
2. Alveolar ridge vertical bone loss: the interarch distance is increased and here onlay grafts and guided bone regeneration (GBR) is recommended to increase alveolar bone height.

3. Horizontal bone loss (buccopalatal) of the alveolar ridge: concentric bone loss that results in poor emergence profile of the implant. Bone graft or GBR is the appropriate treatment.

4. Collection of subantral bone loss: is the most common, occurs as vertical and horizontal bone loss. Bone grafts are the treatment of choice, if intrasinus bone loss is simultaneously present, sinus augmentation should be done also.

1.4 Sinus augmentation (SA)

Maxillary sinus floor elevation was first described by **Tatum** at an Alabama implant conference in 1976 and then first published by Boyne and James in 1980. The procedure allows rehabilitation of deficient posterior maxilla. Pneumatization of maxillary sinus causes insufficient vertical bone volume on posterior maxilla. So the restoration of edentulous posterior maxilla with dental implants is challenging due to a deficient posterior alveolar ridge, poor bone quality and increased maxillary SP. For maxillary SA, the crestal and the lateral window approaches have been used **(Pandit and Chopra, 2016)**.

The procedure of choice will be determined by proposed implant length, residual bone height (RBH), buccopalatal ridge width and implant number to be placed **(Kao, 2014)**.

1.4.1 Indications of SA

Whether to do immediate or delayed implantation is a matter of available RBH. It is recommended to do one stage surgery if minimally 4-5 mm of residual bone available so that primary stability necessary for implant placement can be achieved or two stages surgery will be the better option. Despite the fact that many studies show that concomitant implant placement with membrane elevation was actually done even when 1-2 mm of RBH is available **(Mazor *et al*., 2009)**.

The following are recommendations for SA:

1. When RBH is greater than 10 mm (Class A), a straight forward implant placement can be done.
2. When RBH is 7-9 mm (Class B), crestal sinus lift is allowable with immediate implant placement.
3. When the RBH is 4-6 mm (Class C), then sinus augmentation via lateral approach is the method of choice with immediate or delayed implant placement.
4. When RBH is 1-3 mm (Class D), a lateral approach to augment the sinus with delayed implant placement is recommended **(Batal and Norris, 2013)**.

1.4.2 Contraindications of SA

There are many contraindications for SA such as: recent radiotherapy in maxilla, bisphosphonates therapy, uncontrolled systemic diseases, heavy smoking, heavy alcoholism, psychosis, severe allergic rhinitis, acute / chronic maxillary sinusitis, purulent exudate, antral large cyst or tumor, and unrepaired oroantral fistula **(Ferri and Hunziker, 2011; Pandit and Chopra, 2016)**.

1.5 Sinus lift techniques

1.5.1 Crestal sinus lift

1.5.1.1 Osteotome mediated sinus floor elevation

Summers was the first who used osteotomes for sinus floor elevation in 1994. After gradual preparation of the implant site, elevation of the sinus floor by several millimeters was obtained by using successive wider osteotomes that will also result in expanding buccal and palatal walls and denser bone interface with the implant. The objective of this approach is

to keep, if possible, all of the existing bone by pushing it aside with least trauma **(Summers, 1994)**.

Advantages:

1. The technique was essentially heatless, improved tactile sensitivity to changes in bone texture and density **(Summers, 1994)**.
2. Less invasive.
3.Less postoperative patient morbidity and discomfort due to its simplicity.
4. Less time consuming **(Mazor *et al*., 2013)**.

Disadvantages:

1. Increased incidence of sinus membrane perforation during drilling and bone compaction by osteotome.
2. Benign positional paroxysmal vertigo as a result of injury to the inner ear from striking osteotomes and surgical mallet when sinus floor is broken.
3. Blind technique.
4. Limited augmentation **(Sohn, 2011).**

1.5.1.2 Modified osteotome technique

Osteotomy site is prepared just 1 mm below the sinus floor, then graft material is introduced to osteotomy site and with gentle tapping of suitable osteotom, graft material is apically advanced that result in fracture of the sinus floor. In this technique only 4-5 mm of sinus membrane elevation can be achieved **(Kao, 2014)**.

1.5.1.3 Sinus elevation with hydraulic pressure

Elevation of the MS floor with hydraulic pressure is similar to the **Summers** technique in that it uses osteotomes in a definite sequence to

both deepen and widen the osteotomy site and in-fracture the antral floor. Elevation of the SM is done by injecting normal saline solution under hydraulic pressure underneath the SM with a precisely fitted syringe **(Sohn, 2011)**.

1.5.1.4 Sinus lift balloon technique

The sinus balloon raises the sinus membrane smoothly and atraumatically. The device consists of syringe with a tip linked to a latex mini balloon. The amount of saline solution that is placed in the luer syringe is determined by the number of millimeters that the antral membrane to be elevated and corresponded to the amount of graft material in cubic centimeters that are needed to fill the lifted area. With the balloon in place the syringe is held in a digital-palm position and the syringe plunger is gradually pressed with the thumb to expand the balloon and elevate the antral membrane, once the balloon is detached, the SM moves with the patient's respirations. This movement confirms that there is no mucosal perforation and the site is prepared for augmentation with or without simultaneous DI placement **(Rodrigues *et al*., 2010; Lateef and Asmael, 2016)**.

Advantages

1. Elevates membrane for up to 10 mm.
2. Can be applied when RBH <3 mm.
3. Minimally invasive procedure **(Lateef and Asmael, 2016)**.

1.5.2 Lateral sinus lift

At first **Tatum (1976)** used Caldwell-Luc approach to augment the sinus floor with iliac bone graft. A series of modifications were done by many

authors in subsequent years **(Vereanu *et al.*, 2015)**. It classified as advanced surgery in implant dentistry **(Šimůnek *et al.*, 2007)**.

Advantages

1. Allow for greater augmentation.
2. The SM is under direct vision **(Kao, 2014)**.

Disadvantages

1. More invasive.
2. Very sensitive and requires well trained surgeon because it is highly dependant on tactile sensation during preparation of lateral window and elevation of the membrane that associates with possible tearing of the AAA which results in hemorrhage and more risk of sinus membrane perforation
3. Time consuming **(Kao, 2014)**.

1.5.2.1 Surgical technique

Flap reflection and lateral window preparation

Lateral sinus lift procedure can be done under general, local anesthesia or under sedation. The incision is done with slight palatal bias to assure a thick keratinized tissue will cover the surgical site and the vertical releasing incision (incisions), depending on available access, should be at least 4-6 mm away from margin of estimated lateral window to maximize blood supply to the flap and repositioning on intact base, as well as provides enough space for adaptation of barrier membrane if needed.

After complete reflection of full thickness mucoperiosteal flap, antrostomy preparation on lateral aspect on maxillary buttress with high speed hand piece at 800-50,000 rpm or piezotom with copious irrigation can be done. Using carbide or diamond round bur depending on thickness

of lateral wall as revealed by CBCT, it is recommended to use diamond bur to avoid membrane injury while keeping carbide bur for more bulky wall. Osteotomy shape can be oval or rectangular and when proceeding through the lateral wall cutting using sweeping motion the bluish hue of SM can be visualized. Extension and location of prepared window is affected by anatomical factors such as AAA canal location, and septa, so the upper border of antrostomy should be less than 16 mm to avoid injury to AAA **(Batal and Norris, 2013; Kao, 2014; Kao *et al.*, 2015)**.

Danesh-Sani *et al.* (2016) reported that anterior border of antrostomy is about 3 mm from anterior sinus wall, the inferior border is about 3 mm from sinus floor, and the antrostomy preparation can extend as far as the maxillary tubrosity depending on number of implants to be placed and amount of augmentation material.

To reduce incidence of AAA injury, it is recommended to:

1. Use piezotom owing to its selective cutting property.
2. Use diamond bur **(Froum, 2015)**.
3. Modify the shape of osteotomy window into two separated opening above and below the artery **(Abramovitch and Rice, 2014)**.
4. Novel approach to avoid injury to AAA by using piezoelectric bur to slightly remove the bone in area of AAA during lateral window preparation and proceed for conventional preparation of osteotomy window then after complete release, rotation of bony segment, in which AAA is passed, inward upward using AAA as fulcrum of rotation thus preserves the artery from damage **(Valente *et al.* , 2015)**.

There are 3 techniques for lateral window preparation:

A. Trap door technique

Kao (2014) reported this procedure as *"incomplete fracture"*. The prepared osteotomy window is raised apically and medially providing a

new sinus floor and will be as a roof for implant if it is placed immediately but at same time the bony island may impinge the medial sinus wall or cause injury to the membrane during bending.

B. Wall off technique

It is also called "access hole" technique in which the bony window is completely removed from underlying SM by bur so it allows for more access **(Batal and Norris 2013; Kao, 2014)**.

C. Trephine osteotomy

Emtiaz *et al*. (2006) reported maxillary SA using trephine connected to straight handpiece to create bone cut 4-5 mm above the crest of alveolar bone, then the prepared bony window is carefully and completely detached from the underlying sinus membrane, the elevation of sinus membrane is continued to create the required space for augmentation then the bony piece is readapted to its original position and fitted well that no need for further replacement of absorbable membrane.

Sohn (2011) reported the use of saw with thin blade connected to piezotom to make a *"replaceable bony window*".

Membrane reflection

Membrane reflection is achieved by gentle separation from the sinus floor followed by separation of anterior, posterior and then the apical border of membrane by using special set of elevators. Inferiorly, membrane elevation is continued to the medial wall of sinus to allow for intrusion of the bony island medially and creating space for graft material. Membrane should be elevated enough to ensure placement of adequate implant length **(Kao, 2014)**. Membrane reflection anteriorly,

inferiorly, and medially is necessary to ensure vascularization of graft from blood vessels of bony walls **(froum, 2015)**.

To reduce incidence of SM perforation, it is recommended to:

1. Use piece of cotton soaked in local anesthesia with adrenalin for dissection of membrane in order to get blood free field.
2. Place the window about 3 mm from the sinus floor and anterior wall to allow for better coordination of eye-hand movement.
3. Releasing about 3-5 mm of SM in all directions will reduce rate of perforation because pressure will not focused to one place.
4. The hand instrument must be adapted to bony surface during membrane elevation in order to release membrane at its floor up to medial and anterior walls.
5. Oval shaped window so that no sharp edges that can lead to perforation of membrane **(Batal and Norris, 2013)**.
6. Use of diamond bur reduces the incidence of perforation even more than piezotom.
7. Many practitioners recommend the use of piezotom. In case of large septum, then to avoid perforation, complete removal of bony window by piezoelectric device allows good visualization and better ability to proceed with membrane elevation.
8. Use partial thickness flap in cases of oroantral fistula or severe bone resorption where the mucosa just over SM **(Froum, 2015)**.

New bone formation can be achieved after membrane elevation only or when graft material is used for augmentation **(Sohn, 2011)**.

It is recommended to cover the lateral osteotomy window with a membrane after augmentation as it helps in GBR and provide protection to the graft material with increased implant success rate **(Batal and Norris, 2013)**.

The basic principle of GBR is based on the application of a barrier membrane to cover an osseous defect to prevent soft tissues ingrowth that interferes with bone healing for efficient bone formation. Membranes are either resorbable or non-resorbable; the non-resorbable membranes need second operation for removal, so clinicians prefer biodegradable barriers **(Turri *et al*., 2016)**.

Platelet rich fibrin (PRF) *"as a natural and optimized blood clot"* can be used as a membrane as it can effectively improve the GBR as fibrin mesh serves as matrix for bone morphogenic protein transplants **(Hafez *et al*., 2015)**.

Tension-free primary closure is mandatory to avoid contamination of the grafts from the oral cavity. Removal of the sutures is recommended 2–3 weeks following the procedure **(Kao, 2014)**.

1.6 Sinus lift with/without graft material

1.6.1 Non-grafted sinus lift

Sohn (2011) was the first who demonstrated histological evidence of new bone formation in human MS with membrane elevation alone and simultaneous implant placement. *Schneiderian membrane* has the potential for new bone formation so the most important factor is to maintain the space of the created compartment under the elevated SM to prevent membrane collapse. **Vereanu *et al*. (2015)** reported that no graft material can be considered as the best one.

1.6.2 Grafted sinus lift

After completion of SM elevation, the created space is filled with augmentation material taking into account the following considerations:

1. Avoid blockage of the ostium that result in mucous stagnation and subsequent infection.
2. Avoid over condensation of graft material as it causes reduction in space between graft particles and decreased vascularization.
3. Care should be taken to avoid SM perforation during augmentation **(Kao, 2014)**.
4. Pressure necrosis of SM may result from overfilling the sinus **(Ardekian *et al*., 2006)**.

Bone reconstruction by different grafting material is indicated to rehabilitate function by adding bone to deficient area or to substitute missing bone. Osteoinduction means that osteogenesis occurs by stimulation of undifferentiated osteoprogenitor cells to become osteoblast by chemotactic action. Osteoconduction means that bone graft material acts as scaffold for new bone **(Banihashem, 2013)**.

1.6.2.1 Characteristics of ideal bone graft

1. Availability.
2. No donor site morbidity.
3. No disease transmission.
4. Easiness of manipulation.
5. Biocompatibility.
6. Cost effectiveness.
7. High osteoinductive and osteoconductive properties.
8. Biologic stability.
9. Volume maintenance **(Rossi *et al*., 2012; Vereanu *et al*., 2015)**.

1.6.2.2 Sinus augmentation (SA) materials

1. Autogenous graft: Is derived from the same individual and can be obtained from extra oral sources (ilium, calvarium, tibia, rib) or intra oral sources (symphysis, tubrosity, ramus) **(Froum, 2015)**. Autogenous bone graft is considered the gold standard owing to osteoinductive and osteoconductive properties besides no rejection reaction and no risk of disease transmission but graft resorption, donor site morbidity, and long duration of the procedure are significant drawbacks. Success rate of implant has been observed by many authors when autograft is used in combination with xenograft or alloplast rather than autograft alone owing to high resorption rate **(Hafeez *et al*., 2015)**.

2. Allograft: Is derived from another individual from the same species. It is a good alternative to autograft to skip the pitfall of morbidity of donor site. It is osteoconductive or osteoinductive depending on processing but not osteogenic. It carries the risk of transmission of infectious disease and rejection reaction. Different preparations are available (cortical, cancellous or combination) also (lyophilized, fresh, and demineralized) **(Rossi *et al.*, 2012)**.

3. Xenograft: Is derived from another species, with osteoconductive not osteoinductive properties, biocompatibility and very slow resorption rate. It is not immunogenic as the organic material is removed to obtain deproteineized cancellous bone. This graft has the same structure of the human cancellous bone. Example for this material is Bio-Oss which is a deproteinzed bovine bone. Bio-Oss is widely used in SA without need for a donor site **(Banihashem, 2013)**.

4. Alloplast: Is synthetic material divided into different types according to its density and morphology. The structure is responsible for the way in

which the material is working. Beta-tricalcium phosphate and bioactive glass are examples for this material **(Banihashem, 2013)**. Tricalcium phosphate is used for SA as it is biocompatible and osteoconductive allowing the osteoprogenitor cells to proliferate and rapidly replaced by new bone due to its high resorption rate **(Gultekin *et al.*, 2016)**.

5. Surgicel: Oxidized regenerated cellulose (ORC), it is biocompatible and bioabsorbable polymers and are available in a sterilized knitted fabric or powder form for bleeding management. The mechanism of action for hemostasis depends on physical and mechanical actions in tamponade and surface interactions with proteins and platelets. Surgicel also promotes hemostasis chemically due to its low pH which generates a brownish artificial clot containing acid hematin **(Armstrong *et al.*, 2010)**. Surgicel was used to augment sinus through transcrestal approach and compared with osteon II, the result was sufficient bone height and density that is required for implant support with less postoperative complications **(Hussein and Hassan, 2017)**.

6. Platelet concentrates:

The evolution of platelet concentrate to be the alternative to fibrin glue as platelets normally support healing process by formation of blood clot to seal wounds and by releasing growth factors (GF) **(Ehrenfest *et al.*, 2009a)**.

Classification of platelet concentrates

Platelet concentrates is a misleading name for different preparations. Consensus conference of the Periodontology, Oral Surgery, Esthetic and Implant Dentistry Organization adapted this classification for Platelet concentrate to clarify inconspicuous nomenclature.

1. Platelet-Rich Plasma (PRP) "Pure Platelet-Rich Plasma" (P-PRP).
2. Leukocyte- and Platelet-Rich Plasma (L-PRP).
3. Platelet-Rich Fibrin (PRF): "Pure Platelet-Rich Fibrin" (P-PRF),
4. Leukocyte-and Platelet -Rich Fibrin (L-PRF) **(Ehrenfest *et al*., 2013)**.

Platelet rich plasma (PRP)

New technologies were developed to produce the first generation concentrated platelet rich plasma (cPRP). It is platelet concentrate derived from autogenous blood by centrifugation with addition of thrombin and calcium chloride for induction of polymerization. After activation**,** platelets begin to produce GF rapidly and most of them are completely released in about one hour **(Davis *et al.*, 2014)**.

Leukocyte-and Platelet rich fibrin (L-PRF)

It is the second-generation platelet-rich autologous biomaterial that was first developed in France by **Choukroun *et al*** in 2001. It is rich in leukocytes, cytokines, and circulating stem cells that are embedded in fibrin mesh **(Dülgeroglu and Metineren, 2017)**.

L-PRF preparation technique

According to **Choukroun *et al***. protocol **(Process, Nice, France)** venous blood is collected in sterile 10 mL glass-coated plastic tubes without addition of anticoagulant and immediately centrifuged in table centrifuge for 10 minutes at 3000 rpm. Platelets activated by contact with glass wall of tube. After centrifugation three parts will be obtained, at the bottom of the tube the red blood corpuscles (RBC) are settled, at the top the platelet poor plasma (PPP) is supernatant, and PRF is in between. Valid PRF can only be obtained when quick venous blood collection and quick starting of centrifugation is done by practitioner to avoid coagulation that is

triggered by endogenous thrombin with no fibrin clot obtained **(Dohan *et al*., 2006a)**.

Three dimensional 3D structure of PRF

During centrifugation procedure, progressive fibrin polymerization occurs by endogenous thrombin that results in 3 dimensional 3D fibrin mesh to which cytokines attach, Fig. (1-4).

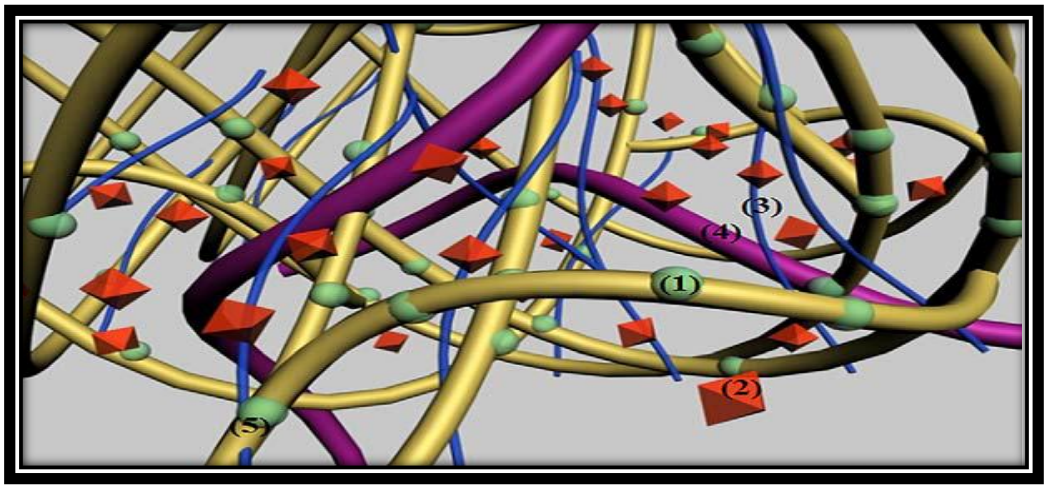


Fig. (1-4): Theoretical computer modeling of a PRF clot. (1) Cytokine intrinsically retained within fibrin fibrillae. (2) Platelet cytokine in solution (extrinsically associated with fibrin polymers). (3) Fibrin-associated glycanic chains. (4) Circulating glycoproteins (fibronectin). (5) Fibrin fibrilla associated with glycanic chains and intrinsic cytokines **(Dohan *et al*., 2006b)**.

The junctions between fibrin febrillae are equilateral that results in flexible fibrin mesh not rigid like cPRP in which the junctions are bilateral. This helps in cytokines entrapment **(Dohan *et al*., 2006b)**.

In **2017 Bai** and his colleagues designed an experimental study on rabbit model using histology and scanning electron microscopy to verify the concentricity of cytokines in PRF gel and how that 3D structure of PRF affect on their distribution and concluded that the distribution of platelets and cytokines depends on compactness of fibrin network which is higher at RBC end that makes incorporation of platelets and thus large molecular weight platelet derived growth factor (PDGF) and vascular endothelial

growth factor (VEGF) are higher in this area therefore this area is called "*essence of PRF*" (ePRF).

Role of fibrin matrix

The 3D structure of fibrin matrix with its enmeshed cytokines support angiogenesis by acting as scaffold. Stem cells are attracted by fibrin mesh and this process is of significant importance for medullary stem cells migration, proliferation, and differentiation to osteoblast cells thus support the restoration of bony defect. Therefore fibrin matrix structure can be considered as the *"key element"* of PRF **(Choukroun *et al*., 2006)**.

Slow release of GF from fibrin network is the singularity of PRF that support healing process of soft and hard tissues healing potential for significant period extends to 1-4 weeks as reported by **Borie *et al*. (2015)**.

Platelet distribution

Dohan *et al.* (2006b) found that histologic section of PRF reveals platelets accumulation near RBC end of the clot and are arranged in lines, Fig. (1-5). This means that PRF clot is composed of three areas: the red thrombus, buffy coat, and fibrin clot which is devoid from any cells. Approximately all platelets from the collected blood sample are trapped in the fibrin mesh **(Zumstein *et al*., 2011)**.

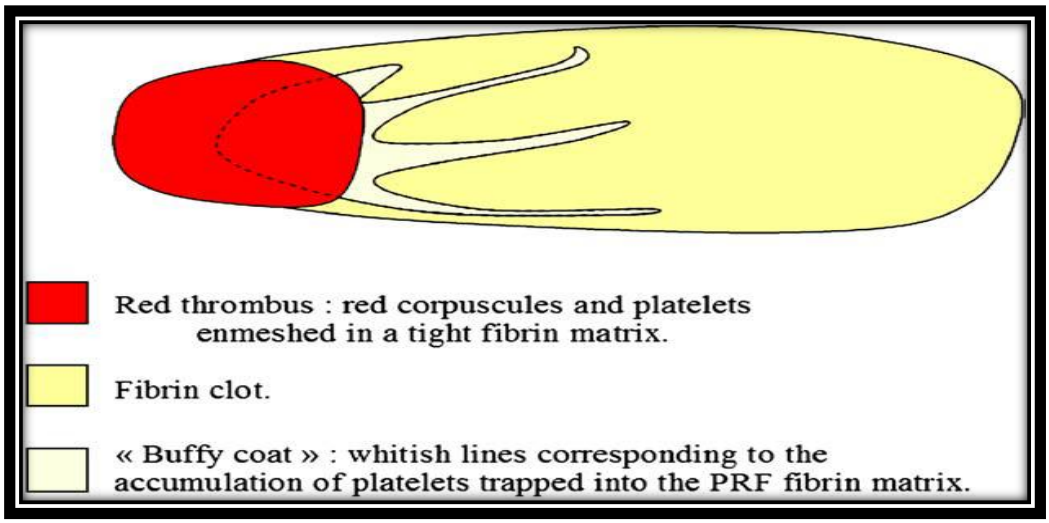


Fig. (1-5): The PRF fibrin clot obtained according to the process protocol is divided into 3 parts: a red thrombus in contact with the red blood corpuscle base, an acellular fibrin gel, and a network of buffy columns corresponding to platelet accumulation **(Dohan *et al.*, 2006b)**.

Role of Leukocyte in PRF

Activated leukocytes secrete main cytokines such as (IL-1β, IL-6, TNF-α, and IL-4). Leukocytes which are concentrated in fibrin matrix in about half of its amount in blood sample have bactericidal effect as well as immune regulatory effect, and secrete a large quantity of VEGF that play significant role in healing especially when the fact that platelets produce the same quantity of angiogenesis inhibitors and stimulators. So it is considered as *"key parameter"*. Leukocytes contribute to the slow release of cytokines as these cytokines are embedded in higher amount in fibrin clot during polymerization and slowly released.

"PRF is not only a platelet concentrate but also an immune node able to stimulate defence mechanisms. It is even likely that the significant inflammatory regulation noted on surgical sites treated with PRF is the outcome of retrocontrol effects from cytokines trapped in the fibrin network and released during the remodeling of this initial matrix" **(Dohan *et al*., 2006c)**.

Growth factors (GF) in PRF

These are polypeptides that have an important role in cells proliferation and survival by stimulating different cell activities such as migration and differentiation. They exert their effects by binding to specific cellular receptors **(Kumar *et al.*, 2017)**. During activation, alpha granules of platelets immediately secrete GF that play a major role in all stages of tissue healing including angiogenesis, chemotaxis, and proliferation, such as transforming growth factors (TGF) β1 and β2, insulin-like growth factor (IGF), VEGF, PDGF, fibroblast growth factor (FGF), glycoprotein **(Tanasković, 2016)**.Their concentrations are affected by mean of activation and they do not affected by platelet concentration **(Vokurka *et al.*, 2016)**. For this reason many authors thought that platelet concentrate is *"cocktail"* of GF **(Zumstein *et al.*, 2011)**.

Su *et al*. (2009) designed an in vitro study to quantify the amount of PDGF-AB, TGF-1, VEGF, epidermal growth factor (EGF), and IGF-1 in fluid released from PRF (PRF releasate) and in the supernatant serum over five hours after clot formation and showed that these growth factors increase constantly during the first hour and continue to increase rapidly during subsequent hours, so immediate use of PRF clot is recommended for optimal benefits.

PRF membrane preparation

The membrane, Fig. (1-6) can be obtained by squeezing PRF clot between two sterile instruments such as cuvette to get benefit from the GF in releasate by mixing it with bone substitute **(Su *et al.*, 2009)**. Another technique is by squeezing the clot between two pieces of sterile surgical gauze with slight pressure **(Dohan Ehrenfest *et al.*, 2009)**.

Fig. (1-6): A Choukroun's PRF membrane **(Dohan Ehrenfest *et al.*, 2009)**.

The PRF box was first introduced by **Dr. Choukroun in 2007** by which collection of PRF releasate can be achieved. The box, Fig. (1-7) contains compression holes to condense PRF clots into cylinders. This device permit releasing of higher concentration of growth factors in the first few hours because it provide equal gentle pressure and keep the membrane soaked in its exudates that is more conservative to membrane **(Toffler *et al*., 2009)**.

The exudate is rich in vetronectine and can be used for the hydration and preservation of the bone graft and surgical wounds **(Tanasković, 2016)**.

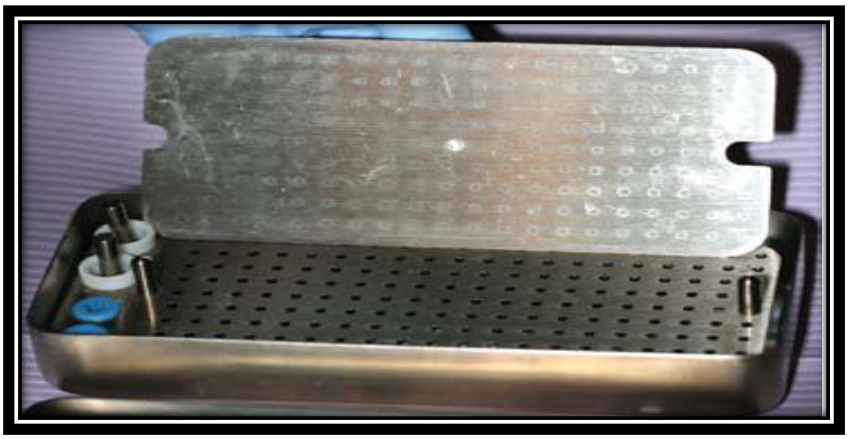


Fig. (1-7): Complete PRF box® set up **(Toffler *et al*., 2009)**.

Kobayashi prepared PRF membrane by using spoon shaped device **(Kobayashi *et al*., 2012)**, Fig. (1-8).

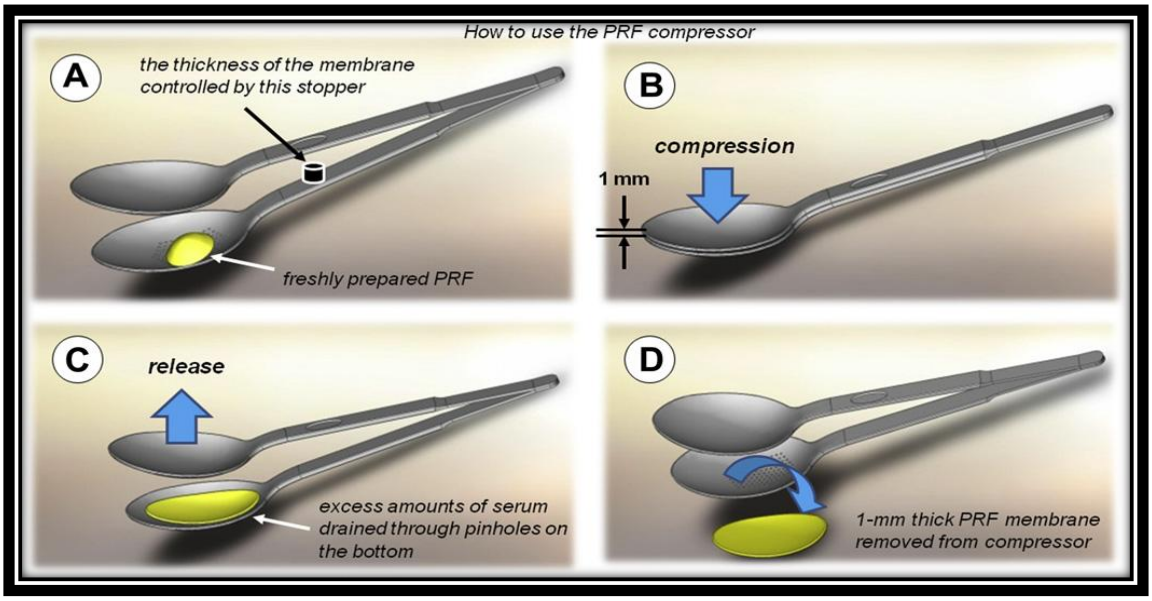


Fig. (1-8): Appearance of the PRF compressor and the protocol for operation. The PRF clot is placed on the lower spoon, which possesses many pinholes (A), and is compressed by pushing the handles together (B). In this step, excess amounts of exudates would be removed. The compression force is then released (C), and the resulting 1-mm thick PRF membrane is removed (D) **(Kobayashi *et al*., 2012)**.

Kawase *et al*. (2015) explained heat compression technique to increase time of membrane biodegradability without affecting biocompatibility.

First compression is done with dry sterile gauze then further compressed with hair straightener for 2-15 seconds at 90 or 120 ˚C to increase fibrin crosslink density thus increasing its stability. This technique preserves PRF membrane for four weeks instead of two weeks or less when using gauze compressing one. This support the use of PRF membrane in guided tissue regeneration.

Agarwal *et al*. (2015) suggested a new technique by using 50 mL syringe connected to 5 mL syringe by three- way stopcock to obtain membrane as well as collect the resultant fluid from clot as shown in Fig. (1-9), (1-10).

Fig. (1-9): Platelet-rich fibrin clot in the 50 syringe ready for squeezing (note the position of the valve of the stopcock, and the third port is open). The 50 mL syringe contains the platelet-rich fibrin membrane that was obtained after squeezing, and 5 mL syringe contains the releasate (note the position of the valve of the stopcock, and the third port is blocked).

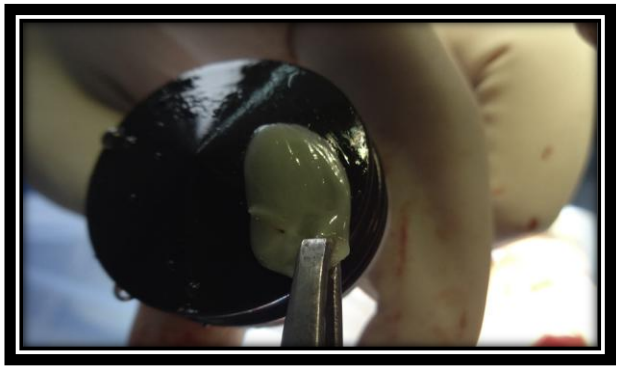


Fig. (1-10): Flat, congealed, platelet-rich fibrin after being squeezed **(Agarwal *et al*., 2015)**.

Clinical applications in oral and maxillofacial surgery

1. Different types of graft materials can be used with PRF. In sinus lift surgeries it is used as sole graft material or mixed with other augmentation materials as reported by many authors in clinical studies with promising results **(Bastami and Khojasteh, 2016)**.

Sohn *et al*. (2008) summarized the benefits of using fibrin rich gel such as PRF in SA as follow: no postoperative infection; decreased morbidity, cross infection, cost; and more bone formation both histologically and radiographically.

2. Socket preservation.

3.Enhancement of bone regeneration in cases of reconstruction of alveolar cleft.

4. Treatment of peri-implant bone defects.

5.Many authors reported the use of PRF for treatment of osteoradionecrosis **(Bastami and Khojasteh, 2016)**.

6. Platelet rich fibrin is reported as resorbable membrane in GBR.

7. Platelet rich fibrin is used to repair SM perforation.

8. During crestal sinus lift PRF membrane provides protection against perforation during elevation of membrane or introducing the graft material through the osteotomy site underneath the membrane.

9. PRF membrane can be adapted to cover the prepared bony window on lateral sinus wall as well to act as barrier prevents the soft tissue invasion.

10. Improves soft tissue healing in mucogingival surgery **(Tanasković; 2016)**.

1.7 Implant success rate

There are several factors increase success and survival of implant placed in augmented sinus including implant length of at least 10 mm and rough

implant surface. Poor RBH and quality, uncontrolled occlusion, poor oral hygiene, smoking habit, estrogen replacement therapy, complications during surgery, and selection of graft material with high absorption rate all have negative impact on implant success rate **(Kao, 2014)**.

In lateral sinus lift procedure, the long term survival for one stage surgery is 72.2-98.4% while for two stage is 77.2-100%. Literatures showed no statistically significant differences between the two approaches **(Kao, 2014)**.

Platelet rich fibrin application improves implant stability during the early healing period owing to faster osseointegration **(Öncü and Alaaddinoðlu, 2013)**. According to a systematic review by **Ali *et al*. (2015)**, the implant survival rate was 100% when PRF used as sole graft material with simultaneous implant placement via lateral approach.

1.8 Postoperative responses to SA surgery

Edema, ecchymosis, Blood spotting from nose, oozing from surgical incision, and nasal congestion are considered among normal responses to sinus lift surgery and can be exist for 3 weeks postoperatively **(Testori *et al*., 2012)**.

Makary *et al*. (2016) Showed that membrane thickness is increased during the inflammatory phase (i.e. 3-7 days) after sinus lift surgery and this thickening is directly proportional to amount of membrane reflection, with greatest thickening at the third month due to altered mucociliary clearance, then membrane thickness returns to preoperative thickness after six months, and reduction to less than preoperative measure after one year.

1.9 Sinus lift complications

1.9.1 Intraoperative complications

These complications may be patient related (thick lateral maxillary wall, thin schneiderian membrane, or septa) or surgeon related (inadequate pre-operative assessment, or iatrogenic). Preoperative evaluation of patient's medical and dental history and assessment of sinus both clinically and radiographically are essential to prevent any anticipated complications **(Kao, 2014)**.

1.9.1.1 Schneiderian membrane perforation

Among the most common complications, occurs in about 19.5-41% of lateral sinus lift procedures and can intervene during antrostomy preparation, rotating the bony window, membrane elevation, placement of graft material, and implant placement **(Kao, 2014; Fugazzotto *et al*., 2015)**.

Predisposing factors

There are many predisposing factors for membrane perforation including septa, previous sinus surgery, excessive graft material, thin membrane, antral pathology, irregular sinus floor, decreased sub-antral bone height, and reduced angle between lateral and palatal sinus wall (<30˚) **(Meleo *et al*., 2012; Nolan *et al*., 2014)**. Thick membrane elevation is safer during surgery this is the case in smokers for example **(Alessandro Geminiani, 2015)**.

Perforation classification

Fugazzotto *et al*. (2015) classified perforation according to site into: class I occur at apical area of osteotomy window; class II located at crestal, mesial, or distal area of osteotomy window and further subdivided into class II A, B depending on their position in relation to sinus wall (class II A if 4-5 mm available space away from sinus wall and class II B when perforation at the end of osteotomy window and no available space remain to reach sinus wall); and class III perforation located at any area within the centre of prepared osteotomy, Fig. (1-11).

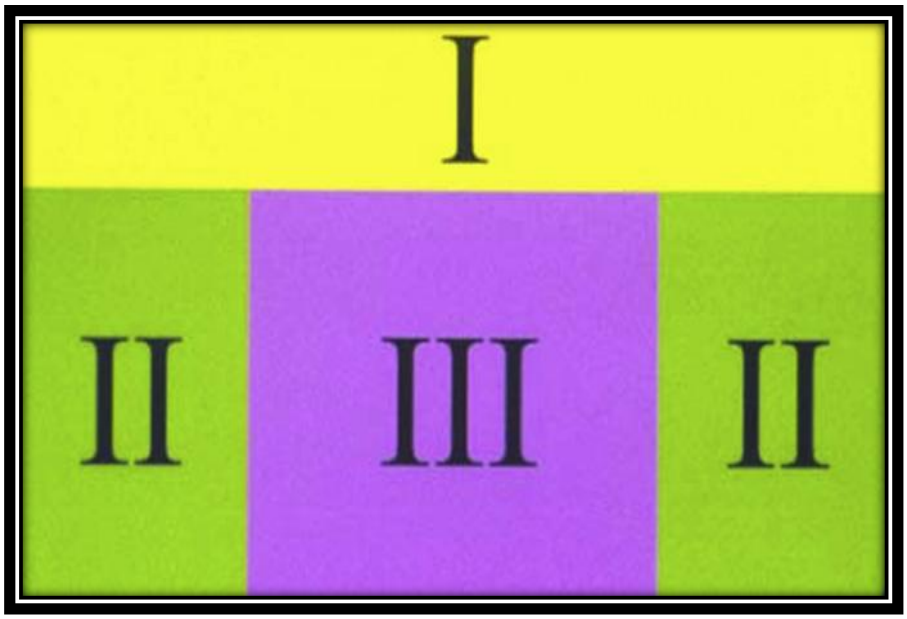


Fig. (1-11): Sinus perforation locations **(Fugazzotto *et al*., 2015)**.

Effects of schneiderian membrane perforation

Membrane integrity is important for normal physiology of sinus. Perforation can lead to leakage of graft material into sinus with subsequent graft and sinus infection, decreased bone formation, and even implants failure **(Sakkas *et al*., 2016)**.

Management of schneiderian membrane perforation

Various techniques are available; the selection of the suitable measure depends on location, size, and available barrier membrane that proposed to be used. Stabilizing the repaired membrane to prevent its shifting toward sinus cavity during grafting is of significant importance during repair, so failure to stabilize membrane necessitate postponing the graft material placement for 2-4 months **(Froum, 2015)**.

1. Collagen membrane application: **Froum (2015)** reported (according to **Testori** paper that small perforation (<5 mm) does not need any repair as it will be sealed during membrane elevation by folding of membrane on itself or occluded by small blood clot even though resorbable membrane can be used, while (5-10 mm) perforation is repaired by more rigid material that is not changed in shape after wetting to ensure stabilization of repaired membrane. In case of larger perforation (>10 mm) additional fixation to outer border of osteotomy window is needed in order to get stable covering membrane.

A clinical study in California was performed at Loma Linda university in 2003 to manage membrane perforation by using collagen membrane but in not only to cover the perforation but to isolate graft material as well as lateral window *(Loma Linda pouch technique)* keeping the graft material well in its place **(Proussaefs and Lozada, 2003)**.

Loma Linda pouch technique results in complete isolation from blood supply that interferes with integration of graft material so a modification was done by fixing the resorbable membrane at superior border of lateral window by titanium or surgical tacks and then bending membrane inside sinus to cover the perforation, then graft material is introduced to fill the created space, a second resorbable membrane is used to cover the lateral window **(Meleo *et al*., 2012)**.

Abdussamad *et al*. (2015) in experimental randomized clinical trial used chitosan; a natural biopolymer was isolated from shrimp shells, as a membrane to cover perforation. It is biocompatible, biodegradable, and antimicrobial material.

2. Surgicel: it is used as haemostatic agent in oral and maxillofacial surgery; however it was used as an alternative to resorbable collagen membrane in management of SM tear during SA procedures. Surgicel gauze was cut to the desired size and applied over the perforation in one or two layers **(Stajcic and Stojkovic, 2008)**.

3. Suturing: perforation repair by using resorbable suture is reported by **Robiony *et al*. (2012)**. Two holes in bony border are prepared through which suturing can be performed using 4/0 Vicryl suture, then a resorbable collagen membrane was applied and continue to augment the sinus, Fig. (1-12).

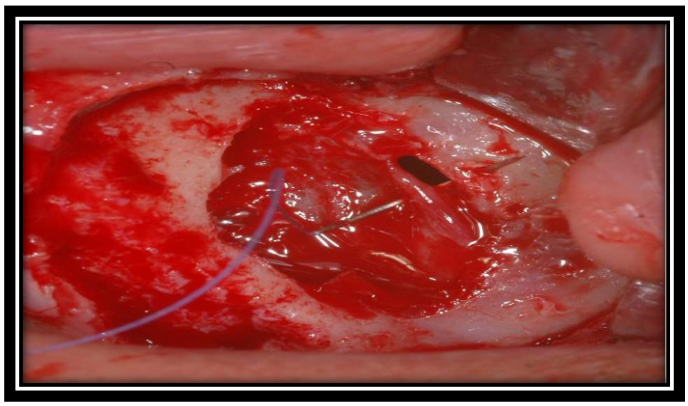


Fig. (1-12): Intraoperative view, suturing the perforated membrane through holes **(Robiony *et al*., 2012).**

4. Platelet rich fibrin (PRF) membrane: Huang *et al.* (2016) reported management of SM perforation in diabetic patient during sinus lift procedure through lateral approach by using PRF membrane and then continued to graft the membrane cavity space with synthetic bone graft

and simultaneous implant placement, healing period was uneventful, follow up with CBCT revealed stable peri-implant bone after one year.

1.9.1.2 Intraoperative bleeding

Bleeding may occur during preparation of osteotomy window due to injury to AAA and it is generally controllable and not life threatening. The incidence of injury is increased when diameter of AAA >0.5 mm **(Valente *et al.*, 2015)**.

Sequelae of bleeding

Damage to AAA may associate with local bone necrosis. It can be a causative factor for perforation as it interferes with visibility of surgeon especially when bleeding vessel >2 mm in diameter. Bleeding may lead to hematoma and infection; also it may dislodge graft material due to "washing effect" of bleeding in addition to compromised vascularization to graft material **(Rosano *et al*., 2011)**.

Bleeding may be caused by posterior lateral nasal artery during membrane elevation from medial wall **(Froum, 2015)**.

Management:

1. Direct firm pressure on the bleeding point for several minutes is sufficient in some cases.
2. Bone wax.
3. Crushing the bony canal of the artery.
4. Cauterization with caution to avoid any damage to the membrane.
5. Ligation **(Froum, 2015)**.
6. Cauterization by handpiece and diamond bur without water irrigation **(Resnik and Misch, 2017)**.

1.9.1.3 Other intraoperative complications

A. Infraorbital nerve injury may result from flap retraction during surgery.

B. Traumatic flap injury.

C. Graft material or implant displacement into sinus.

D. Graft material contamination.

E. Injury to blood vessels of adjacent teeth.

F.Imperfect schneiderian membrane elevation that results in new compartment with impaired drainage and subsequent infection **(Kao, 2014)**.

1.9.2 Postoperative complications

Early postoperative complications usually happen within 21 days following surgery while late complications set in more than 3 weeks postoperatively **(Testori *et al*., 2012)**.

1.9.2.1 Graft infection

It is the most common complication after sinus lift procedure, the incidence is 2-5% and symptoms of graft infection can appear soon after two weeks or after months **(Froum, 2015)** which include: pain, swelling, purulent discharge from surgical wound, and dehiscence. Graft infection can be due to odontogenic pathology, contamination of graft from saliva or contaminated instrument, or chronic sinus disease. Radiographically infected graft appears as *"black hole"* surrounded by radio-opacity **(Froum, 2015)**.

Treatment

According to consensus by experts (periodontists, implantologists, maxillofacial surgeons, ENT, and microbiology specialists) the treatment

depends on duration and severity of symptom as well as location of infected graft in relation to sinus membrane. The consensus suggested that pharmacological treatment can be sufficient in case of slight exudates and graft settles in membrane cavity space, while surgical debridement can be added if more severe and extended symptoms (more than 3 weeks) intervene. Functional endoscopic sinus surgery (FESS) may be necessary to remove the infected graft material that is scattered into the sinus cavity proper **(Testori *et al*., 2012)**.

Chiapasco *et al*. (2013) advocated that intra oral approach (Caldwell-Luc approach) is indicated to "toilette" the sinus, to remove the migrated implant and close the oroantral fistula (if present) but may be insufficient to examine the obstructed ostium as well as to get access to other infected sinus in cases of pan sinusitis that may occur as a sequel for maxillary sinus infection, all these obstacles make FESS is a good option to consider in conjunction with intraoral approach despite its limited ability to reach every part of maxillary sinus.

1.9.2.2 Sinusitis

Its incidence is about 3-20 %, postoperative sinus infection is mainly due to either preexisting sinus pathology that exacerbated by sinus lift surgery or subsequent sinus contamination from odontogenic infection or oral cavity bacteria through a perforation. Acute sinusitis results from blockage of osteomeatal complex that is the consequence of inflammatory membrane thickening, excessive elevation of membrane during lifting, antral bleeding, or dislodgment of graft particles through perforation into the ostium **(Kfir *et al*., 2014; Froum, 2015)**.

Treatment

Antibiotic, anti-inflammatory drug and nasal decongestant are prescribed depending on severity of symptoms. Ostium blockage that impairs sinus drainage needs surgical intervention **(Froum, 2015)**.

1.9.2.3 Other postoperative complications

A. Wound dehiscence.

B. Paresthesia.

C. Flap necrosis.

D. Oroantral fistula.

E. Cyst formation.

F. Osteomyelitis.

G. Cavernous sinus thrombosis and orbital cellulitis.

H. Insufficient new formed bone for implant placement.

I. Migration of dental implant into the sinus graft or into the sinus cavity.

J. Failure of dental implants.

K. Escapement of graft material into sinus cavity space via perforation or outside the lateral osteotomy window **(Kao, 2014; Froum, 2015)**.

Chapter Two

Materials and Methods

2.1 Study sample

This study was conducted from October 2016 to September 2017 at the Department of Oral and Maxillofacial Surgery, College of Dentistry, University of Baghdad, and Radiology Department of Al-Sadr Specialized Health Center.

The selected sample involved patients with single or multiple missing tooth/teeth in the sinus area of atrophic maxilla in which the RBH was 3-6 mm for one-stage surgery (SA with simultaneous implant placement) and <3 mm for two-stage surgery (SA only and delayed implant placement) for both follow up was decided to be 24 weeks. A total of 16 patients aged 29-65 years, 10 males and 6 females who met the inclusion criteria were included in this study. Seventeen implants were placed simultaneously in 14 sinus lift procedures for 12 patients. Five cases (sinuses) underwent sinus augmentation only with delayed implant placement protocol for 4 patients. Three patients were treated bilaterally. All the cases underwent lateral sinus lift procedures in which PRF was used as the sole graft material, table (2-1).

Table (2-1): Study sample.

16 patients (19 sinuses)	
One-stage surgery	Two-stage surgery
***** RBH 3-6 mm. ***** 17 implants placed in 14 cases (sinuses) for 12 patients.	***** RBH < 3 mm. ***** 5 cases (sinuses) for 4 patients.

2.1.1 Inclusion criteria

1. Patients presented with partially or completely edentulous maxilla with sinus pneumatization seeking for dental implant placement.
2. Sinus augmentation with simultaneous implant placement were performed in cases of subantral bone height 3-6 mm while delayed implant placement in cases of subantral bone height <3 mm.

2.1.2 Exclusion criteria

1. Local pathology or systemic diseases that compromise bone healing potential as radiotherapy, fibrous dysplasia, hyperparathyroidism, uncontrolled diabetes, etc…..
2. Clinical or radiographical features of rhinosinusitis and acute/chronic infection in the implant zone.
3. Parafunctional habits such as severe bruxism and clenching.
4. Alveolar ridge width <6 mm.
5. Previous sinus surgery.
6. Patients with recent history of radio or chemotherapy, or those receive bisphosphonates and other related drugs.

2.2 Armamentariums and medications

1. Surgical set

The main constituents are 1.mirror,2.toothed tissue forceps,3.tweezers, 4. probe ,5. scalpel, 6.molt periosteal elevator, 7.surgical currete,8.needle holder,9. iris scissors, ,10.3/0 silk suture,11.blade No.15, 12.handpiece with surgical burs, 13.Kilner double ended retractor, 14. dental syringe, 15.sucktion tip, and 16. kidney dish with surgical gauze, Fig. (2-1).

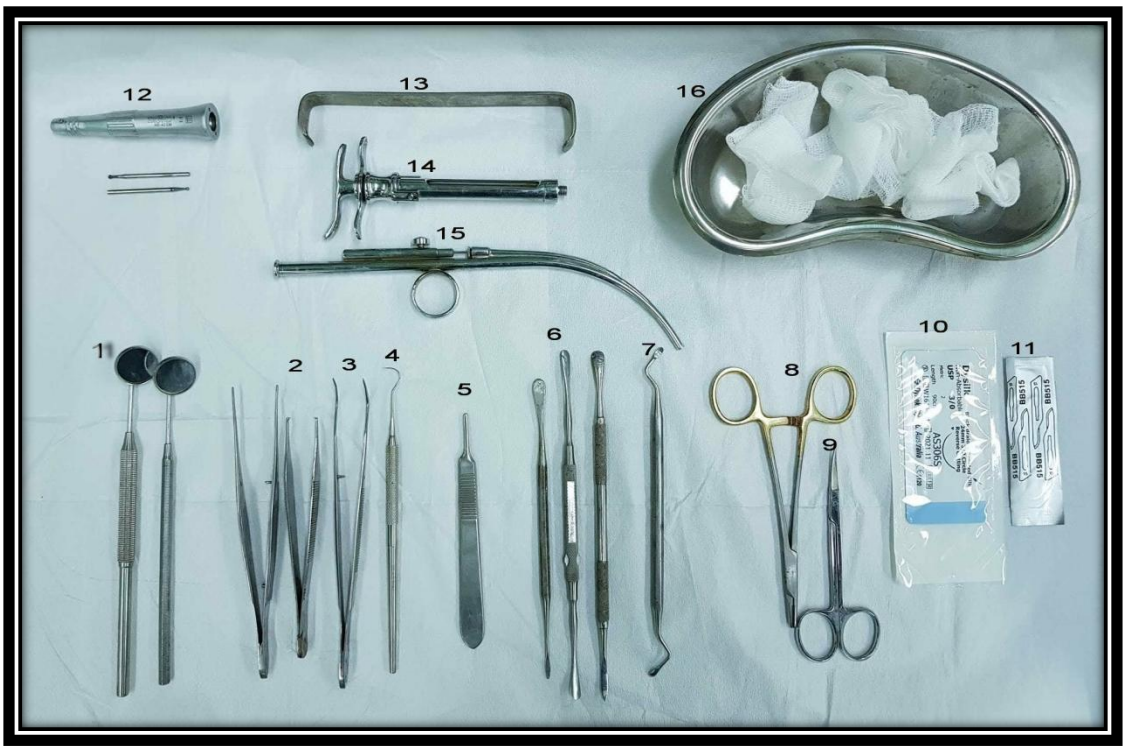


Fig. (2-1): The surgical set.

2. Dental implant (DI) micromotor engine

Dental implant engine (Dentium, Korea) set at 600-800 rpm and tourque equals to 35 N/cm coupled with external irrigation system, Fig. (2-2).

Fig. (2-2): Dental implant engine (Dentium Co., Korea) with settings operated on.

3. Implant surgical kit and DI

One system of DI system with S.L.A. surface (Implantium & Superline, Dentium Co., Korea) was used in this study, Fig. (2-3).

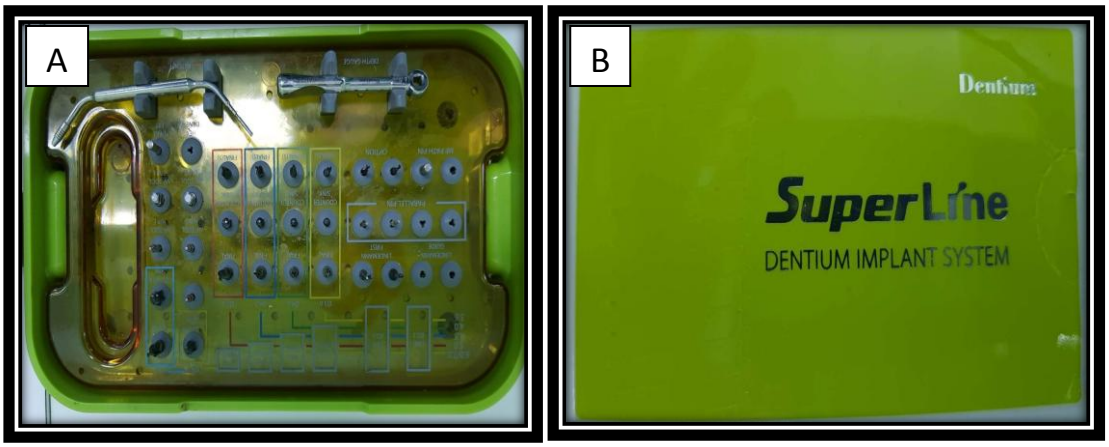


Fig. (2-3): (A) Implant surgical kit (Dentium Co., Korea). (B) DI in its package.

4. Tissue punch and healing abutments

Motorized tissue punch (Dentium, Korea, 4 mm diameter) at speed 300 rpm mounted in DI micromotor engine handpiece for fixtures uncovering at second stage surgery, Fig.(2-4). Healing abutments size 4.5, 5.5, 6.5 mm were utilized at this stage (Dentium Co., Korea), Fig. (2-5).

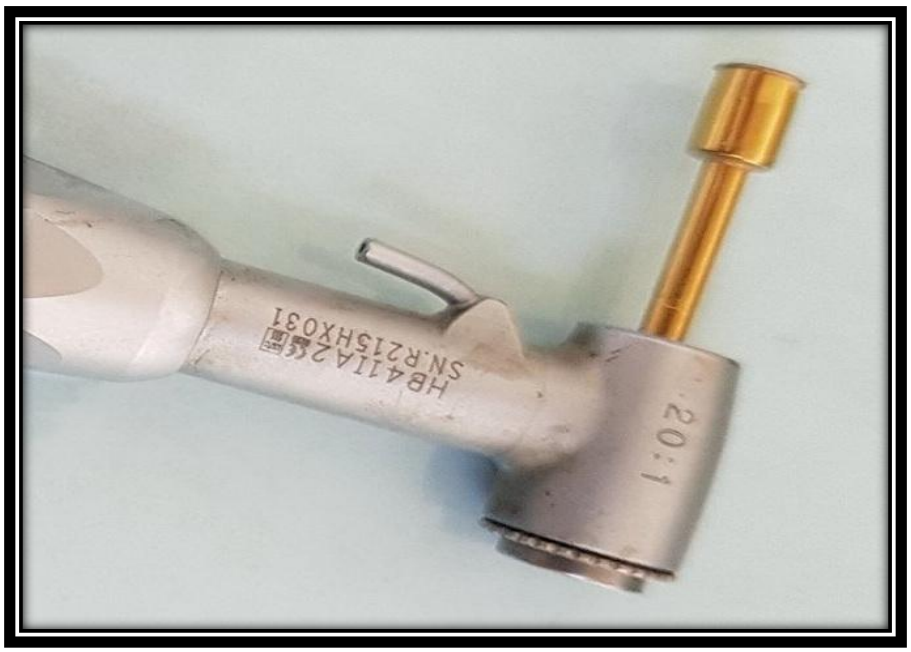


Fig. (2-4): Motorized tissue punch (Dentium Co., Korea).

Fig. (2-5): Healing abutments 4.5 mm in diameter for anterior area and 5.5, 6.5 mm for posterior area (Dentium Co., Korea).

5. Sliding caliper

Sliding caliper (Medident, Australia) is a measurment tool calibrated in mm (0-95). It is used to measure distance between implants, mesiodistal distance between teeth, and inter-arch distance, Fig. (2-6).

Fig. (2-6): Sliding caliper (Medident Co., Australia).

6. Autoclave

It was used for sterilization of instruments and gauze (Melag, Germany) employing universal program settings (134 °C, 30 psi for 15 minutes), Fig. (2-7).

Fig. (2-7): Autoclave (Melag,Germany).

7. CBCT device

Cone beam 3D system with effective dose 92 µSv (Carestream Health Inc., USA) set at 90 kV, 10 mA, 9 seconds and 300 mm voxel size, Fig. (2-8).

Fig.(2-8): Kodac 9500 cone beam 3D system with effective dose 92 µSv (Carestream Health Inc., USA).

8. Sinus lift kit

This kit from (Friadent GmbH, Mannheim/Germany) was used for SM elevation and its instruments provides different angulations for easier adaptation during membrane reflection, Fig. (2-9).

Fig (2-9): Sinus lift kit.

9. Surgical handpiece and burs

Surgical high speed straight handpiece (W&H Trend HD-43 EM/ Austria) at speed (410.000 rpm) and burs No. 4, 6, 8 carbide and diamond round burs, Fig. (2-10).

Fig (2-10): Surgical handpiece (W&H Trend HD-43 EM/ Austria) and No. 4, 6, 8 carbide and diamond round burs.

10. Blood collection set

Ten mL glass plain vacutainer blood collection tubes were used (AFCO/Jordan), BD Vacutainer® 23G, (Becton, Dickinson and Company Franklin Lakes, NJ 07417 USA), plastic holder,and tourniquet, Fig.(2-11).

Fig. (2-11): Blood collection set.

11. Centrifuge

For PRF preparation, laboratory electronic centrifuge 80-1 was used (Xiangtian/Jiangsu China) with maximum speed 4000 rpm and timer range between 0-120 min, Fig. (2-12).

Fig. (2-12): Laboratory electronic centrifuge 80-1 (Xiangtian/Jiangsu China).

Medications

1. Topical spray anasthesia (Lidocaine 10%).
2. Lidocaine hydrochloride 2% with adrenaline 1:80,000 in 2.2 mL glass cartridge (Septodont, France).
3. Cefixime trihydrate, 400 mg tab.
4. Metronidazole, 250 mg tab.
5. Acetaminophen, 500 mg tab.
6. Phenylephrine, 0.5% (decongestant nasal drops).
7. Chlorhexidine digluconate 0.2% mouth wash.
8. Povidone iodine 10% skin disinfectant, pure medical alcohol 96%, and normal saline (sodium chloride 0.9%).

2.3 Methodology

2.3.1 Study design

This was a prospective interventional non-controlled clinical study. The steps are summariezed in the following algorithm, Fig. (2-13).

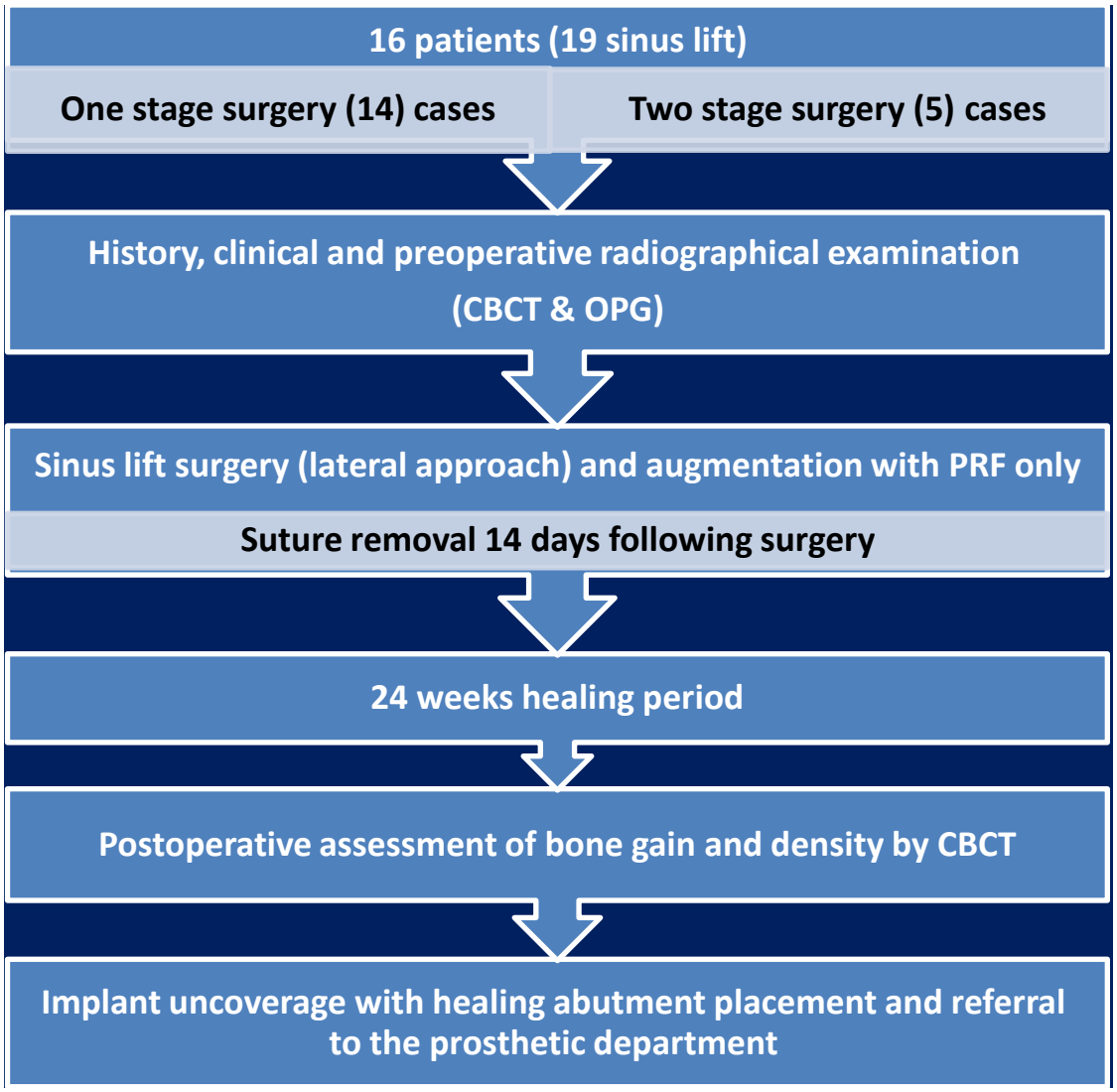


Fig. (2-13): Sequential flow chart.

2.3.2 Preoperative assessment

2.3.2.1. History

A detailed medical, dental and family history was obtained from patients regarding any systemic diseases that influence bone healing. History of previous surgery and/or radiotherapy, and history of trauma that results in permanent damage to sinus function was obtained also.

2.3.2.2 Clinical examination

Extraoral

It included facial symmetry, muscle strength, facial profile, lip support, regional lymph nodes, and smile line.

Intraoral

Mouth opening, ridge morphology and periodontal biotype, oral hygiene, occlusion and parafunctional habits.

Space analysis for proposed implant site was performed in which ridge width was measured by blunt osteometer (bone caliper), intercoronal (mesiodistal distance), height between alveolar ridge and opposing teeth or ridge (interarch distance) using sliding caliper.

2.3.2.3 Radiographical examination

For each patient, preoperative OPG was taken for initial assessment and CBCT for assessment of bone height, width, and density of implant site, tooth proximity to implant site, septa, membrane thickness, antral pathology, ostium patency, SP, lateral wall thickness, and intraosseous AAA, Fig. (2-14), (2-15), (2-16), (2-17).

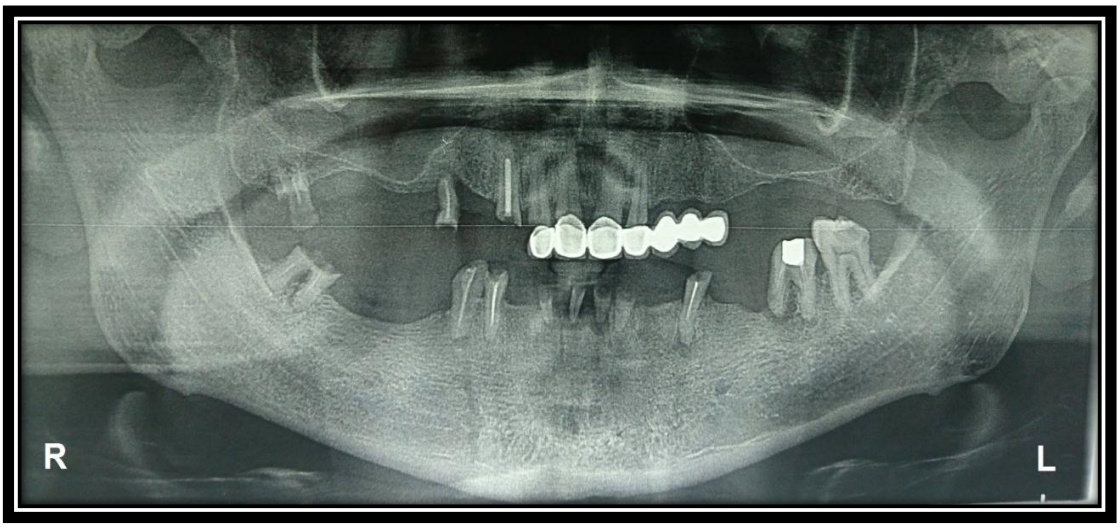


Fig. (2-14): Preoperative OPG view showing borders of MS and height of residual alveolar ridge .

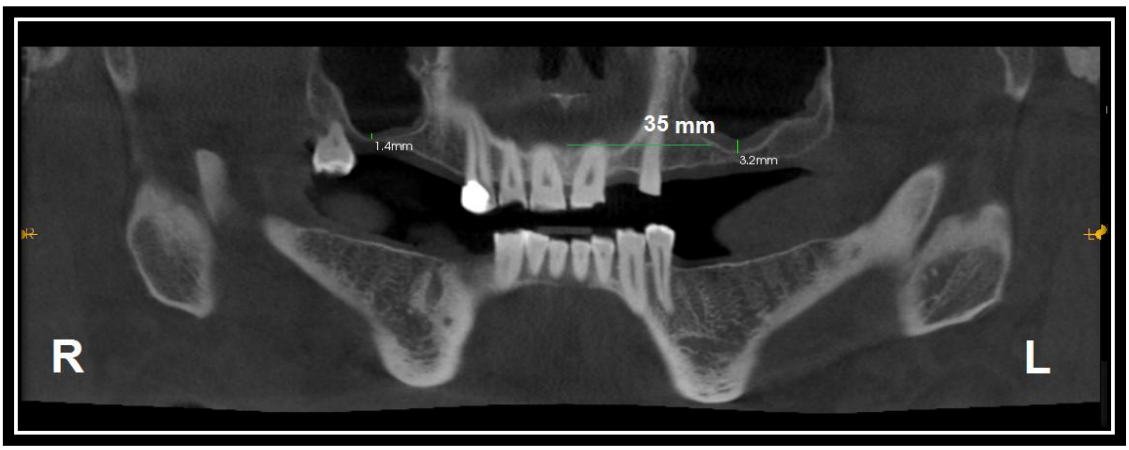


Fig. (2-15): Panoramic layout of CBCT interpretates SP of the left sinus and SM thickness.

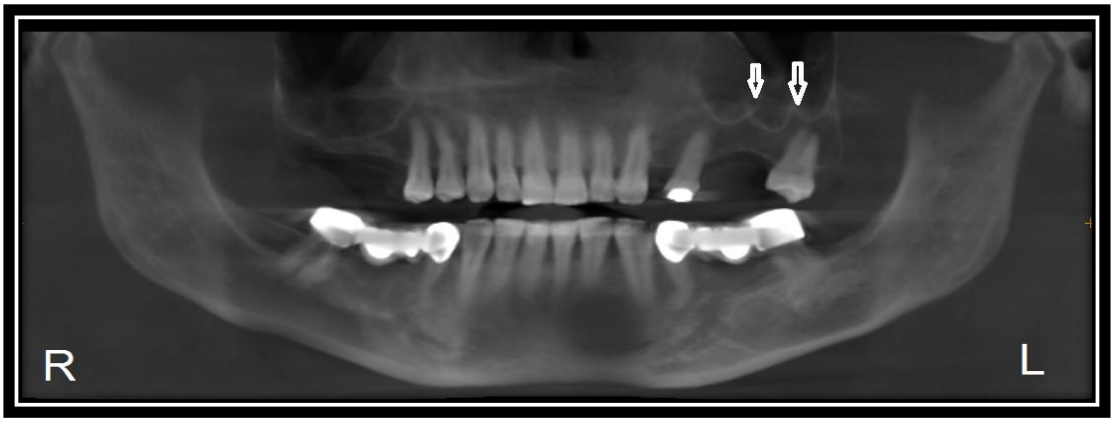


Fig. (2-16): Panoramic layout of CBCT interpretates sinus septa of left sinus.

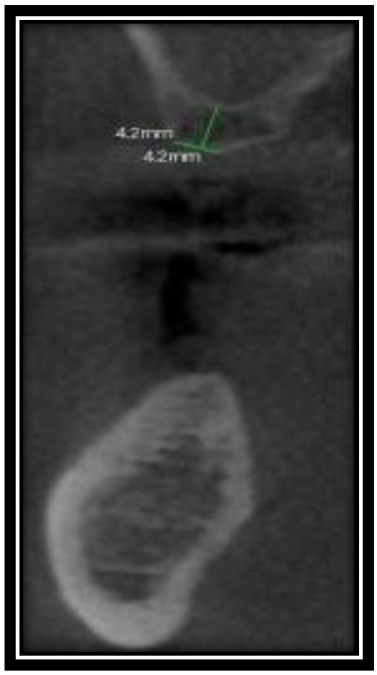


Fig. (2-17): Coronal view of CBCT illustrating height and width of residual alveolar bone.

2.4 Patient's preparation

The patients were informed about the surgical procedure and possible complications, they signed a written consent (appendex I), the preparation included: gargling with chlorhexidine, scrubbing perioral area with povidone iodine, and draping with sterile dispossable surgical drapes, head caps, and wearing protective eyeglass.

2.5 Surgical procedure

Topical spray anaesthesia lidocaine 10% was applied on the surgical field to reduce pain sensation during injection. Anaethesia to the surgical site was obtained by giving infiltration anaesthesia lidocaine 2% to posterior, middle, anterior superior alveolar nerves buccally about one tooth anterior and posterior to planned surgical field, and to the greater palatine nerve palatally, then giving infraorbital nerve block injection. The flap began with vertical releasing incision anterioly (its location depends on number of implants to be placed) then proceed with the crestal incision that was made with slight palatal bias extending to the area of maxillary tubrosity if the ridge is completely edentulous, then the second vertical releasing incision was made posteriorly. Reflection of full thickness mucoperiosteal three sided flap with care by molt periosteal elevator, the reflection shoud permit full visualization to the surgical field, initial slight palatal reflection was also done to facilitate subsequent suturing, at this step; the border of maxillary sinus can be visualized as a bulge on the lateral side of maxilla, Fig. (2-18).

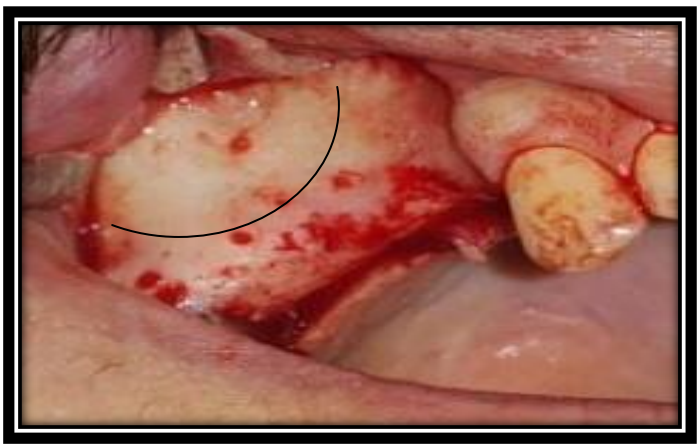


Fig. (2-18): Flap reflection, the MS boundary is clear.

First point of drilling to start the preparation of lateral osteotomy window was located at 3 mm from anterior and inferior border of the sinus wall, and could be adequately determined with the aid of CBCT. Drilling was in soft, intermitent, and sweeping motion with copious irrigation using round diamond bur attached to handpiece. Drilling was continued posteriorly according to edentulous area and amount of required augmentation. Then again from the starting point, the drilling upward continued to a point that not exceed (if possible, depending on RBH) 16 mm from the alveolar ridge. Then the osteotomy preparation was continued to obtain the rectangular or oval shape window. With contineous deepening of drilling the bluish hue of sinus membrane could be visible, Fig. (2-19).

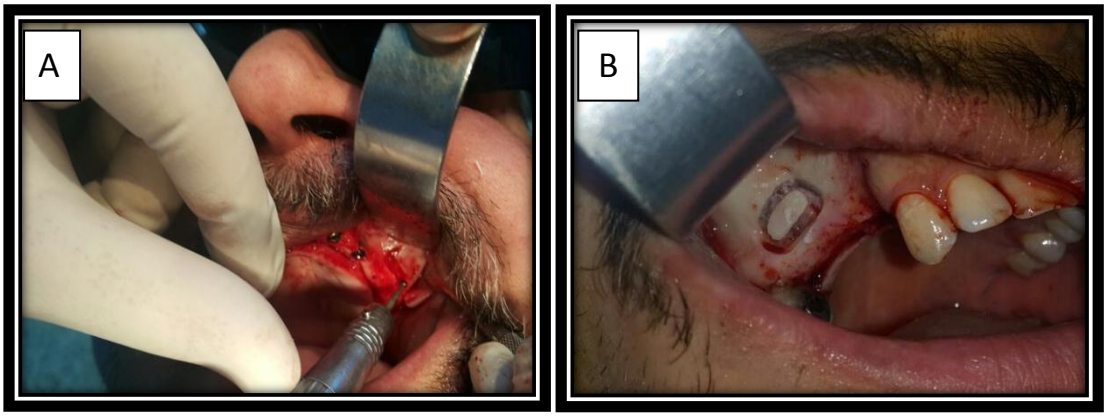


Fig. (2-19): (A) Osteotomy window praparation. (B) *Schneiderian membrane* is clearly visible following complete drilling procedure.

At this point checking the complete detachment of all borders of the window by slight and very gentle pressure on the bony island using the handle of a mirror, here slight movement should indicate adequate release and that no residual bone attachment remained.

Appropriate sinus membrane elevator from the kit was used to start separation of membrane from floor of sinus for only a few millimetres then mesial, distal, and apical seperation of membrane, then went back to the floor and complete elevation of sinus membrane according to amount of needed augmentation. This is associated with gradual upward inward elevation of the bony island of window toward the medial sinus wall, Fig. (2-20).

Fig. (2-20): *Schneiderian membrane* elevation.

Checking of SM integrity was done at this stage by asking the patient to take deep breath and watching the upward and downward movement of the membrane with the attached bony island, Fig. (2-21).

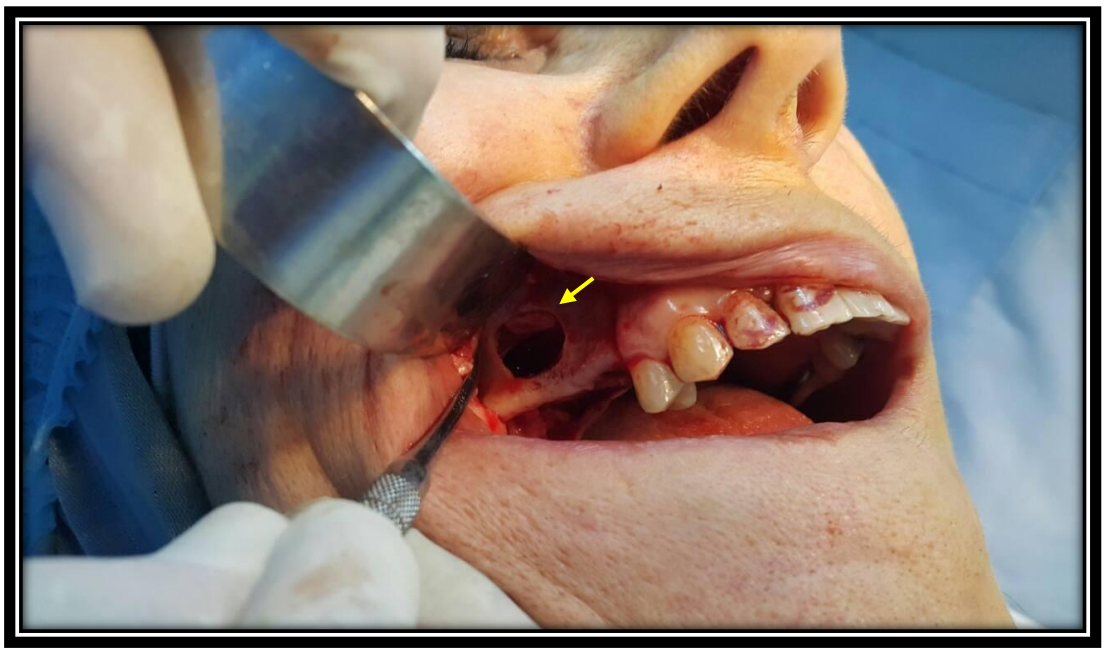


Fig. (2-21): The elevated SM with bony island when taking deep inspiration.

The second part of operation was the preparation of implant osteotomy sites. Beginning with pilot drill to start preparation of the osteotomy then paralleling pin was used to check parallelism with the adjacent implant beds or teeth, then subsequent drillng with gradually increasing size drills untill reaching the desired implant size but not to the full length of drill and without countersink in an attempt to attain good stability of the implant, Fig. (2-22).

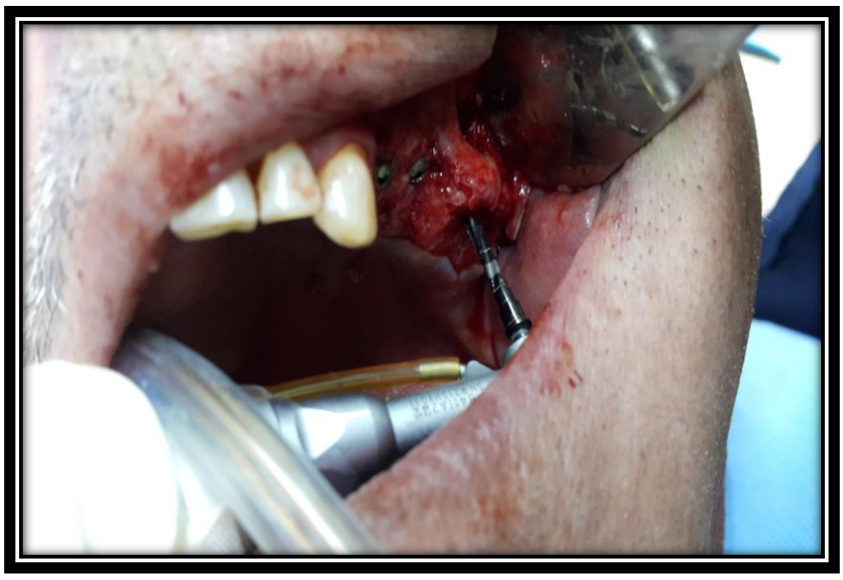


Fig. (2-22): Implant osteotomy site preparation.

Platelet rich fibrin preparation:

During surgery, after skin rubbing with alcohol, tourniquet was applied on the arm, and 20 mL whole blood was collected from one of the superficial veins in cubital fossa (cephalic, basilic, median cubital, and median antebrachial veins), Fig. (2-23) **(Lee *et al*., 2015)** into two plain glass tubes and was immediately centrifuged at 3000 rpm for 10 minutes according to (Process, Nice, France) **(Dohan *et al*., 2006a)**, Fig. (2-24).

Fig. (2-23): Blood collection with BD Vacutainer® 23G.

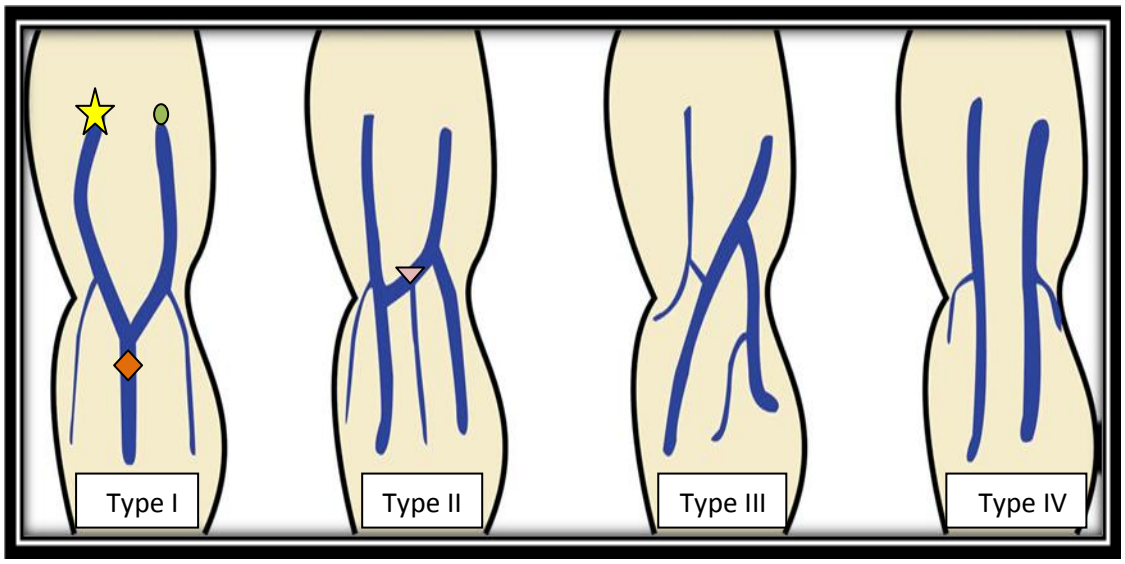


Fig. (2-24): Running patterns of superficial veins in right cubital fossa. The patterns were classified into four types: ☆CV, cephalic vein; ○ BV, basilic vein; ▽MCV, median cubital vein;◇ MABV, median antebrachial vein **(Lee *et al*., 2015)**.

PRF clot was pulled from the tube and separated from the blood clot by milking action with tweezers and placed on a wet gauze (with few drops of normal saline 0.9%), Fig. (2-25).

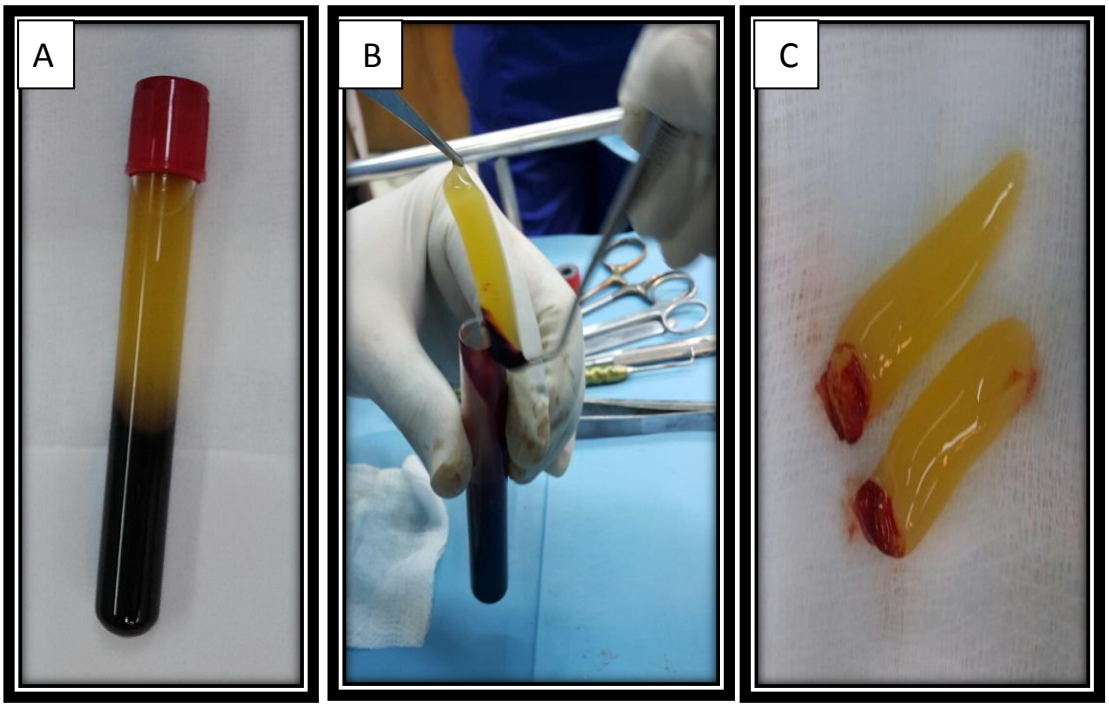


Fig. (2-25): (A) PRF in the tube after centrifugation. (B) PRF is pulled from the tube and seperated from RBC part. (C) PRF clots placed on a wet gauze.

One and a half of PRF clots were taken and gently introduced into the the created artificial space (sinus membrane space), Fig. (2-26).

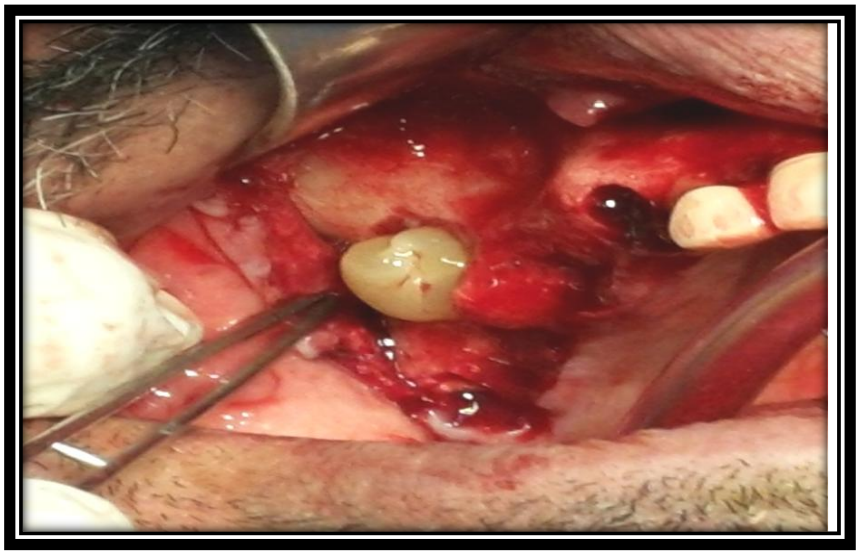


Fig. (2-26): Sinus augmentation with PRF clot.

The implant is placed in its prepared site to serve as a tentpeg and during its tightening, PRF clot elevatation with the bony island is accomplished to be the new sinus floor level, Fig. (2-27).

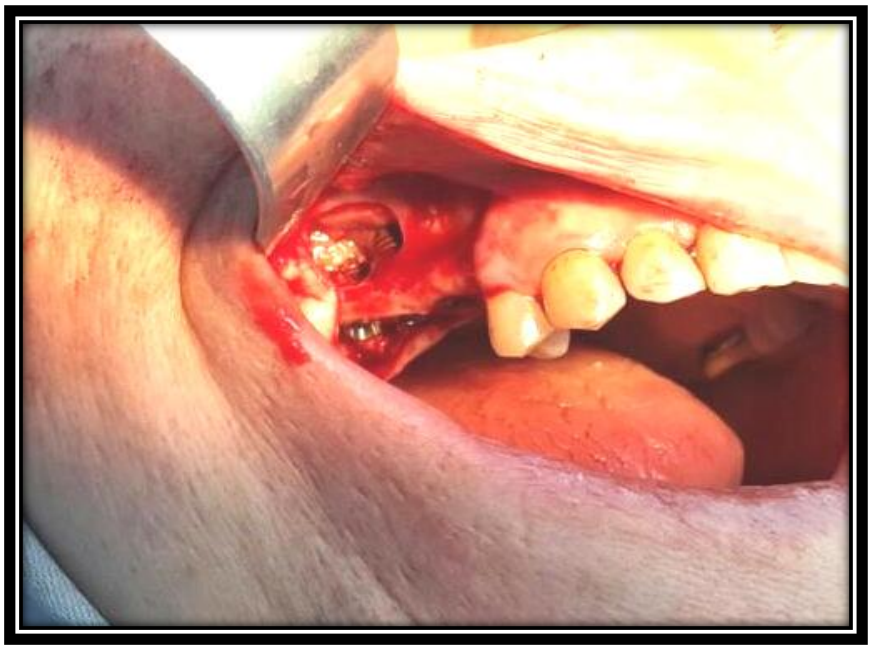


Fig (2-27): Implant placement below the prepared bony island and PRF clot.

Half of one of PRF clot was then compressed slightly between two pieces of wet sterile gauze to be used as a membrane covering the lateral window, Fig. (2-28).

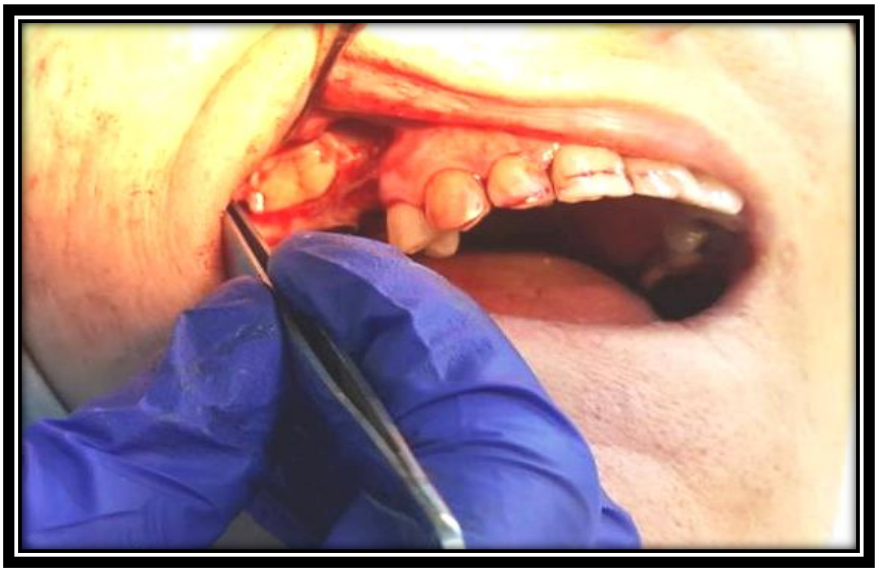


Fig. (2-28): Lateral osteotomy window with PRF membrane coverage.

The flap was adapted to its position and wound closure is performed with simple interrupted suturing with black silk 3/0 suture, Fig. (2-29).

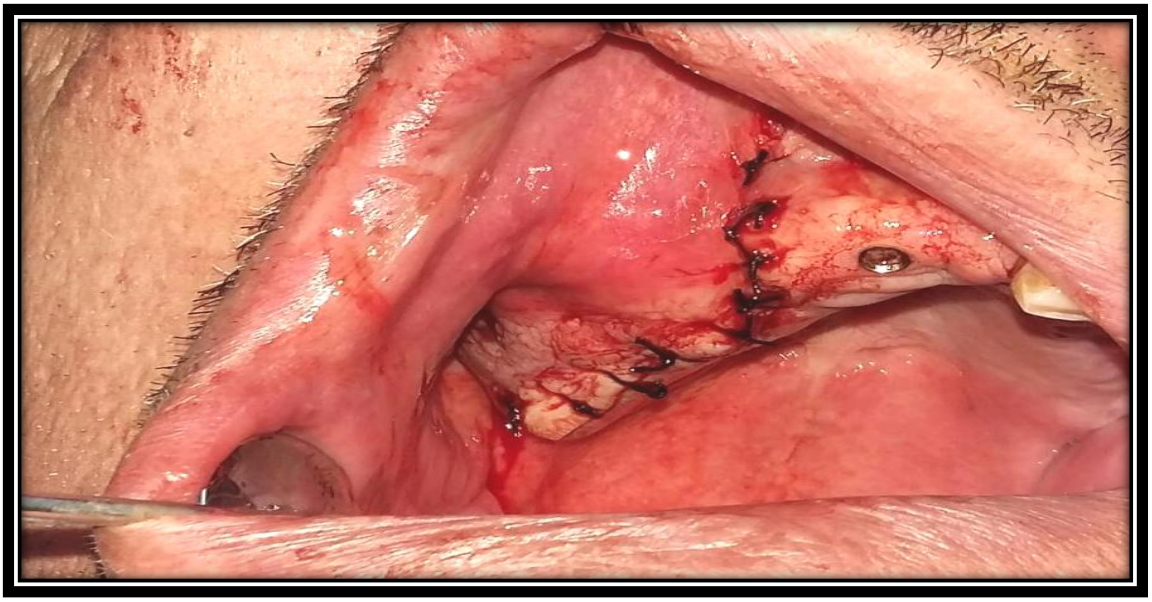


Fig. (2-29): Wound closure.

2.6 Instructions and postoperative care

1. Keeping a piece of gauze on the surgical site for 30 min.
2. Application of cold pack on face at operated side to reduce swelling (15 min on, 15 min off) during the first 12 hours after surgery.
3. The patients were instructed that on the day of surgery, no mouth rinse. and the next day to rinse mouth for 30 seconds with chlorhexidine mouth wash 0.2% after breakfast and at bedtime for 14 days, and during the day rinse gently with warm salt water (1/2 teaspoon of salt dissolved in 1 cup of warm water) three times a day .
4. Teeth brushing should begin the next day (gently near surgical site) to avoid plaque accomulation on teeth and sutures that interferes with normal healing as it will be a source of infection.
5. The patients were instructed to keep on soft diet during the day of operation, and avoid any hard or sticky diet for 2 weeks.

6. The patients were informed not to blow or sneeze hard, not to use straw,avoid forceful spitting for 2 weeks and stop smoking 8 weeks after surgery.

7. Avoid provisionalization, partial or complete denture should not be worn for 2 weeks, then after relief of denture base, patient can wear it for esthetic pupose only (non-functional).

8. Ask the patients to return back for suture removal after 14 days.

2.7 Study protocol

1. All patients were informed about the surgical procedure, possible complications and had signed a written consent prior to surgery.

2. Preoperative OPG, pre and 24 weeks postoperative CBCT were taken by the same device and same exposure parameter.

3. All procedures were done by the same surgeon in strict aseptic protocol.

4. All patients received infraorbital, greater palatine and superior alveolar (posterior, middle, and anterior) nerves local anesthesia injections.

5. Trapezoidal flap design was utilized for all procedures.

6. Lateral sinus lift approach was done for all patients.

7. The amount of collected blood for PRF preparation was 20 mL.

8. Centrifugation was done at speed 3000 rpm for 10 minutes.

9. One-stage surgery was done in cases where RBH was 3-6 mm and two stage-surgery was done with RBH <3 mm.

10. Dental implant engine was set at 600-800 rpm with torque 35 N/cm.

11. Simple interrupted suture were performed for wound closure.

12. Postoperative instructions (verbal and written) was given to all patients.

14. Drug regimen: all patients were given Cefixime trihydrate 400 mg tab orally once/day for 5 days, Metronidazole 250 mg tab orally three

times/day for 5 days, Phenylephrine 0.5% nasal drops 2-3 drops every 4 hours for 5 days, Acetaminophen 500 mg tab orally on need, and chlorhexidine digluconate 0.2% mouthwash twice/day for 2 weeks.

15. Follow up for all patients was; 14 days postsurgery for suture removal and then 24 weeks following surgery for assessment and implant uncovering stage.

2.8 Postoperative assessment (evaluation method)

1. The neoformed bone was measured in submillimeters using special CBCT software tools by substracting the preoperative RBH (measure X) from the postoperative submembraneous bone height (SBH)(measure Y) which was calibrated from alveolar bone to the uppermost point of bone above the DI.

Neoformed bone = measure Y – measure X .

2. Density of neoformed bone was measured at three points; mesial, distal, and apical to the implant, and mean density was calculated. Density estimation was performed utilizing CBCT depending on Misch scale for density estimation as follow: D1>1250 HU, D2= 850-1250 HU, D3= 350-850 HU, D4 =150-350 HU, and D5 <150 HU **(Misch, 2008)**.

3. Ossseointegration of implant is assessed according to Albrektsson criteria of success (immobility, asymptomatic, no peri-implant radiolucency).

4. Sinus was evaluated for any complications or pathological changes clinically and radiographically, Fig. (2-30), (2-31), (2-32).

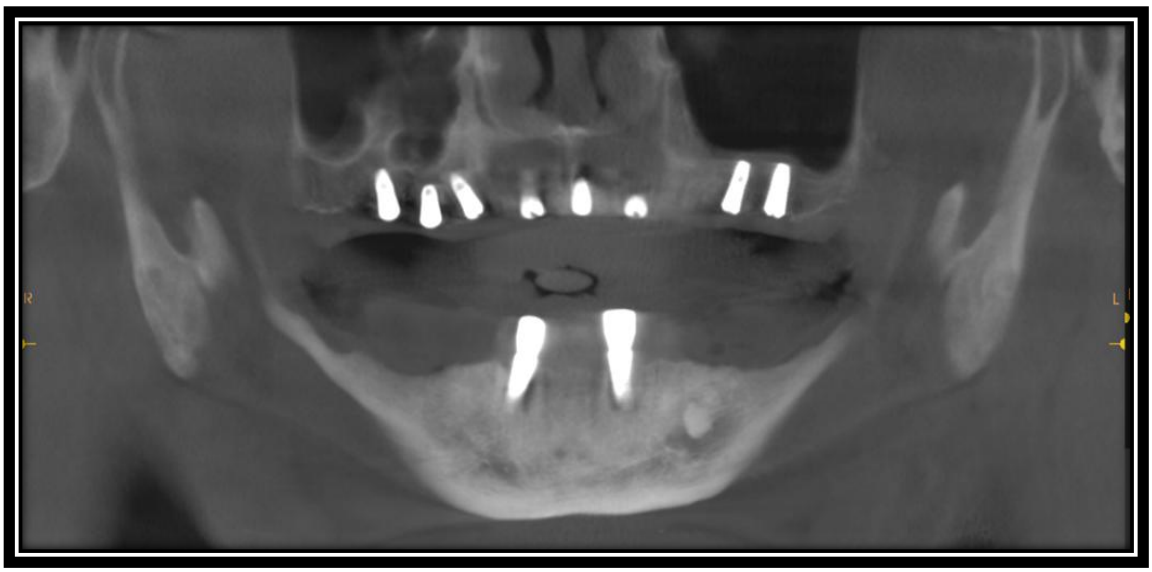


Fig. (2-30): Postoperative panoramic view of CBCT shows new sinus floor in continuity with DI tip.

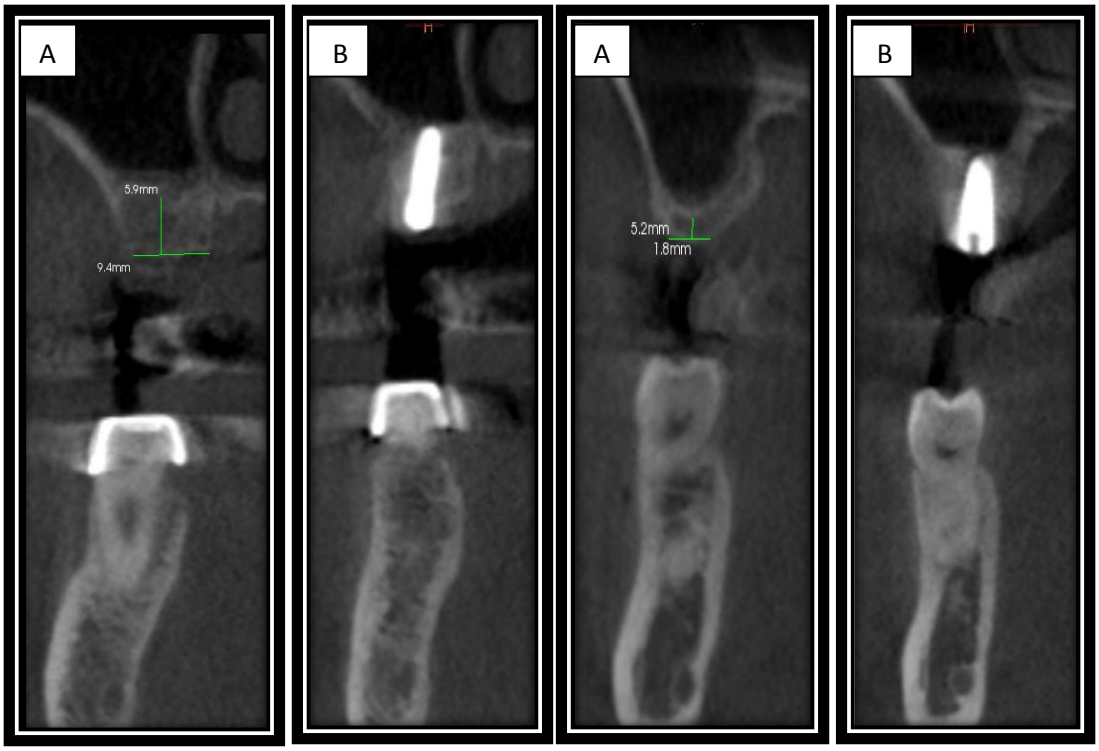


Fig. (2-31): Coronal view of CBCT. (A) Preoperative hight and width of residual alveolar bone.(B) 24 weeks posoperatively reveals bone gained around implant.

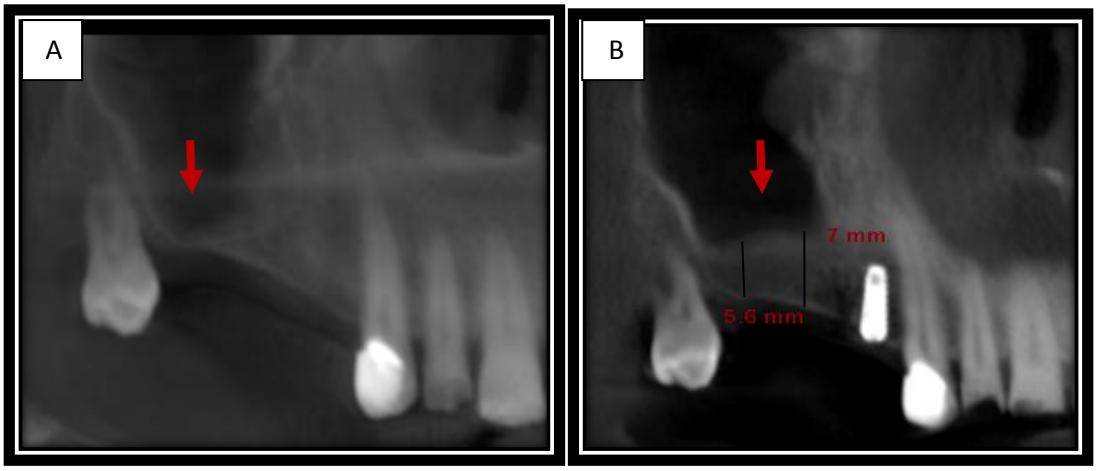


Fig. (2-32): Panoramic view of CBCT for two stage-surgery. (A) Preoperative RBH. (B) Postoperative SBH.

2.9 Follow up

Patients were informed to return back 14 days postoperatively for suture removal, then reattend 24 weeks after surgery for evaluation and prosthesis fabrication. Localization of implannt fixture according to CBCT or explored by probe after administration of local anasthaesia, fixture exposure was done by using tissue punch at speed 300 rpm then the cover screw was removed and the healing abutment was inserted instead for about 10-14 days, thereafter the patient was referred to the prosthodontic department for fabrication of the final prosthesis, Fig.(2-33)

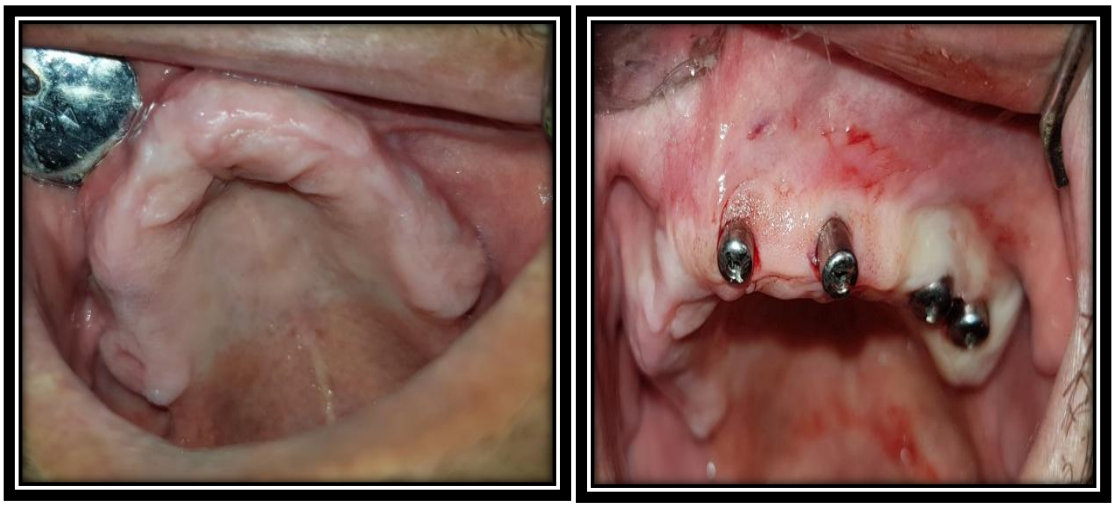
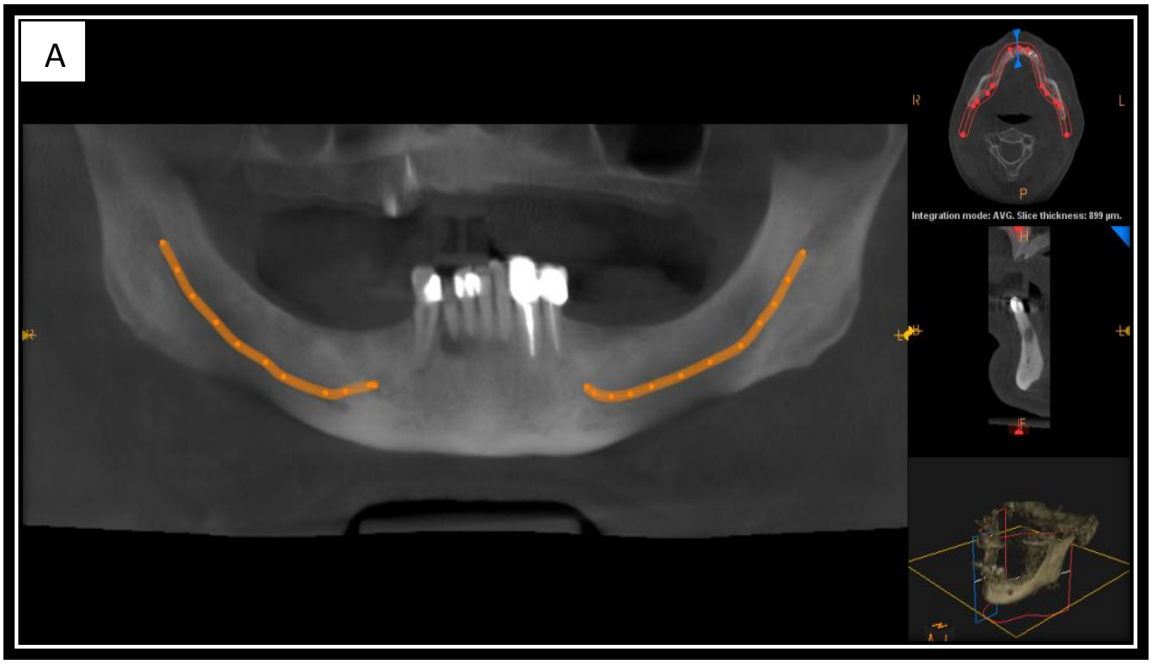
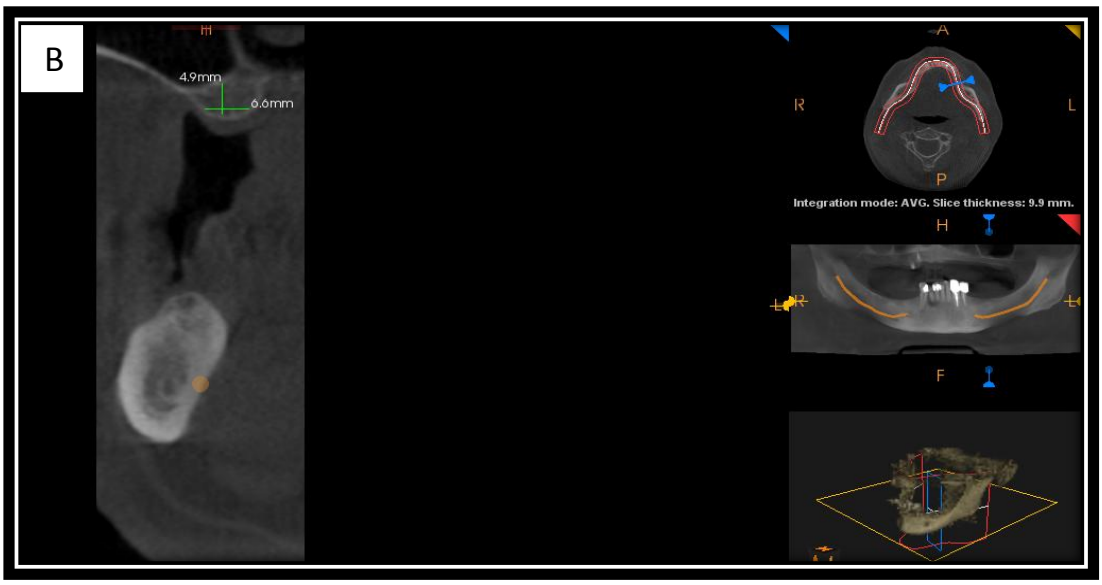


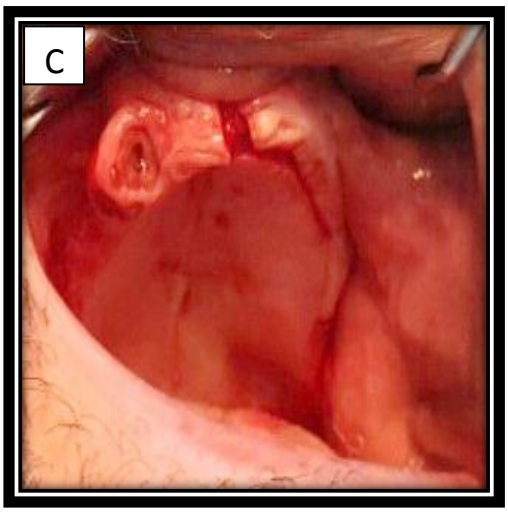
Fig. (2-33): (A) Alveolar ridge before fixtures exposure. (B) Healing abutments insertion.

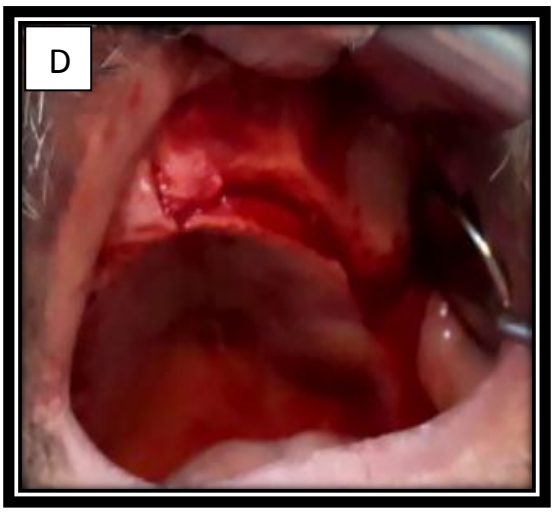
2.10 Case presentation

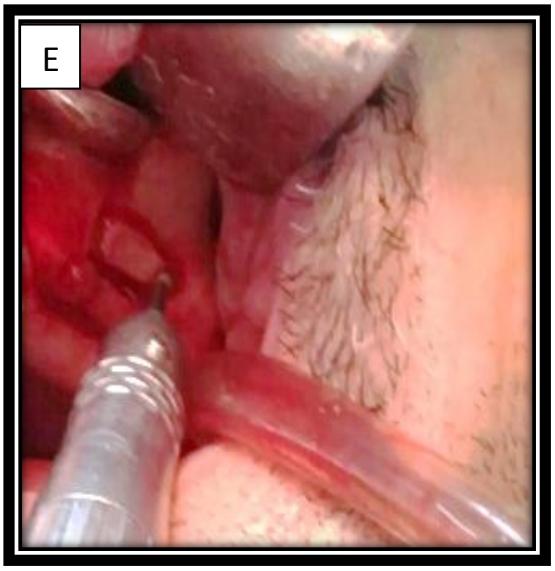
A 46 years old male patient attended to the Implantology Unit with no history of systemic disease and no history of any complication during previous dental intervention. He presented with edentulous posterior maxilla and RBH 4.9, 4 mm measured at tooth site #14 and #15 respectively. The mean bone density 151 HU, SP1, and with *Schneiderian membrane* thickness 2 mm.The treatment of choice was sinus augmentation through lateral approach with simultaneous implant placemet. Implant dimensions were 3612, 3612, 3810 were placed in teeth site #9, #11, #13, and implant size 4010 was placed in tooth site # 14 (sinusal) to rehabilitate the left upper quadrant. Platelet rich fibrin was used as a sole filling material, Fig. (2-34).

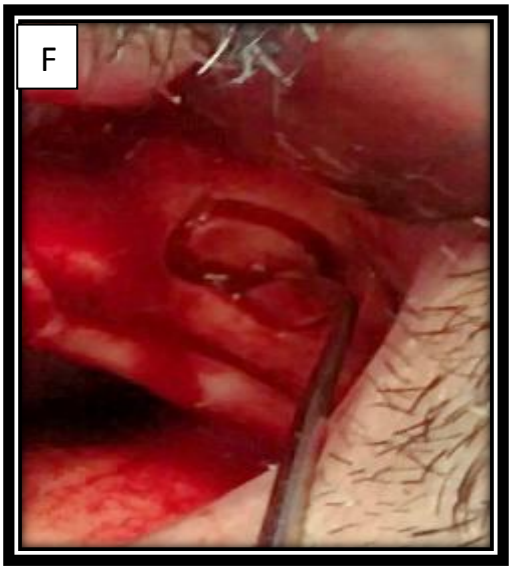


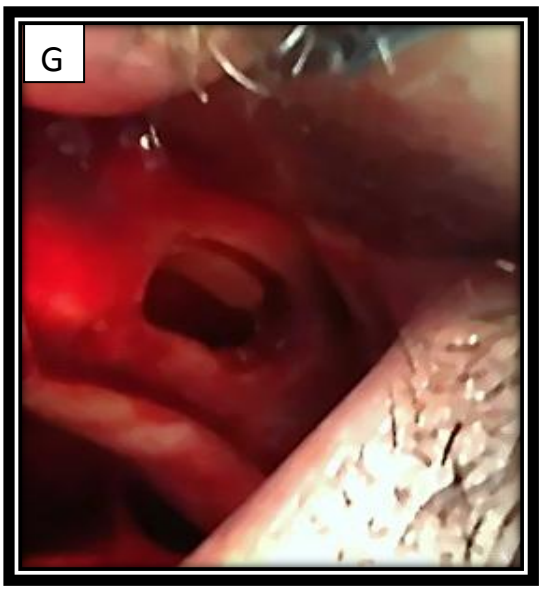

B
4.9mm
6.6mm
A
R
L
P
Integration mode: AVG. Slice thickness: 9.9 mm.
H
F

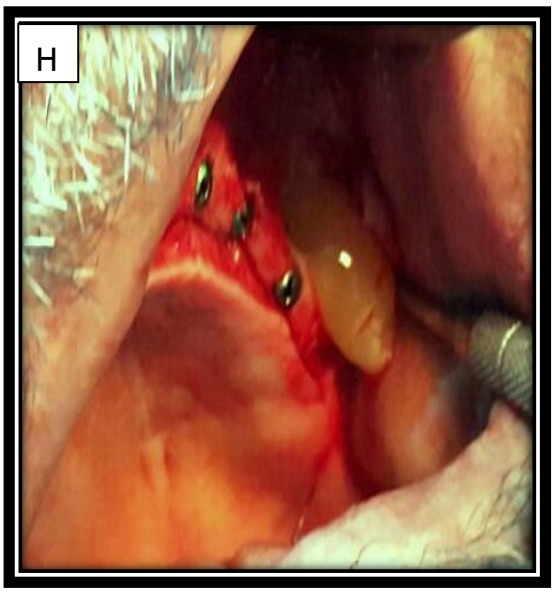

C

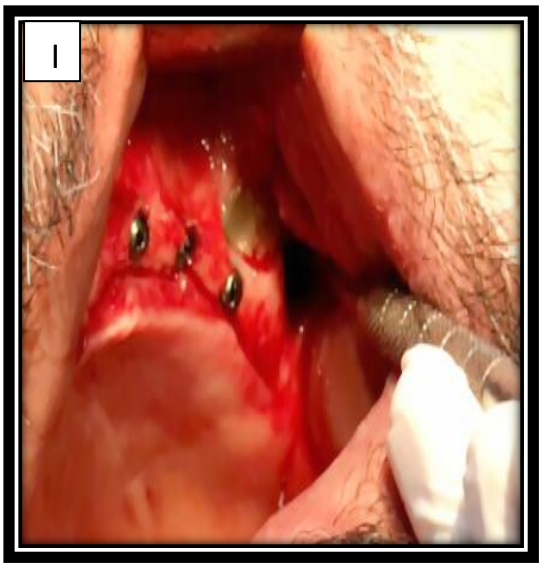

D

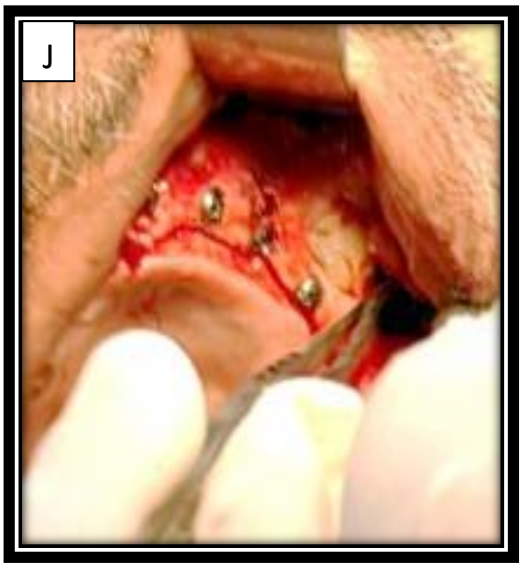

E


F


G


H


I


J

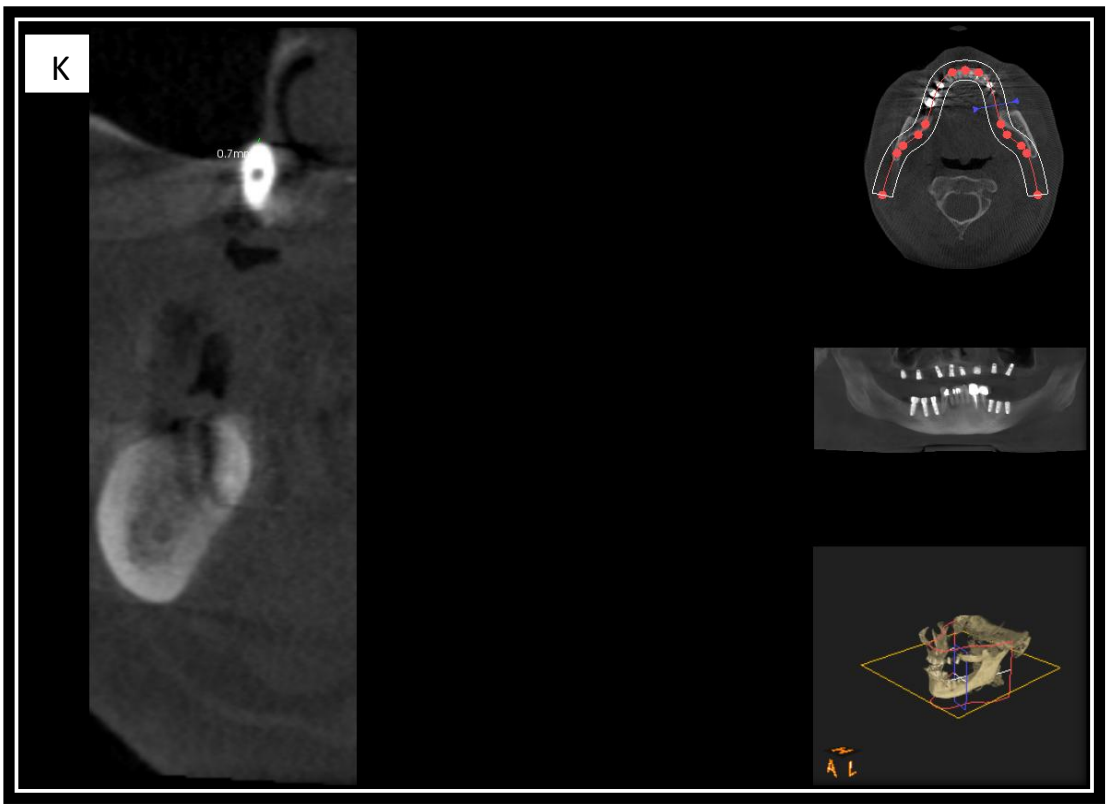


Fig. (2-34): (A) Panoramic view of CBCT reveals SP and RBH. (B) Coronal view of CBCT shows preoperative height and width of residual bone. (C) Horizontal and vertical flap incisions. (D) Three sided flap was raised. (E) Lateral osteotomy window preparation. (F) *Schneiderian membrane* elevation. (G) Superiorly positioned bony island that during deep inspiration indicates intact SM. (H) Insertion of PRF clot after implant placement. (I) Adaptation of PRF clot. (J) Lateral osteotomy window covered with PRF membrane. (K) Coronal view of CBCT 24 weeks after SA reveals the DI is completely surrounded by bone.

2.11 Statistical Analysis

Data description, analysis and presentation were performed using Statistical Package for social Science (SPSS version 21). Statistical analyses can be classified into two categories:

1-Descriptive Analysis:

A- Frequency, percentage for nominal variables, minimum, maximum, range, mean, standard deviation, and standard error for quantitative variables.

B- Graphs:

1- Simple and Cluster chart bars with error bars based on 95% confidence intervals (CI).

2- Pie charts.

2- Inferential analysis:

A- Two independent samples T-test: Test the significant differences of means between two groups.

B- Paired sample T test: The data may consist of two measurements taken on the same subject or one measurement taken on a matched pair of subjects.

C- Pearson Correlation (r): test the correlation between two quantitative variables.

Level of significance as: not significant $P>0.05$, significant $P<0.05$, highly significant $P<0.01$.

Chapter Three

Results

3.1 Data description of study sample and treatment protocol

Sixteen patients were included in this study. Ten males and 6 females with mean age of 48.88 years (range: 29-65), table (3-1), 3 patients underwent bilateral sinus augmentation so each sinus was considered as a single case resulting in total 19 sinus augmentation procedures. Simultaneous 17 implants placement with sinus augmentation (one-stage surgery) were done for 14 cases while augmentation with delayed implant placement (two-stage surgery) was done for 5 cases, table (3-2).

Table (3-1): Descriptive analysis of age and gender distribution.

Variable	Category	No.	%
Age (Year)	20-29	1	6.25
	30-39	2	12.5
	40-49	5	31.25
	50-59	5	31.25
	60-69	3	18.75
Gender	Males	10	62.5
	Females	6	37.5

Table (3-2): Descriptive analysis of surgical sides and stages.

Surgical sides and stages	No.	%
Unilateral sinus augmentation	13	81.25
Bilateral sinus augmentation	3	18.75
One-Stage surgery	14	73.68
Two-Stage surgery	5	26.32

3.2 Dental implant dimensions and site distribution

Seventeen implants were placed simultaneously during SA procedures; and implant size 4512 was the most frequently used (52.95%) followed by 4510 (23.53%) as shown in table (3-3).

Table (3-3): Sinusal implants dimensions.

Implant Site	Dimensions	No.	%
Sinusal	4010	2	11.76
	4510	4	23.53
	4012	2	11.76
	4512	**9**	**52.95**

The most common site for implant placement was the tooth site # 14 (29.42 %) followed by tooth site # 2 and 3(23.53 %), and the least sites were # 12 and 15 (5.88%) as shown in Fig. (3-1):

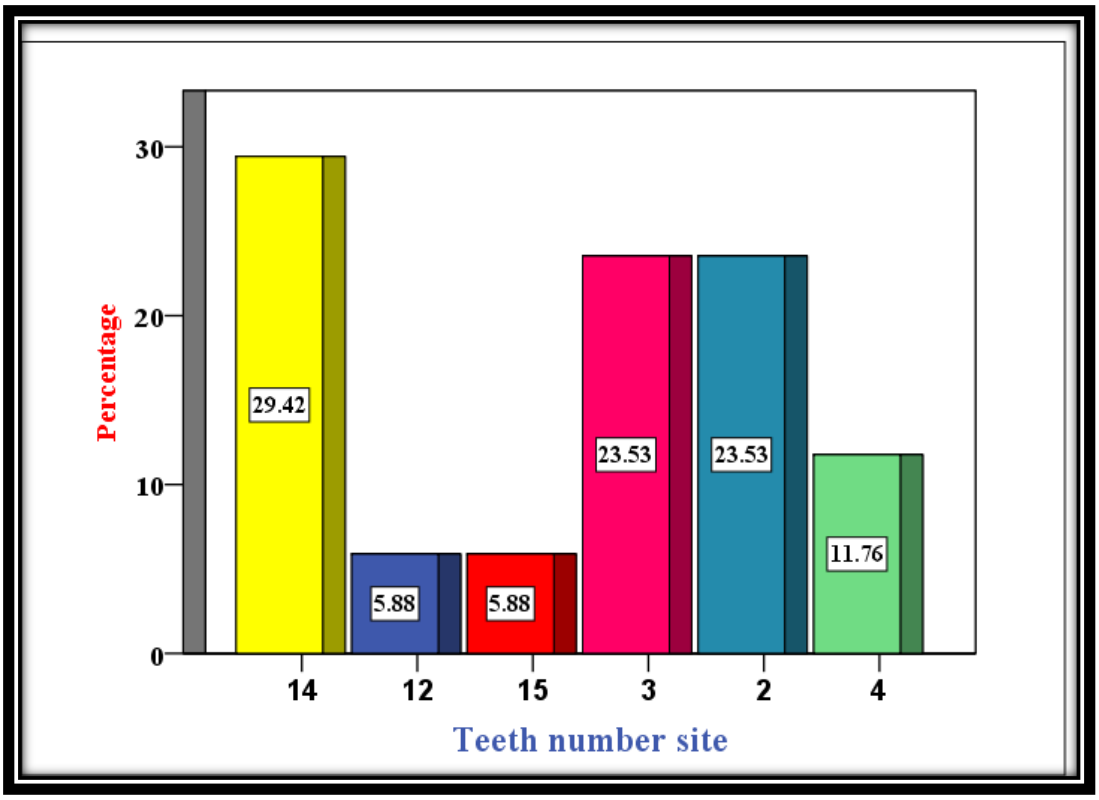


Fig. (3-1): Sinusal implant site distribution.

3.3 Sinus pneumatization distribution

Among the 19 sinuses of this study, SP0 was the commonest category found in the sample, it represented 68.41%. No case of SP4 was found. SP1, 2, 3 were equally distributed in the sample and represented 10.53% each. The majority of patients were partially edentulous 78.95%. Sinus septa were present in 6 sinuses (31.58 %), table (3-4).

Table (3-4): Sinus pneumatization category and dentition status.

SP category	No.	%	Septa No. (%)
SP0	13	68.41	6 (31.58)
SP1	2	10.53	
SP2	2	10.53	
SP3	2	10.53	
SP4	0	00.00	
Complete edentulism	4	21.05	
Partial edentulism	15	78.95	

3.4 Descriptive and inferential analysis of gained bone

The SBH (RBH+ neoformed bone) for one-stage surgery in each implant site ranged between 10.70 and 13.90 mm **(mean±SD 12.44±0.99)** and for two-stage surgery ranged between 1.20-7.20 mm **(mean 4.93±1.61)** in proposed implant site, which was highly significant for both protocols, table (3-5). The mean of gained bone in one-stage surgery was 7.98±1.70 mm and 3.01±1.63 mm in two-stage surgery which was also **HS**, table (3-6), (3-7).

Table (3-5): Descriptive and statistical test of postoperative SBH (mm) between one-stage and two-stage surgery.

Description	Stages		Independent Sample T test		
	One-Stage	Two-Stage	T	DF	P-value
Min.	10.70	1.20	15.021	25	**0.000 HS**
Max.	13.90	7.20			
Mean	**12.44**	**4.93**			
SD	0.99	1.61			
SE	0.24	0.51			

HS=highly significant at P<0.01.

Table (3-6): Descriptive and statistical test of bone gained (mm) between one-stage and two-stage surgery..

Description	Stage		Independent Sample T test		
	One-Stage	Two-Stage	T	DF	P-value
Min.	5.00	.00	7.443	25	**0.00000 HS**
Max.	10.80	4.20			
Mean	**7.98**	**3.01**			
SD	1.70	1.63			
SE	.41	.51			

HS=highly significant at P<0.01.

Table (3-7): Descriptive and statistical test of bone change between one-stage and two-stage surgery.

Stages		Pre RBH (mm)	Post RBH (mm)	Paired sample Test		
				T	DF	P-value
One-Stage	Min.	3.00	10.70	19.335	16	**0.000 HS**
	Max.	6.00	13.90			
	Mean	4.46	12.44			
	SD	1.25	0.99			
	SE	0.30	0.24			
Two-Stage	Min.	0.50	1.20	5.855	9	**0.000 HS**
	Max.	2.90	7.20			
	Mean	1.92	4.93			
	SD	1.08	1.61			
	SE	0.34	0.51			
Total	Min.	0.50	1.20	10.831	26	**0.000 HS**
	Max.	6.00	13.90			
	Mean	**3.51**	**9.66**			
	SD	1.71	3.89			
	SE	0.32	0.74			

HS=highly significant at P<0.01.

3.5 Descriptive and inferential analysis of density

The density of gained bone was measured for each treatment protocol and it was found that the density in the one-stage surgery cases was **408.28±169.89 HU** which falls in **D3** category according to Misch scale of density, while for two-stage surgery the mean of gained bone density was **183.60±97.67 HU** which falls in **D4** category, table (3-8).

Table (3-8): Descriptive and statistical test of density change within stages and in the total.

Stage		Subantral bone density (HU)	Gained bone density (HU)	Paired sample Test		
				T	DF	P-value
One-Stage	Min.	110.00	236.10	4.457	16	**0.001 HS**
	Max.	623.00	863.60			
	Mean	**256.59**	**408.28**			
	SD	135.99	169.89			
	SE	32.98	41.20			
Two-Stage	Min.	113.00	.00	0.675	9	**0.517 NS**
	Max.	341.00	244.00			
	Mean	**222.20**	**183.60**			
	SD	95.74	97.67			
	SE	30.28	30.89			
Total	Min.	110.00	.00	2.351	26	**0.027 Sig.**
	Max.	623.00	863.60			
	Mean	**243.85**	**325.07**			
	SD	121.82	182.46			
	SE	23.45	35.11			

NS=Not significant at P>0.05, Sig.=significant at P<0.05,HS=highly significant at P<0.01.

Table (3-9) shows that, for one-stage surgery there was 5.88% of cases were located in D2 category followed by 35.29% D3, and 58.82% D4. For two-stage surgery 80% of cases fall in D4 category and 20% in D5. Bone density of D1 category was not obtained in one or two-stage surgery as shown in Fig. (3-2).

Table (3-9): Density of gained bone for each implant site.

Density		Stage		Total
		One-Stage	Two-Stage	
D1	No.	0	0	0
	% within Stage	0	0	0
	% of Total	0	0	0
D2	No.	1	0	1
	% within Stage	5.88	.00	3.70
	% of Total	3.70	.00	3.70
D3	No.	6	0	6
	% within Stage	35.29	.00	22.22
	% of Total	22.22	.00	22.22
D4	No.	10	8	18
	% within Stage	58.82	80.00	66.67
	% of Total	37.04	29.63	66.67
D5	No.	0	2	2
	% within Stage	.00	20.00	7.41
	% of Total	.00	7.41	7.41
Total	No.	17	10	27
	% within Stage	100.00	100.00	100.00
	% of Total	62.96	37.04	100.00

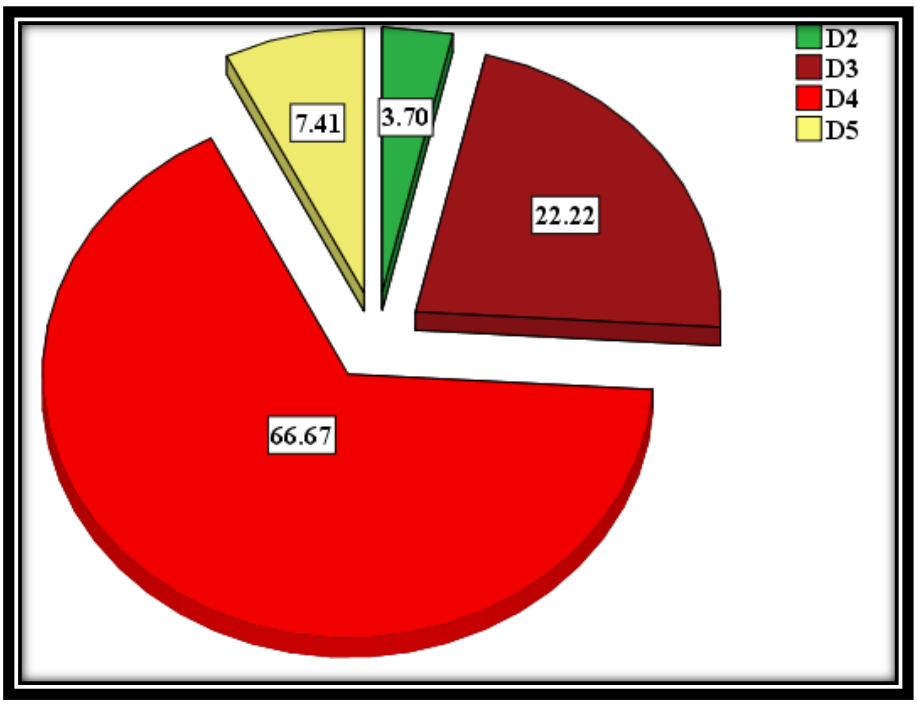


Fig. (3-2): Density of gained bone distribution.

3.6 Correlation between implant dimensions, gained bone and its density

Strong positive correlation was found between implant length and gained bone (r=0.65) and this is highly significant (0.005) at p<0.01, Fig (3-3), while NS correlation was found between implant length and density. No statistically significant correlation was found between implant diameter, gained bone and density.

Table (3-10): Correlation between implant dimensions, gained bone and density.

		Gained bone	Density
Diameter (mm)	r	0.14	0.13
	P-value	0.60	0.61
Length (mm)	r	**0.65**	0.23
	P-value	**0.005****	0.37

**=highly significant at P<0.01.

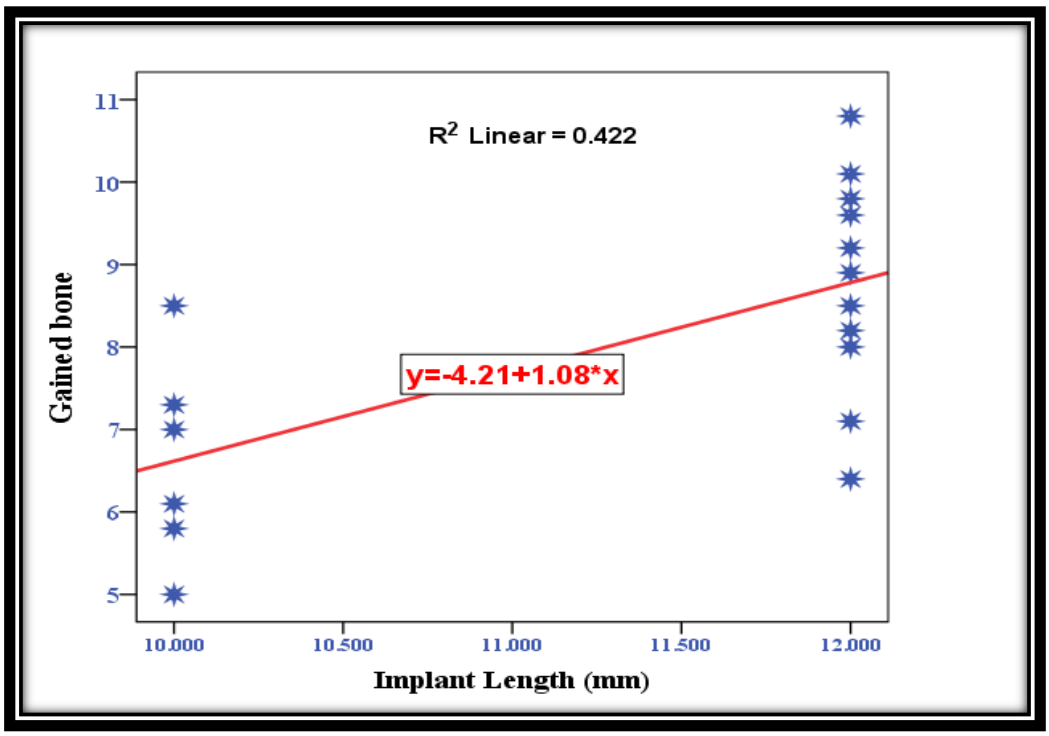


Fig. (3-3): Correlation between implant length and gained bone.

3.7 Complications

Intraoperative complications were reported as bleeding from injured AAA in 3 cases (15.79%) and SM perforation occurred in 4 cases (21.05%). Neither postoperative complications such as infection, wound dehiscence, nor implant failure were recorded as described in table (3-11).

Table (3-11): Intra and postoperative complications.

Variable	No.	%
Perforation	4	21.05
Bleeding	3	15.79
Infection	0	0
Wound dehiscence	0	0
Implant failure	0	0
Total	7	36.84

For both treatment protocols, the total mean of preoperative membrane thickness (MT) was 3.17 mm and 2.46 mm postoperatively. There were no statistically significant changes in membrane thickness (P-value=0.53) as shown in Fig. (3-4).

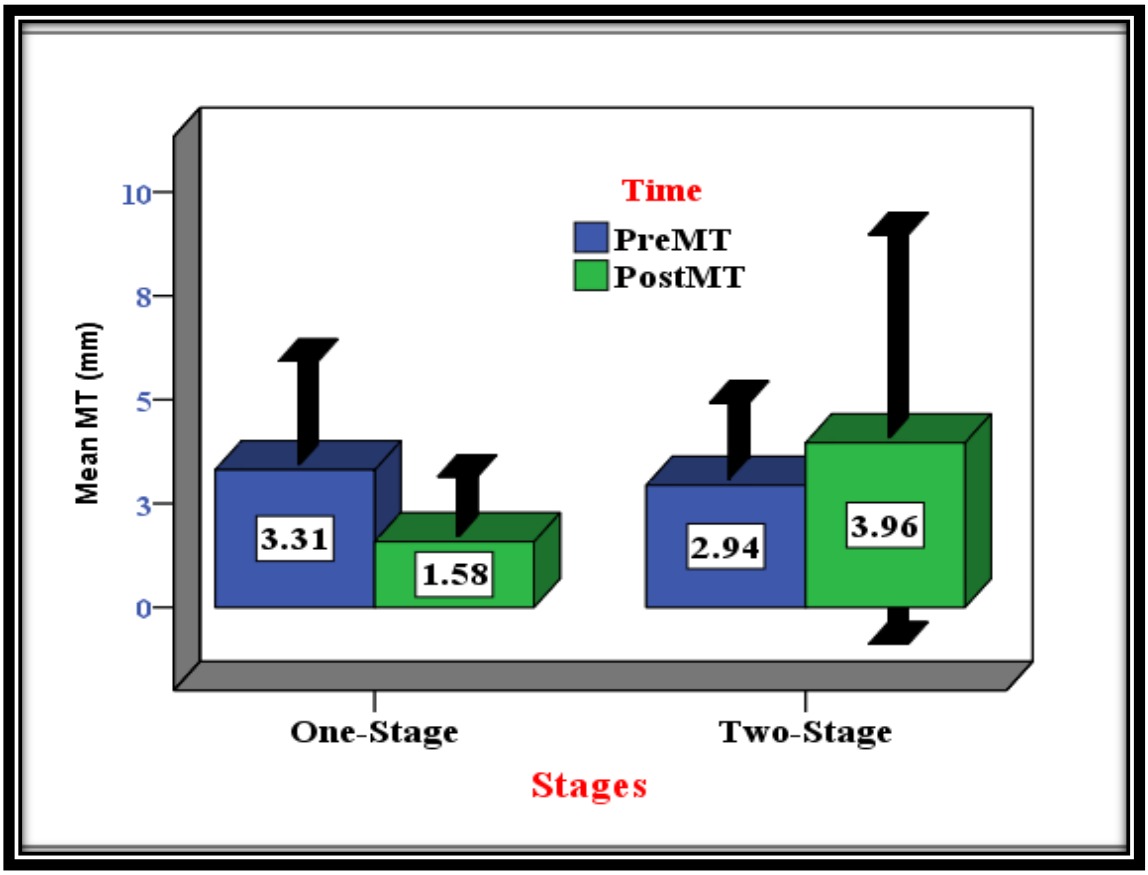


Fig. (3-4): Descriptive analysis of mean pre and postoperative MT for each treatment protocol.

Chapter Four

Discussion

The result of this interventional non-controlled clinical study was that PRF clot is effective when used as a sole filling material during a lateral sinus lift with immediate implant placement and less effective when delayed implant placement protocol is performed, utilizing CBCT for radiographical analyses of height and density of neoformed bone .

4.1 Submembraneous bone gain

The final SBH revealed by CBCT 6 months after surgery for each implant site was **HS**. For one-stage surgery; the SBH ranged between 10.70 mm and 13.90 mm (mean 12.44±0.99 mm). On clinical examination all implants were stable at the time of surgical exposure and radiographically the end of implant was in continuity with the sinus floor as shown in Fig. (2-30). This is comparable with other available studies in the same topic **(Mazor *et al*., 2009; Simonpieri *et al*., 2011; Tajima *et al*., 2013)** although in these studies greater amount of PRF clots were used (72 mL of whole blood withdrawn to prepare 8 PRF membranes). In Mazor *et al*. study; the final bone height was between 7 and 13 mm (mean ± SD: 10.1 ± 0.9 mm). In Simonpieri *et al*. study final bone height was 8.5-12 mm (mean 10.4 ± 1.2) and Tajima *et al*. reported 9.1-14.1 mm (mean 11.8±1.67 mm) as the final bone height.

The placement of PRF clot in close relation with SM may be responsible for more stable bone at the level of implant apex due to stimulation of periosteal-like layer of SM as it is documented that PRF clot has a great potential for intense osteoblast stimulation **(Ehrenfest *et al*., 2009b; Ehrenfest *et al*., 2010)**.

The implant serves as a space maintainer, i.e. keeps the SM elevated and prevents its collapse, so the natural bone regeneration is highly stabilized in the submembraneous space up to the implant apex **(Mazor *et al*. 2009)**.

Graftless sinus lift is well documented procedure and published by many authors, but ends up with limited bone volume that results in embedment

of implant apex in thick connective tissue of sinus "not osseoitegrated" **(Sul *et al*., 2008 a,b)**.

The use of PRF simply and safely allows placement of the preferable length of implant if primary stability can be obtained clinically (in this study the minimum RBH was 3 mm provided primary stability). **Sohn (2011)** reported the advantages of such augmentation material as no cross infection, no donor site morbidity, no reported infection and more gained bone with reducing operation cost.

In this study sinus augmentation depending on two-stage protocol was done when RBH being <3 mm (mean 1.92 ±1.08 mm) and the mean gained bone at time of second stage surgery was 3.01±1.63 mm. This bone gain is statistically significant but clinically the mean final SBH was 4.93±1.61 mm so the sinus augmentation still insufficient for adequate implant placement. This may be explained by the limited capacity of PRF clot to keep the artificial space created during SM elevation that results in membrane collapse; and could be avoided if space maintainer is to be used. It is documented that PRF clot dissolves gradually during 1-2 weeks **(Dohan Ehrenfest *et al.*, 2009; Borie *et al*., 2015)**. Another explanation is that insufficient PRF clots were used in the two-stage surgery while it was sufficient when placed with DI. However, the space maintaining capacity of PRF clot need further studies and more PRF clots can be used for stronger evidence.

To the best of author's knowledge, there was only one case report published by **Aoki *et al.* (2016)** in which 2 PRF membranes were used in sinus augmentation without implant placement and the results were comparable to this study.

One SA procedure was failed and no bone was formed after 24 weeks (the case was from the two-stage group). In this patient severe intra and immediate postoperative bleeding encountered from branch of the

superior labial artery that necessitated wound re-exploration to identify the source of bleeding and cauterization with hot Ash 49 was done.

The bleeding washing effect is documented **(Rosano *et al*., 2011)**. It may be that PRF clot is washed out and dislodged from the submembraneous space particularly the clot was not supported by implant.

4.2 Density of gained bone

In this study, the mean density of gained bone in one-stage surgery cases was 408.28±169.89 HU which falls in **D3** category according to Misch scale of density. That was comparable to the density of posterior maxilla which falls in D4 category **(Ali *et al*., 2015)** and this result is in agreement with study published by **Tajima *et al*. (2013)** in which the researcher reported that the density of gained bone was 323±156.2 HU.

In two-stage surgery the mean density of gained bone was 183.60±97.67 HU which is categorized as **D4**. This difference between densities of gained bone between the two surgical protocols may be explained by the compactness of PRF clot in the artificial space created after SM elevation, that mean when the implant is placed simultaneously with PRF clot in the submembraneous space, it may help in keeping PRF clot well condensed, supported, and confined between the sinus walls around it, while in two-stage surgery there is no implant to support the elevated membrane that gradually compress the PRF clot with respiration movement result in rolling out of the clot making it not to be confined in a precise area. Taking in consideration the degree of SP which may also influence the degree of compactness of PRF clot in space particularly a standardized amount of PRF clots were used in this study (2 PRF clots for all procedures) regardless the volume to be augmented .

In a histological examination of the gained bone around implant 6 months after sinus augmentation with PRF, **Mazor *et al*. (2009) and**

Sohn (2011) found that the bone is dense and mature and this was attributed to formation of architecturally strong bone matrix begins from PRF fibrin matrix and high concentration of GFs. Fibrin matrix is well organized scaffold supporting BMP **(Naik *et al*., 2013)**.

The tissue biopsy in case of two-stage surgery revealed woven bone around mature lamellar bone **(Aoki *et al*., 2016)**. That is supportive explanation to the low density obtained in delayed implant placement protocol.

Hussein and Hassan (2017) established a study utilizing surgicel as a non-autogenous graft material for indirect sinus lift procedure (crestal approach) and the density of gained bone was 489.62 HU which is very comparable to the density obtained with PRF clot but it is worth to point out the privilege of PRF as an autogenous, inexpensive, and easily prepared graft material.

4.3 Dental implant dimensions

Seventeen implants were placed; and implant size 4512 was the most frequently used (52.95%) followed by 4510 (23.53%), this is closely comparable to studies by **(Mazor *et al*., 2009; Lateef and Asmael, 2016; Hussein and Hassan, 2017)**.

Mazor *et al*. (2009) utilized implant length 11.5, 13 and 15 mm with diameter of 3.25, 3.75, 4, 4.3 and 5 mm.

. **Hussein and Hassan (2017)** used implant length 10, 12 mm and diameter 3.8, 4.3, and 4.8 mm.

Lemos *et al*. (2016) reported that standard implant (i.e. longer than 8 mm) provides more contact area and thus osseointegration therefore associated with higher success rate than shorter implant.

This explains the greater amount of gained bone when implant was inserted immediately with sinus lift procedure was more than when delayed placement was performed.

It is well known that posterior maxilla is subjected to higher stress so that wider implant diameter is used to decrease this mechanical stress **(Morand and Irinakis, 2007; Goiato *et al*., 2014)**.

Strong positive correlation between gained bone and implant length was found in this study in accordance with other studies that explained this result as a sequel of tenting action served by the implant as described by **(Nedir *et al*., 2006; Mazor *et al*. 2009; Tajima *et al*, 2013)**.

Nonsignificant effect of implant width on gained bone or density, also density of gained bone was not affected by the length of the implant. This was also demonstrated by **Hussein and Hassan (2017)**.

4.4 Implant site distribution

The most common site for implant placement was the site of tooth # 14, #2, and #3. This is logic due to morphology of occlusal surface that makes it more susceptible to caries and subsequent loss. This is in accordance with **Hussein and Hassan (2017)**. These teeth are also closely related to area of pneumatized sinus.

4.5 Sinus pneumatization

Among the 19 sinuses of this study, SP0 (68.41%) was the most prevalent category found in the sample. In this study the most common status was partial edentulism (78.95%) of patients; this may explain why the SP in this study was not so extensive.

Sharan and Madjar (2008) reported that the loss of maxillary posterior teeth results in alveolar bone resorption as well as maxillary SP. The loss

of two adjacent upper posterior teeth or loss of upper 2nd molar were found to be associated with greater degree of pneumatization also inferior direction of SP occurs after extraction and its degree increased with increasing number of missing posterior teeth. This is supportive explanation to the result of this study in which SP0 was the most common classification encountered as the SP may occur in inferior rather than mesiodistal direction in partially edentulous patients.

Hussein and Hassan (2017) reported that estimation of SP is important to determine the requested amount of augmentation material.

4.6 Intra and postoperative complications

Schneiderian membrane perforation occurred in 4 sinus lift procedures (21.05%) may be due to the presence of septa and/or irregular sinus floor that contravened the smoothness of membrane dissection. The presence of septa was reported as a risk factor for membrane perforation **(Meleo *et al*., 2012; Nolan *et al*., 2014)**. Many authors reported that it is the most common complication during lateral SA and its incidence ranges between 11% and 56% **(Batal and Norris 2013; Froum, 2015)**. Other studies reported perforation incidence about 19.5-41% in lateral sinus lift procedure **(Fugazzotto *et al*., 2015)**.

The use of PRF membrane in management of SM perforation is reported by many authors as it enhances the healing process **(Tanasković; 2016)**.

In this study the perforation in the 4 cases, was < 2 mm (according to **Fugazzotto *et al*. (2015)**, class II A) and was managed successfully by application of the easily adapted PRF membrane as shown in Fig. (4-1).

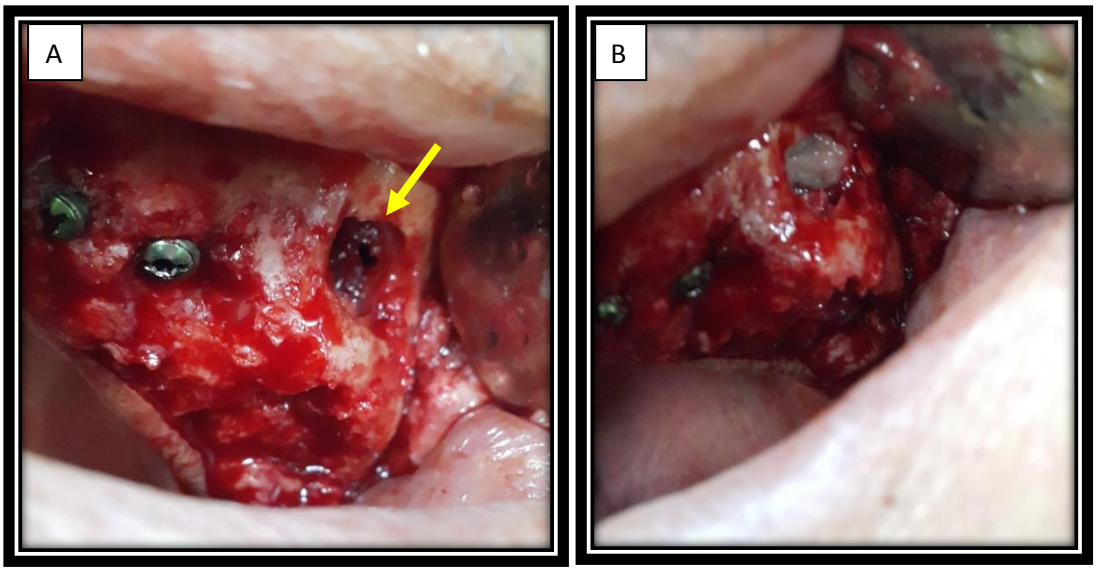


Fig. (4-1): (A) Perforated SM. (B) Platelet rich fibrin membrane applied on the perforated area.

Intraoperative bleeding from injured AAA associated with 3 procedures (15.79%) during lateral osteotomy window preparation and this is reported as one of the most common intraoperative complications of lateral sinus lift procedure as assumed by **(Fugazzotto *et al.*, 2015)**.

In two cases the bleeding was not so severe and stopped spontaneously while proceeding in the operation. The researcher encountered with one case with profuse bleeding of injured AAA as shown in Fig. (4-2), it is documented by **Valente *et al.* (2015)** that the incidence of injury is increased when diameter of AAA >0.5 mm.

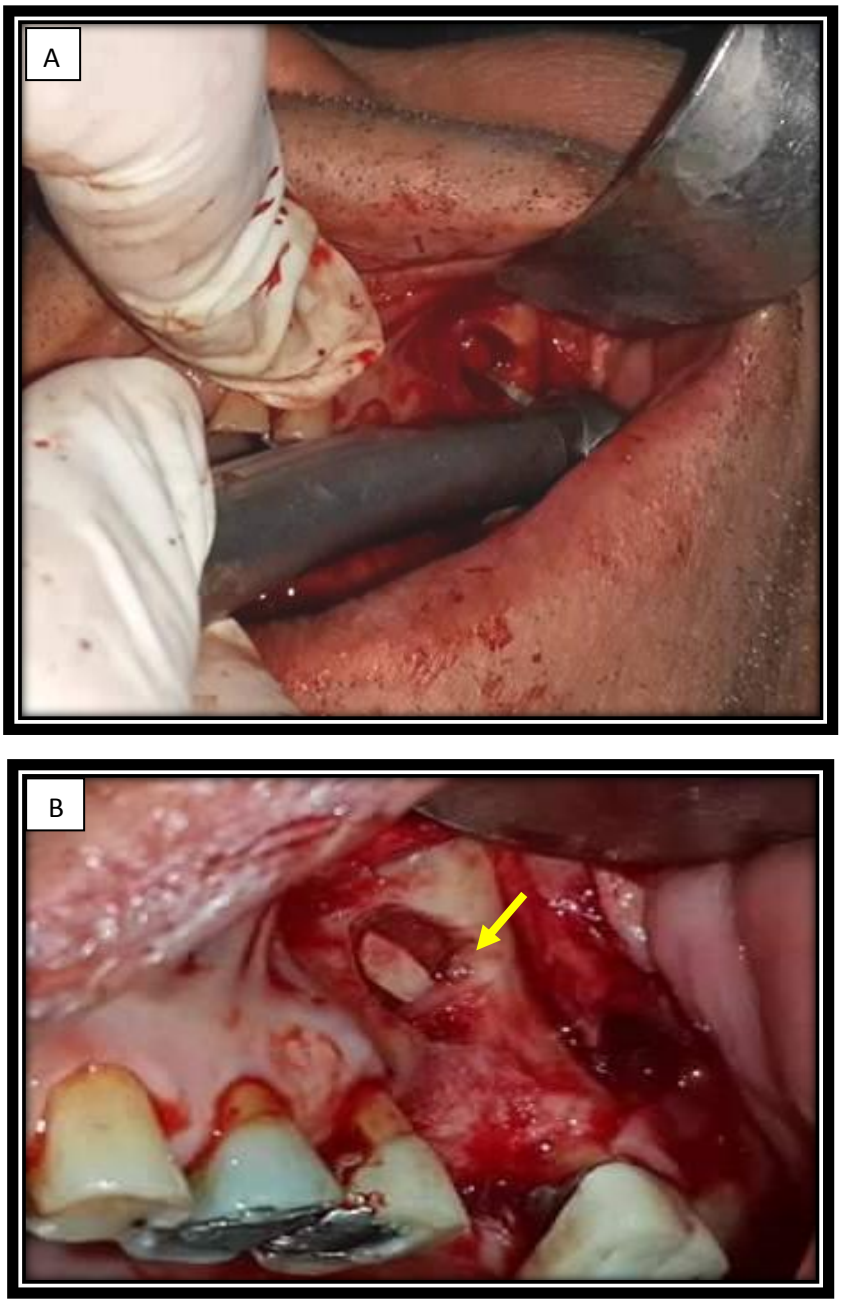


Fig. (4-2): (A) Cauterization of severed AAA with bur without irrigation (cooling). (B) Alveolar antral artery after cauterization.

In this case the bleeding was severe so that cauterization with diamond bur attached to turbine without water irrigation was done; this maneuver was confirmed by **Resnik and Misch (2017)**.

Intact AAA and SM are important for proper revascularization of the area and neoangiogenesis **(Rysz *et al.*, 2014)**.

No postoperative infection was reported in this study, this is coincident with other studies **(Bastami *et al*., 2016)**. This is may be related to the well established anti-infectious and immune regulation properties of leukocyte entrapped in fibrin mesh of PRF as documented by **Dohan Ehrenfest *et al*. (2009)** and **Bielecki *et al*. (2012)**.

Platelets are responsible for releasing modulator proteins of humoral and cellular immunity. Antibacterial and fungicidal proteins also stored in platelets granules **(Anitua *et al*., 2011; Joshi *et al*., 2016)**.

Survival rate of DI 6 months after surgery was 100%, all implants were clinically stable at the time of 2nd stage surgery (implant uncoverage). In a systematic review by **Ali *et al.(*2015)**, a total of 57 SA using PRF as a sole graft material were done and 110 implants were placed in 46 patients, in all cases during uncovering time, the 110 implants placed were clinically stable. Platelet rich fibrin application improves implant stability during the early healing period owing to faster osseointegration **(Öncü and Alaaddinoðlu, 2013)**.

For both treatment protocols, the total mean preoperative MT was 3.17 mm and 2.46 mm postoperatively. There were no statistically significant changes in membrane thickness (P-value=0.53). The minimum radiographically detected mucosal thickness is 2 mm and the greater thickness is considered pathological thickening. It was reported that the preoperative CBCT for patients who need SA procedure greatly revealed mucosal thickening >2 mm **(Kao, 2014)**. This is in acceptance with the preoperative findings of this study as the mean preoperative MT was 3.17 mm.

Surprisingly 5 sinuses (26.32%) with preoperative membranous thickening >2 mm were found to resolve completely. This may be attributed to the anti-inflammatory effect of (IL-4) secreted by activated leukocyte of PRF clot **(Dohan *et al*., 2006c)**. To the best of author's

knowledge there is no published study discuss such changes in SM when PRF used as graft material.

Limitations of the study

1. There is no control group to evaluate if the same results can be obtained if graftless sinus lift technique is used (i.e. depending on coagulum in the submembraneous space without any augmentation material).
2. Short follow up period that may inflate the obtained result regarding implant stability and long term success.
3. Relatively small sample size.

Chapter Five

Conclusions and Suggestions

5.1 Conclusions

1. The use of PRF as the sole graft material during sinus lift with simultaneous implant placement (one-stage surgery) provides stable, high level of natural bone which is comparable to normal bone density of posterior maxilla in the submembraneous cavity in continuity with the tip of the implant.
2. Sinus augmentation with PRF alone without implant placement (two-stage surgery) results in a limited bone formation.
3. Higher level of bone can be achieved when longer implant is used.
4. Platelet rich fibrin as optimized blood clot is an easily obtained and cost effective biomaterial uptrend natural bone regeneration around implant.
5. No postoperative complications or implant failure were encountered.

5.2 Suggestions

1. Comparative study between PRF as sole graft material and graftless sinus lift or bone substitute with simultaneous implant placement.
2. Long term study to evaluate the long term success of implant when PRF is used as the only graft material.
3. Introduce larger amount of PRF clots to augment the sinus in delayed implantation protocol with or without space maintainer.
4. Histological evaluation of the neoformed bone.
5. Earlier postoperative radiographical examination to assess the ability of PRF to accelerate bone healing.

References

A

- Abdussamad, R.A.E., Sadakah, A.A., Allah, O.G. and Nowair, I.M., 2015. Evaluation of maxillary sinus membrane repair using two different sutureless techniques. *Tanta Dent J*, *12*(4), pp.225-234.
- Abramovitch, K. and Rice, D.D., 2014. Basic principles of cone beam computed tomography. *Dent Clin North Am*, *58*(3), pp.463-484.
- Acero, J., 2011. Maxillary sinus grafting for implant insertion. *Preprosthetic and Maxillofacial Surgery: Biomaterials, Bone Grafting and Tissue Engineering*, p.54.
- Agarwal, B. Gagnani, S. Roychoudhury, A., and Bhutia, O., 2015. Optimum use of platelet-rich fibrin: technical note. *Br J Oral Maxillofac Surg*, *53* (7), pp.664-665.
- Alessandro Geminiani, D.D.S.,2015. Diagnosis and Management of Pre-Intra-and Post-Operative Complications for Sinus Augmentation Surgery. Available at www.dentalacademyofce/ courses/2936/pdf/ 2015.
- Ali, S., Bakry, S. A. and Abd-Elhakam, H., 2015. Platelet-rich fibrin in maxillary sinus augmentation: a systematic review. *J Oral Implantol*, *41* (6), pp.746-753.
- Anduze-Acher, G., Brochery, B., Felizardo, R., Valentini, P., Katsahian, S. and Bouchard, P., 2013. Change in sinus membrane dimension following sinus floor elevation: a retrospective cohort study. *Clin Oral Implants Res*, *24*(10), pp.1123-1129.
- Anitua, E., Muruzabal, F. and Orive, G. 2011. Antimicrobial properties of plasma rich in growth factors (PRGF-ENDORET) technology. Science against microbial pathogens: communicating

current research and technological advances. A. Méndez-Vilas (Ed.), pp.414-421.

- Aoki, N., Kanayama, T., Maeda, M., Horii, K., Miyamoto, H., Wada, K., Ojima, Y., Tsuchimochi, T. and Shibuya, Y., 2016. Sinus augmentation by platelet-rich fibrin alone: A report of two cases with histological examinations. *Case Rep Dent*, *2016*.7 pages.
- Ardekian, L., Oved-Peleg, E., Mactei, E.E. and Peled, M., 2006. The clinical significance of sinus membrane perforation during augmentation of the maxillary sinus. *J Oral Maxillofac Surg*, *64*(2), pp.277-282.
- Armstrong, J.K., Han, B., Kuwahara, K., Yang, Z., Magyar, C.E., Dry, S.M., Atti, E., Tetradis, S. and Fisher, T.C., 2010. The effect of three hemostatic agents on early bone healing in an animal model. *BMC surg*, *10*(1), p.37.

B

- Batal, H. and Norris, O., 2013. Lateral antrostomy technique for maxillary sinus augmentation. *Implants*, 1, pp.12-20.
- Bai, M.Y., Wang, C.W., Wang, J.Y., Lin, M.F. and Chan, W.P., 2017. Three-dimensional structure and cytokine distribution of platelet-rich fibrin. *Clinics*, *72*(2), pp.116-124.
- Banihashem T., 2013.Maxillary sinus floor augmentation with different bone grafting materials for dental implant treatment: A systematic review. Available at:https://dspace.mah.se/ bitstream/ handle/ 2043/ 15431/ TiBaFlZu.pdf? sequence=2.
- Bastami, F. and Khojasteh, A., 2016. Use of leukocyte-and platelet-rich fibrin for bone regeneration: a systematic review. *Regen. Reconstr. Restor*., *1*(2), pp.47-68.

- Benavides, E., Rios, H.F., Ganz, S.D., An, C.H., Resnik, R., Reardon, G.T., Feldman, S.J., Mah, J.K., Hatcher, D., Kim, M.J. and Sohn, D.S., 2012. Use of cone beam computed tomography in implant dentistry: the International Congress of Oral Implantologists consensus report. *Implant dent*, *21*(2), pp.78-86.
- Bielecki, T., M Dohan Ehrenfest, D., A Everts, P. and Wiczkowski, A., 2012. The role of leukocytes from L-PRP/L-PRF in wound healing and immune defense: new perspectives. *Curr Pharm Biotechnol*, *13*(7), pp.1153-1162.
- Borie, E., Oliví, D.G., Orsi, I.A., Garlet, K., Weber, B., Beltrán, V. and Fuentes, R., 2015. Platelet-rich fibrin application in dentistry: a literature review. *Int J Clin Exp Med*, *8*(5), pp.7922-7929.

C

- Chiapasco, M., Felisati, G., Zaniboni, M., Pipolo, C., Borloni, R. and Lozza, P., 2013. The treatment of sinusitis following maxillary sinus grafting with the association of functional endoscopic sinus surgery (FESS) and an intra-oral approach. *Clin Oral Implants Res*, *24*(6), pp.623-629.
- Choukroun, J., Diss, A., Simonpieri, A., Girard, M.O., Schoeffler, C., Dohan, S.L., Dohan, A.J., Mouhyi, J. and Dohan, D.M., 2006. Platelet-rich fibrin (PRF): a second-generation platelet concentrate. Part IV: clinical effects on tissue healing. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, *101*(3), pp.e56-e60.

D

- Danesh-Sani, S.A., Loomer, P.M. and Wallace, S.S., 2016. A comprehensive clinical review of maxillary sinus floor elevation: anatomy, techniques, biomaterials and complications. *Br J Oral Maxillofac Surg*, *54*(7), pp.724-730.

- Davarpanah, M., Martinez, H., Tecucianu, J.F., Hage, G. and Lazzara, R., 2001. The modified osteotome technique. *Int J Periodont Rest Dent*, *21*(6).
- Davis, V.L., Abukabda, A.B., Radio, N.M., Witt-Enderby, P.A., Clafshenkel, W.P., Cairone, J.V. and Rutkowski, J.L., 2014. Platelet-rich preparations to improve healing. Part II: platelet activation and enrichment, leukocyte inclusion, and other selection criteria. *J Oral Implantol* , *40*(4), pp.511-521.
- Dohan, D.M., Choukroun, J., Diss, A., Dohan, S.L., Dohan, A.J., Mouhyi, J. and Gogly, B., 2006a. Platelet-rich fibrin (PRF): a second-generation platelet concentrate. Part I: technological concepts and evolution. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, *101*(3), pp.e37-e44.
- Dohan, D.M., Choukroun, J., Diss, A., Dohan, S.L., Dohan, A.J., Mouhyi, J. and Gogly, B., 2006b. Platelet-rich fibrin (PRF): a second-generation platelet concentrate. Part II: platelet-related biologic features. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, *101*(3), pp.e45-e50.
- Dohan, D.M., Choukroun, J., Diss, A., Dohan, S.L., Dohan, A.J., Mouhyi, J. and Gogly, B., 2006c. Platelet-rich fibrin (PRF): a second-generation platelet concentrate. Part III: leucocyte activation: a new feature for platelet concentrates. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*,*101*(3), pp.e51-e55.
- Dohan Ehrenfest, D.M., de Peppo, G.M., Doglioli, P. and Sammartino, G., 2009. Slow release of growth factors and thrombospondin-1 in Choukroun's platelet-rich fibrin (PRF): a gold standard to achieve for all surgical platelet concentrates technologies. *Growth Factors*, *27*(1), pp.63-69.

- Dülgeroglu, T.C. and Metineren, H., 2017. Evaluation of the Effect of Platelet-Rich Fibrin on Long Bone Healing: An Experimental Rat Model. *Orthopedics*, *40*(3), pp.e479-e484.
- Duncavage, J.A. and Becker, S.S. eds., 2011. *Maxillary Sinus: Medical and Surgical Management*. Thieme.

E

- Ehrenfest, D.M.D., Diss, A., Odin, G., Doglioli, P., Hippolyte, M.P. and Charrier, J.B., 2009b. In vitro effects of Choukroun's PRF (platelet-rich fibrin) on human gingival fibroblasts, dermal prekeratinocytes, preadipocytes, and maxillofacial osteoblasts in primary cultures. *Oral Surg, Oral Med, Oral Pathol, Oral Radiol, Endod*, *108*(3), pp.341-352.
- Ehrenfest, D.D., Sammartino, G., Shibli, J.A., Wang, H.L., Zou, D.R. and Bernard, J.P., 2013. Guidelines for the publication of articles related to platelet concentrates (Platelet-Rich Plasma-PRP, or Platelet-Rich Fibrin-PRF): the international classification of the POSEIDO. *Poseido J*, *1*, pp.17-28.
- Ehrenfest, D.M.D., Doglioli, P., Giuseppe, M., Del Corso, M. and Charrier, J.B., 2010. Choukroun's platelet-rich fibrin (PRF) stimulates in vitro proliferation and differentiation of human oral bone mesenchymal stem cell in a dose-dependent way. *Arch Oral Biol*, *55*(3), pp.185-194.
- Ehrenfest, D.M.D., Rasmusson, L. and Albrektsson, T., 2009a. Classification of platelet concentrates: from pure platelet-rich plasma (P-PRP) to leucocyte-and platelet-rich fibrin (L-PRF). *Trends in Biotechnol*, *27*(3), pp.158-167.

- Ella, B., Noble, R.D.C., Lauverjat, Y., Sédarat, C., Zwetyenga, N., Siberchicot, F. and Caix, P., 2008. Septa within the sinus: effect on elevation of the sinus floor. *Br J Oral Maxillofac Surg*, *46*(6), pp.464-467.
- Emtiaz, S., Caramês, J.M. and Pragosa, A., 2006. An alternative sinus floor elevation procedure: trephine osteotomy. *Implant dentistry*, *15*(2), pp.171-177.

F

- Froum, S. ed., 2015. *Dental implant complications: etiology, prevention, and treatment*. John Wiley & Sons.
- Ferri, J. and Hunziker, E. eds., 2011. *Preprosthetic and maxillofacial surgery: Biomaterials, bone grafting and tissue engineering*. Elsevier.
- Fugazzotto, P., Melnick, P.R. and Al-Sabbagh, M., 2015. Complications when augmenting the posterior maxilla. *Dent Clin North Am*, *59*(1), pp.97-130.

G

- Goiato, M.C., Pesqueira, A.A., Dos Santos, D.M., Haddad, M.F. and Moreno, A., 2014. Photoelastic stress analysis in prosthetic implants of different diameters: mini, narrow, standard or wide. *J Clin Diagn Res: JCDR*, *8*(9), p.ZC86-ZC90.
- Gulsahi, A., 2011. Bone quality assessment for dental implants. *Implant Dentistry-The Most Promising Discipline of Dentistry*. InTech. pp.437-452.
- Gülşen, U., Mehdiyev, İ., Üngör, C., Şentürk, M.F. and Ulaşan, A.D., 2015. Horizontal maxillary sinus septa: An uncommon entity. *Int j surg case rep*, *12*, pp.67-70.

- Gultekin, B.A., Borahan, O., Sirali, A., Karabuda, Z.C. and Mijiritsky, E., 2016. Three-dimensional assessment of volumetric changes in sinuses augmented with two different bone substitutes. *BioMed Res Int*, *2016*.
- Güngör, E. and Doğan, M.S., 2017. Reliability and accuracy of cone-beam computed tomography voxel density and linear distance measurement at different voxel sizes: A study on sheep head cadaver. *J Dent Sci*, *12*(2), pp.145-150.

H

- Hafeez, K., Wahaj, A., Zafar, M. S. & Shahab, S. 2015. Sinus lift grafting materials and immediate implant placement: A systematic review. *International Dental Journal of Student's Research IDJSR*, 3(2), pp.69-74.
- Hafez, W.K., Seif, S.A., Shawky, H. and Hakam, M.M., 2015. Platelet rich fibrin as a membrane for coverage of immediate implants: Case-series study on eight patients. *Tanta Dent J*, *12*(3), pp.203-210.
- Hong, K.L., Wong, R.C., Lim, A.A., Loh, F.C., Yeo, J.F. and Islam, I., 2017. Cone beam computed tomographic evaluation of the maxillary sinus septa and location of blood vessels at the lateral maxillary sinus wall in a sample of the Singaporean population. *J Oral Maxillofac Surg Med Pathol*, *29*(1), pp.39-44.
- Huang, J.I.S., Yu, H.C. and Chang, Y.C., 2016. Schneiderian membrane repair with platelet-rich fibrin during maxillary sinus augmentation with simultaneous implant placement. *J Formos Med Assoc*, *115*(9), pp.820-821.

- Hussein, L.A. and Hassan, T.A., 2017. The Effectiveness of Oxidized Regenerated Cellulose as a Graft Material in Transalveolar Osteotome Sinus Lift Procedure. *J Craniofac Surg*, *28*(7), pp.1766-1771.

J

- Jaju, P.P. and Jaju, S.P., 2014. Clinical utility of dental cone-beam computed tomography: current perspectives. *Clin Cosmet Investig Dent*, *6*, p.29-43.
- Joshi, C.P., Patil, A.G., Karde, P.A., Khedkar, S.U., Mahale, S.A. and Dani, N.H., 2016. Autologous Platelet Rich Fibrin as a potential antiperiopathogenic agent: An in-vitro study. *Int J Periodontol Implantol*, *1*(2), pp.50-54.

K

- Kao, D. W. 2014. *Clinical Maxillary Sinus Elevation Surgery*, John Wiley & Sons.
- Kao, S.Y., Lui, M.T., Cheng, D.H. and Chen, T.W., 2015. Lateral trap-door window approach with maxillary sinus membrane lifting for dental implant placement in atrophied edentulous alveolar ridge. *J Chin Med Assoc*, *78*(2), pp.85-88.
- Kawase, T., Kamiya, M., Kobayashi, M., Tanaka, T., Okuda, K., Wolff, L.F. and Yoshie, H., 2015. The heat-compression technique for the conversion of platelet-rich fibrin preparation to a barrier membrane with a reduced rate of biodegradation. *J Biomed Mater Res Part B: Applied Biomaterials*, *103*(4), pp.825-831.

- Kfir, E., Goldstein, M., Abramovitz, I., Kfir, V., Mazor, Z. and Kaluski, E., 2014. The effects of sinus membrane pathology on bone augmentation and procedural outcome using minimal invasive antral membrane balloon elevation. *J Oral Implantol*, *40*(3), pp.285-293.
- Kim, E.S., Moon, S.Y., Kim, S.G., Park, H.C. and Oh, J.S., 2013. Three-dimensional volumetric analysis after sinus grafts. *Implant Dent*, *22*(2), pp.170-174.
- Kobayashi, M., Kawase, T., Horimizu, M., Okuda, K., Wolff, L.F. and Yoshie, H., 2012. A proposed protocol for the standardized preparation of PRF membranes for clinical use. *Biologicals*, *40*(5), pp.323-329.
- Kumar, V., Abbas, A.K. and Aster, J.C., 2017. *Robbins Basic Pathology E-Book*. Elsevier Health Sciences.

L

- Lateef, T.A. and Asmael, H.M., 2016. An Assessment of the Efficacy of Sinus Balloon Technique on Transcrestal Maxillary Sinus Floor Elevation Surgery. *J Bagh Coll Dentistry*, *28*(1), pp.109-113.
- Lee, H., Lee, S.H., Kim, S.J., Choi, W.I., Lee, J.H. and Choi, I.J., 2015. Variations of the cubital superficial vein investigated by using the intravenous illuminator. *Anat cell biol*, *48*(1), pp.62-65.
- Lemos, C.A.A., Ferro-Alves, M.L., Okamoto, R., Mendonça, M.R. and Pellizzer, E.P., 2016. Short dental implants versus standard dental implants placed in the posterior jaws: A systematic review and meta-analysis. *J Dent*, *47*, pp.8-17.

- Lindh, C., Obrant, K. and Petersson, A., 2004. Maxillary bone mineral density and its relationship to the bone mineral density of the lumbar spine and hip. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, *98*(1), pp.102-109.
- Liversedge, R.L. and Wong, K., 2002. Use of the buccal fat pad in maxillary and sinus grafting of the severely atrophic maxilla preparatory to implant reconstruction of the partially or completely edentulous patient. *Int J Oral Maxillofac Implants*, *17*(3), pp. 424-428.

M

- Makary, C., Rebaudi, A., Menhall, A. and Naaman, N., 2016. Changes in Sinus Membrane Thickness After Lateral Sinus Floor Elevation: A Radiographic Study. *Int J Oral Maxillofac Implants*, *31*(2), pp. 331-337.
- Mavrodi, A. and Paraskevas, G., 2013. Evolution of the paranasal sinuses' anatomy through the ages. *Anat Cell Biol*, *46*(4), pp.235-238.
- Mazor, Z., Horowitz, R.A., Del Corso, M., Prasad, H.S., Rohrer, M.D. and Dohan Ehrenfest, D.M., 2009. Sinus floor augmentation with simultaneous implant placement using Choukroun's platelet-rich fibrin as the sole grafting material: a radiologic and histologic study at 6 months. *J Periodontol*, *80*(12), pp.2056-2064.
- Mazor, Z., Ioannou, A., Venkataraman, N. and Kotsakis, G., 2013. A minimally invasive sinus augmentation technique using a novel bone graft delivery system. *Int J Oral Implantol Clin Res*, *4*(2), pp.78-82.

- Meleo, D., Mangione, F., Corbi, S. and Pacifici, L., 2012. Management of the Schneiderian membrane perforation during the maxillary sinus elevation procedure: a case report. *Annali Di Stomatologia*, *3*(1), p.24-30.
- Misch, C.E., 2008. Contemporary implant dentistry. Mosby Elsevier. Ch: 3. P.48.
- Morand, M. and Irinakis, T., 2007. The challenge of implant therapy in the posterior maxilla: providing a rationale for the use of short implants. *J Oral Implantol*, *33*(5), pp.257-266.

N

- Naik, B., Karunakar, P., Jayadev, M. and Marshal, V.R., 2013. Role of Platelet rich fibrin in wound healing: A critical review. *J Conserv Dent: JCD*, *16*(4), pp.284-293.
- Nascimento, E.H.L., Pontual, M.L.A., Pontual, A.A., Freitas, D.Q., Perez, D.E.C. and Ramos-Perez, F.M., 2016. Association between Odontogenic Conditions and Maxillary Sinus Disease: A Study Using Cone-beam Computed Tomography. *J Endod*, *42*(10), pp.1509-1515.
- Nedir, R., Bischof, M., Vazquez, L., Szmukler-Moncler, S. and Bernard, J.P., 2006. Osteotome sinus floor elevation without grafting material: a 1-year prospective pilot study with ITI implants. *Clin Oral Impl Res*, *17*(6), pp.679-686.
- Nolan, P.J., Freeman, K. and Kraut, R.A., 2014. Correlation between Schneiderian membrane perforation and sinus lift graft outcome: a retrospective evaluation of 359 augmented sinus. *J Oral Maxillofac Surg*, *72*(1), pp.47-52.

O

- Ortega-Oller, I., Suárez, F., Galindo-Moreno, P., Torrecillas-Martínez, L., Monje, A., Catena, A. and Wang, H.L., 2014. The influence of implant diameter on its survival: a meta-analysis based on prospective clinical trials. *J Periodontol*, *85*(4), pp.569-580.
- Öncü, E. and Alaaddinoðlu, E., 2013. Effect of platelet-rich fibrin on osseointegration. *Int J Oral Maxillofac Surg*, *42*(10), pp.1265-1266.

P

- Pandit, A. and Chopra, S., 2016. Maxillary sinus floor elevation: review of anatomy and lateral sinus lift technique. *IOSR J Dent Med Sci*, *(15)1*, pp.29-33.
- Pauwels, R., Nackaerts, O., Bellaiche, N., Stamatakis, H., Tsiklakis, K., Walker, A., Bosmans, H., Bogaerts, R., Jacobs, R., Horner, K. and SEDENTEXCT Project Consortium, 2013. Variability of dental cone beam CT grey values for density estimations. *Br J Radiol*, *86*(1021), pp.20120135-20120135.
- Pommer, B., Busenlechner, D., Fürhauser, R., Watzek, G., Mailath-Pokorny, G. and Haas, R., 2016. Trends in techniques to avoid bone augmentation surgery: Application of short implants, narrow-diameter implants and guided surgery. *J Cranio-Maxillofac Surg*, *44*(10), pp.1630-1634.
- Pommer, B., Unger, E., Sütö, D., Hack, N. and Watzek, G., 2009. Mechanical properties of the Schneiderian membrane in vitro. *Clin Oral Implants Res*, *20*(6), pp.633-637.

- Proussaefs, P. and Lozada, J., 2003. The" Loma Linda pouch": a technique for repairing the perforated sinus membrane. *Int J Periodontics Restorative Dent*, *23*(6), pp.539-598.

R

- Rahpeyma, A. and Khajehahmadi, S., 2015. Open sinus lift surgery and the importance of preoperative cone-beam computed tomography scan: a review. *J Int Oral Health: JIOH*, *7*(9), pp.127-133.
- Rapani, M., Rapani, C. and Ricci, L., 2016. Schneider membrane thickness classification evaluated by cone-beam computed tomography and its importance in the predictability of perforation. Retrospective analysis of 200 patients. *Br J Oral Maxillofac Surg*, *54*(10), pp.1106-1110.
- Razi, T., Niknami, M. and Ghazani, F.A., 2014. Relationship between hounsfield unit in CT scan and gray scale in CBCT. *J Dent Res Dent Clin Dent Prospects*, *8*(2), p.107-110.
- Resnik, R. and Misch CE. 2017. Avoiding Complications in Oral Implantology. Elsevier. 1st ed. Ch:7.p. 290.
- Robiony, M., Tenani, G., Sbuelz, M. and Casadei, M., 2012. A simple method for repairing membrane sinus perforation. *Open J Stomatol*, *2*(04), pp.348-351.
- Rodrigues, A.F., da Silva Campos, M.J., Chaoubah, A., Fraga, M.R. and Vitral, R.W.F., 2015. Use of gray values in CBCT and MSCT images for determination of density: influence of variation of FOV size. *Implant Dent*, *24*(2), pp.155-159.
- Rodrigues, G. N., Katayama, A. Y. & Cardoso, R. F. 2010. Subantral Augmentation Utilizing the Zimmer® Sinus Lift Balloon Technique. Zimmer Dent Inc.

- Rosano, G., Taschieri, S., Gaudy, J.F., Weinstein, T. and Del Fabbro, M., 2011. Maxillary sinus vascular anatomy and its relation to sinus lift surgery. *Clin Oral Implants Res*, *22*(7), pp.711-715.
- Rossi, A.C., Freire, A.R., Perussi, M.R., Caria, P.H.F. and Prado, F.B., 2012. Use of homologous bone grafts in maxillary sinus lifting. *Int J Odontostomat*, *6*(1), pp.19-26.
- Rysz, M., Ciszek, B., Rogowska, M. and Krajewski, R., 2014. Arteries of the anterior wall of the maxilla in sinus lift surgery. *Int j oral maxillofac surg*, *43*(9), pp.1127-1130.

S

- Sakkas, A., Konstantinidis, I., Winter, K., Schramm, A. & Wilde, F. 2016. Effect of Schneiderian membrane perforation on sinus lift graft outcome using two different donor sites: a retrospective study of 105 maxillary sinus elevation procedures. *GMS Interdiscip Plast Reconstr Surg DGPW,* 5, pp. 2193-8091.
- Shahidi, Sh., Zamiri, B., Danaei, S. M., Salehi, S. & Hamedani, S. 2016. Evaluation of Anatomic Variations in Maxillary Sinus with the Aid of Cone Beam Computed Tomography (CBCT) in a Population in South of Iran. *J Dent, 17*(1), pp. 7-15.
- Sharan, A. and Madjar, D., 2008. Maxillary sinus pneumatization following extractions: a radiographic study. *Int J Oral Maxillofac Implants*, *23*(1), pp.48-56.
- Šimůnek, A., Kopecká, D., Brázda, T. & Somanathan, R. 2007. Is lateral sinus lift an effective and safe technique? Contemplations after the performance of one thousand surgeries. *Implantologie J.*

- Simonpieri, A., Choukroun, J., Del Corso, M., Sammartino, G. and Ehrenfest, D.M.D., 2011. Simultaneous sinus-lift and implantation using microthreaded implants and leukocyte-and platelet-rich fibrin as sole grafting material: a six-year experience. *Implant Dent*, *20*(1), pp.2-12.
- Sohn, D.S., 2011. New Bone Formation in the Maxillary Sinus With/Without Bone Graft.In *Implant Dentistry-The Most Promising Discipline of Dentistry*. InTech.pp.53-90.
- Sohn, D.S., Lee, J.S., Ahn, M.R. and Shin, H.I., 2008. New bone formation in the maxillary sinus without bone grafts. *Implant Dent*, *17*(3), pp.321-331.
- Sohn, D. S., Heo, J.U., Kwak, D. H., Kim,D. E. Kim, J.M., Moon, J.W. Lee, J.H. and Park, I. S. 2011. Bone regeneration in the maxillary sinus using an autologous fibrin-rich block with concentrated growth factors alone. *Implant Dent* 20, PP.389–395.
- Starch-Jensen, T., Aludden, H., Hallman, M., Dahlin, C., Christensen, A.E. and Mordenfeld, A., 2017. A systematic review and meta-analysis of long-term studies (five or more years) assessing maxillary sinus floor augmentation. *Int J Oral Maxillofac Sur*.
- Srouji, S., Ben-David, D., Lotan, R., Riminucci, M., Livne, E. and Bianco, P., 2010. The innate osteogenic potential of the maxillary sinus (Schneiderian) membrane: an ectopic tissue transplant model simulating sinus lifting. *Int J Oral Maxillofac Surg*, *39*(8), pp.793-801.
- Stojcev Stajcic, S., Stojkovic, G. 2008. Surgicel as a substitute for resorbable collagen membranes. *J Craniomaxillofac Surg.* 36,p.S224.

- Su, C.Y., Kuo, Y.P., Tseng, Y.H., Su, C.H. and Burnouf, T., 2009. In vitro release of growth factors from platelet-rich fibrin (PRF): a proposal to optimize the clinical applications of PRF. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, *108*(1), pp.56-61.
- Sul, S.H., Choi, B.H., Li, J., Jeong, S.M. and Xuan, F., 2008a. Histologic changes in the maxillary sinus membrane after sinus membrane elevation and the simultaneous insertion of dental implants without the use of grafting materials. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, *105*(4), pp.e1-e5.
- Sul, S.H., Choi, B.H., Li, J., Jeong, S.M. and Xuan, F., 2008b. Effects of sinus membrane elevation on bone formation around implants placed in the maxillary sinus cavity: an experimental study. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod*, *105*(6), pp.684-687.
- Summers, R.B., 1994. A new concept in maxillary implant surgery: the osteotome technique. *Compendium (Newtown, Pa.)*, *15*(2), pp.152-154.

T

- Tajima N, Ohba S, Sawase T, Asahina I., 2013. Evaluation of sinus floor augmentation with simultaneous implant placement using platelet-rich fibrin as sole grafting material. Int J Oral Maxillofac Implants. *28*(1), pp.77-83.
- Tanaskovitć, N., 2016. Use of platelet- rich fibrin in maxillofacial surgery. *Surgery*,*3*(1):45-50.
- Testori, T., Drago, L., Wallace, S. S., Capelli, M., Galli, F., Zuffetti, F., Parenti, A., Deflorian, M., Fumagalli, L. & Weinstein, R. L., 2012. Prevention and treatment of postoperative infections

after sinus elevation surgery: clinical consensus and recommendations. *Int J Dent*, 2012.1-5.

- Toffler, M., Toscano, N., Holtzclaw, D., Corso, M.D. and Ehrenfest, D.D., 2009. Introducing Choukroun's platelet rich fibrin (PRF) to the reconstructive surgery milieu. *J Implant Adv Clin Dent*, *1*(6), pp.21-30.
- Tolstunov, L., Thai, D. & Arellano, L., 2012. Implant-guided volumetric analysis of edentulous maxillary bone with cone-beam computerized tomography scan. Maxillary sinus pneumatization classification. *J Oral Implantol*, *38*(4), pp.377-390.
- Turri, A., Elgali, I., Vazirisani, F., Johansson, A., Emanuelsson, L., Dahlin, C., Thomsen, P. and Omar, O., 2016. Guided bone regeneration is promoted by the molecular events in the membrane compartment. *Biomaterials*, *84*, pp. 167-183.

V

- Valente, N.A., Harogiannis, K. and Andreana, S., 2015. Alveolar antral artery management during sinus elevation: A case report of a novel approach with review of the literature. *Int J Contemp Dent Med Rev*, *2015*.
- Vereanu, A. D., Tomescu, D., Savu, M. A., Sarafoleanu, C. 2015. Maxillary sinus augmentation - diagnostic and surgical technique. *J Transl Med Res 2*(20), pp.94-99.
- Vokurka, J., Gopfert, E., Blahutkova, M., Buchalova, E. and Faldyna, M., 2016. Concentrations of growth factors in platelet-rich plasma and platelet-rich fibrin in a rabbit model. *Vet Med*, *61*(10), pp.567-570.

W

- Wolff, C., Mucke, T., Wagenpfeil, S., Kanatas, A., Bissinger, O. & Deppe, H. 2016. Do CBCT scans alter surgical treatment plans? Comparison of preoperative surgical diagnosis using panoramic versus cone-beam CT images. *J Craniomaxillofac Surg*, *44*(10), pp.1700-1705.

Z

- Zhao, J.H., Tsai, C.H. and Chang, Y.C., 2015. Clinical application of platelet-rich fibrin as the sole grafting material in maxillary sinus augmentation. *J Formos Med Assoc*, *114*(8), pp.779-780.
- Zijderveld, S.A., van den Bergh, J.P., Schulten, E.A. and Christiaan, M., 2008. Anatomical and surgical findings and complications in 100 consecutive maxillary sinus floor elevation procedures. *J Oral Maxillofac Surg*, *66*(7), pp.1426-1438.
- Zumstein, M.A., Bielecki, T. and Ehrenfest, D.M.D., 2011. The future of platelet concentrates in sports medicine: platelet-rich plasma, platelet-rich fibrin, and the impact of scaffolds and cells on the long-term delivery of growth factors. *Oper Tech Sports Med*, *19*(3), pp.190-197.

Appendix I

Sinus lift case sheet

Name: Age: gender:

Occupation: Telephone No. Date:

Medical history:

Dental history:

Smoking:

Tooth (teeth) to be replaced

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
32	31	30	29	28	27	26	25	24	23	22	21	20	19	18	17

Preoperative CBCT examination:

- Residual bone height……
- Density…….
- Buccopalatal dimensions……
- Sinus pneumatization classification……..
- Schneiderian membrane thickness ……
- Sinus septa……

Surgical phase:

Side of sinus lift right …… left……

Treatment protocol one-stage…… two-stage…….

Dental implant system ……

No. of dental implants to be placed ……..

Dental implant dimensions ……..

Amount of collected blood …….. mL

Centrifugation time ……. min speed ……rpm

No. of PRF clots: ……..

Intraoperative complications:

Schneiderian membrane perforation……

Bleeding …….

Others……..

1st post-operative appointment (2 weeks following surgery):

Infection…… nasal bleeding…… pain…… edema…….

Wound dehiscence……. nasal obstruction &/or congestion……..

Ecchymosis (infraorbital, periorbital)…….

Others

2nd postoperative appointment (6 months following surgery):

- Submembraneous bone height
- Density

Complications

اني المريض ..... موافق على اجراء عملية زراعة الاسنان ورفع الجيوب الفكية في كلية طب الاسنان جامعة بغداد \وحدة زراعة الاسنان \وقد تم ابلاغي بجميع تفاصيل العملية وعواقبها الايجابية والسلبية.

التوقيع.....

Appendix II Dental Implant Case Sheet

College of Dentistry – Baghdad University

Department of Oral & Maxillofacial Surgery- Dental Implantology

Name:

Age:

Gender:

Occupation:

Telephone No.

Address:

Date:

General Health: BHP 1 2 3

Patient Interrogation: Obsessional neurosis - Availability

Esthetic demands: (realistic - high - unrealistic)

Etiology of Edentulism: caries- trauma- periodontal disease-occlusal trauma

Extraoral Exam: Smile line → dental - gingival

Intraoral Exam:

Missing teeth to be replaced by DI:

Hygiene: good - moderate - poor

Pathology: no - yes

Depth of vestibule: good - moderate - poor

Alveolar crest width: wide - sharp

Vestibular concavity: no - yes

Jaw opening: 3 fingers - 2 fingers - 1 finger

Interarch distance at maximal opening: mm

Mesiodistal distance: mm

Height between alveolar crest and opposing teeth or ridge: mm

Vertical bone resorption: no - yes

Gingiva: thick & fibrous - fine

Papillae of adjacent teeth: flat - scalloped

Periodontal evaluation: gingivitis - treated periodontitis - active periodontitis

Functional evaluation: bruxism - parafunction – no

Radiographic Exam: OPG - CT - Periapical - Others

Chronic lesions: close to implant zone - distant from implant zone

Bone density: D1 (type I) - D2 (II) - D3 (III) - D4 (IV)

Vertical bone resorption: no - yes

Study models surgical template

Surgical (operative) data:

Treatment protocol → I (delayed) - II (intermediate) - III (immediate)

Jaw operated upon → maxilla - mandible

DI system: No of DI

DI dimensions:

Surgical approach →

Level of DI in relation to crest:

Bone expansion: bone condensation:

GBR→ barrier membrane space filler

Bone grafting:

Sinus Lift:

Surgical notes:

……

……

Length of healing phase:

2nd stage surgery:

Uncoverage → tissue punch scalpel others

Gingival former dimensions→

Follow-up and maintenance:

Complications:

Appendix III

موافقة المريض للاشتراك في البحث العلمي

اسم الباحث:

عنوان البحث:

مكان اجراء البحث:

انت مدعو/ة للمشاركة ببحث علمي سريري سيجرى في_____

الرجاء ان تأخذ/ي الوقت الكافي لقراءة المعلومات التالية بتأن قبل أن تقرر/ي (اذا كنت تريد/ين المشاركة أم لا .بامكانك طلب إيضاحات أو معلومات اضافية عن أي شيء مذكور في الاستمارة أو عن هذه الدراسة ككل من طبيبك في حال وافقت على المشاركة في هذه الدراسة، سيبقى اسمك طي الكتمان.لن يكون لأي شخص، مالم ينص القانون على ذلك حق الاطلاع على ملفك الطبي باستثناء الطبيب المسؤول عن الدراسة او معاونيه.

موافقة المشترك:

لقد قرأت استمارة القبول هذه وفهمت مضمونها. تمت الاجابة على أسئلتي جميعها .وبناءا عليها فأنني حرا مختارا، أجيز اجراء هذا البحث و أوافق على الاشتراك فيه واني أعلم ان الباحث الدكتور _____وزملاءه ومعاونيه او مساعديه سيكونون مستعدين للإجابة عن أسئلتي وأنه باستطاعتي الاتصال بهم على الهاتف _____ ، كما أعرف تمام المعرفة بانني حر في الانسحاب من هذا البحث متى شئت حتى بعد التوقيع على الموافقة دون ان يؤثر ذلك على العناية الطبية المقدمة لي.

اسم المشترك:

توقيع المشترك:

Appendix IV

Participation approval in a clinical study

Name of researcher

Location of the surgical procedure

Mr. /Ms. _____ you are requested to participate in a clinical research in the College of Dentistry/University of Baghdad/Dental Implantology Unit. You have the right to accept or refuse the involvement in the current study after reading the details of the procedure that will be explained by the researcher.

Any information mentioned in your file will be classified as no one has the authority to see it unless authorized by the law.

Signing the consent:

I'm Mr. /Ms. _____ signed this consent after readings all the details related to the surgical procedure and the possible postoperative complications after every vague been clarified by the researcher and I signed in full freedom and consciousness.

Name and signature of the participant

الخلاصة

الخلفية: ان اعادة تأهيل الجزء الخلفي من الفك الاعلى يتزعزع بتناقص طول العظم المتبقي والذي يكون رقيق بطبيعته اصلا مما يؤثر بصورة عكسية على الثبوتية الاولية للزرعة السنية. تعتبر زيادة عظم ارضية الجيب الانفي عملية متوقعة النتائج حول امكانية توفير كمية العظم المطلوبة لتنصيب الغرسات السنية. ان عملية تجديد العظم طبيعيا لملء الفراغ المتكون تحت الجيوب الأنفية بعد عملية رفع غشاء الجيب الأنفي قابلة للتحسين عن طريق استعمال الفايبرين الغني بالصفيحات بوصفها خثرة دموية مثالية حيث انها تعمل كسقالة تمهد لتكوين عظم جديد مع الاخذ بنظر الاعتبار القابلية الكامنة لتكوين العظم الموجودة في الطبقة الشبيهة بالسمحاق للغشاء الجيبي الانفي (غشاء شنايدر).

الهدف: ان الغرض من هذه الدراسة هو تقييم فعالية الفايبرين الغني بالصفيحات كطعم منفرد مع غرس الزرعات السنية بالتزامن مع عملية رفع الجيوب الانفية او بعد فترة الشفاء وذلك من خلال تقييم ارتفاع وكثافة العظم المتكون تحت الغشاء الجيبي المرفوع بالتصوير الشعاعي.

المواد وطرائق العمل: اجريت ١٧ عملية تنصيب لزرعات سنية بالتزامن مع رفع الجيوب الانفية (جراحة احادية الطور) ل١٤ حالة بينما اجريت ٥ حالات بدون تنصيب الزرعات السنية (جراحة ثنائية الطور) باستخدام الفايبرين الغني بالصفيحات كطعم حيوي منفرد.اشرك في الدراسة ١٠ ذكور و٦ اناث تتراوح اعمارهم بين (٢٩-٦٥) سنة وبمعدل ٤٨,٨٨ سنة. اجري فحص شعاعي لكل مريض قبل العملية الجراحية باخذ اشعة البانوراما والمفراس المخروطي لغرض التقييم الاولي لارتفاع العظم السنخي المتبقي. بعد مرور ٢٤ أسبوع على اجراء العملية تم اجراء فحص شعاعي اخر بالمفراس المخروطي لحساب الارتفاع النهائي للعظم المتكون تحت الغشاء الجيبي الانفي مع تقييم كثافته.

النتائج: ستة عشر من المرضى المتتابعين بمعدل عمر ٤٨,٨٨ سنة استقبلت ١٤ حالة منهم ١٧ زرعة سنية في منطقة الجيوب الانفية. جميع الزرعات السنية غرست في عظم سنخي ضامر بارتفاع ٣,٠٠-٦,٠٠ ملم (المعدل ± الانحراف المعياري ٤,٤٦±١,٢٥ ملم)، وبالنسبة للجراحة ثنائية الطور فقد كان ارتفاع العظم السنخي الضامريتراوح بين ٠,٥_ ٢,٩٠ ملم (المعدل ١,٩٢±١,٠٨).

بلغ معدل ارتفاع العظم تحت الغشائي (ارتفاع العظم السنخي الضامر+ ارتفاع العظم حديث التكوين) في موقع كل زرعة سنية ١٢,٤٤±٠,٩٩ملم (يتراوح بين ١٠,٧٠-١٣,٩٠ملم)

للجراحة احادية الطور، وبلغ معدله ٤,٩٣±١,٦١ملم (يتراوح بين١,٢٠-٧,٢٠ملم) في حالات الجراحة ثنائية الطور، وهذه النتئائج ذات تأثير معنوي عالي احصائيا عند القيمة الاحتمالية٠,٠٥. بلغ معدل كثافة العظم حديث التكوين في حالات الجراحة احادية الطور ٤٠٨,٢٨±١٦٩,٨٩ وحدة هاونسفيلد والتي تقع ضمن حدود الكثافة من الصنف الثالث حسب مقياس ميش ،بينما كانت كثافة العظم حديث التكوين للحالات التي خضعت للجراحة ثنائية الطور بمعدل ١٨٣,٦٠±٩٧,٦٧ وحدة هاونسفيلد والتي توضع ضمن الكثافة من الصنف الرابع. كانت الفترة مابعد اجراء العملية خالية من اي مضاعفات وجميع الزرعات كانت ثابتة بعد مرور ٢٤ اسبوع على اجراء العملية. أظهرتحليل النتائج بالتصوير الشعاعي وجود علاقة معنوية عالية للارتفاع النهائي للعظم تحت الغشائي مع الزرعات ذات الاكثر طولا. لم يحصل تغيير معنوي ملحوظ احصائيا فيما يخص مقدار سمك غشاء شنايدر وبالرغم من ذلك يجدر القول انه ٢٦,٣٢% من الحالات التي زاد فيها سمك الغشاء عن ٢ ملم ما قبل التداخل الجراحي، شفيت تماما بعد اجراء العملية.

الاستنتاجات: الفايبرين الغني بالصفيحات بصفته خثرة دموية مثالية يعتبر مادة حيوية سهلة التحصيل وغير مكلفة وتحسن من جودة تجديد العظم طبيعيا حول الزرعات السنية. من الناحية السريرية والدراسة الاشعاعية بعد مرور ٢٤ اسبوعا من عملية رفع الجيوب الانفية وجد انه استخدام مادة الفايبرين الغني بالصفيحات كطعم منفرد بالتزامن مع تنصيب الزرعات السنية سوف ينتج عنه عظم ذا جودة وارتفاع عالي يمتد الى قمة الزرعات السنية وبكثافة مقارنة لما هو عليه في الجزء الخلفي من الفك العلوي. بالرغم من قدرة مادة الفايبرين الغني بالصفيحات على تكوين عظم جديد في الحالات التي اجري لها جراحة ثنائية الطور الا ان قدرتها على حفظ الفراغ تحت غشاء شنايدر المرفوع تبقى غير واضحة وتحتاج لمزيد من الدراسة.

جمهورية العراق
وزارة التعليم العالي والبحث العلمي
جامعة بغداد-كلية طب الأسنان

فعالية الفايبرين الغني بالصفيحات كطعم لرفع الجيب الأنفي عن طريق النافذة الجانبية

رسالة مقدمة الى مجلس كلية طب الاسنان في جامعة بغداد كجزء من متطلبات نيل شهادة
الماجستير في جراحة الفم والوجه والفكين
قدمت من قبل

دنيـــا سعد محمد فتحي
بكالوريوس طب وجراحة الفم والأسنان

إشراف
أ.م.د. ثائرعبد اللطيف حسن
بكالوريوس طب وجراحة الفم والاسنان
دبلوم عالي جراحة الفم والوجه والفكين
بورد جراحة الوجه والفكين

١٤٣٩هـ ٢٠١٨م