PROSPECTIVE EVALUATION OF RIDGE AUGMENTATION IN THE POSTERIOR MAXILLA BY HYDRAULIC PRESSURE INDIRECT SINUS LIFT METHOD

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CERTIFICATE

This is to certify that this dissertation titled **"PROSPECTIVE EVALUATION OF RIDGE AUGMENTATION IN THE POSTERIOR MAXILLA BY HYDRAULIC PRESSURE INDIRECT SINUS LIFT METHOD"** is a bonafide record of work done by **Dr. A. PREETHI** under my guidance and to my satisfaction during her Post Graduate study period of 2016-2019. This dissertation is submitted to **THE TAMILNADU Dr. MGR MEDICAL UNIVERSITY,** in partial fulfillment for the award of the degree of **MASTER OF DENTAL SURGERY** in Branch III- **ORAL AND MAXILLOFACIAL SURGERY.** It has not been submitted (partially or fully) for the award of any other degree or diploma.

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TABLE OF CONTENTS

INTRODUCTION

The success of dental implants in prosthetic rehabilitation is to favorably position the implants into the alveolar bone, overcoming any shortfalls like inadequate bone quantity. Implant placement in posterior maxilla poses a challenge due to faster resorption rate and position of floor of the maxillary sinus due to pneumatization. Inadequate height of bone in this region needs augmentation of bone height by repositioning the sinus floor superiorly. This process is termed sinus lift. Of all the prosthodontic treatment options available to replace a missing tooth, implants provide a more predictable treatment course than traditional methods.

The dental implants invention dates back to ancient Egypt more than 3000 years ago, where stones, bones, Nobel metals or carved seashells were used as implants. In 1948, Dr. Aaron Gershkoff invented the first successful sub-periosteal implant. In 1957, an orthopedic surgeon Dr. Per-Ingvar Branemark studied the bone healing and regeneration and discovered the effective adherence of the newly formed bone to the surface of titanium implants without being rejected and he termed this phenomenon as “Osseo-integration”[1].

An essential requirement for successful dental implant therapy is the presence of an adequate quantity and quality of bone. When there is advanced ridge resorption, it would prohibit the placement of implant. This problem is usually magnified in the maxillary posterior alveolar ridge as this region is accompanied by the maxillary sinus superiorly[2]. For many patients, edentulous posterior maxilla presents with inadequate bone volume and reduced vertical subsinosal bone height (i.e., between the floor of the sinus and the crest of the edentulous ridge) making it inadequate to receive an implant.

Various methods are being practiced in advanced implantology to overcome the problem of inadequate bone height in the subsinosal region. This includes mini implants, zygomatic implants and pre-prosthetic surgical procedures like ridge or sinus augmentation. Short implants can be preferably placed in regions where the bone is dense[3]. Although Zygomatic implants provide a good solution for completely resorbed ridges, the placement of these implants are limited by the anatomy of the zygoma and requires high technical expertise[4]. Bone augmentation surgery is suggested in regions where the interocclusal clearance is more than the optimum required level for the accommodation of crown.

In the last 30 years, many implant surgeons made attempts to enter the cavity of the maxillary sinus, to elevate the schneiderian membrane. The different techniques of sinus lift include direct techniques like lateral window approach and indirect techniques like osteotomy technique, antral membrane balloon elevation (AMBE) and hydraulic pressure sinus lift[5].

Maxillary sinus floor elevation was first done by lateral window approach by Dr.Hilt Tatum in 1975. He described the technique at the Alabama implant conference in 1976 and was then published by Boyne and James in 1980. In this technique, a bony window is created surgically in the lateral wall of the maxillary sinus followed by elevation of the Schneiderian membrane and the gap created was packed with autogenous bone from the iliac crest[6].

In 1988, Tomaso Vercellotti invented the piezoelectric bone surgery and in the same year Torrella et al. used of piezoelectric tips for the direct sinus elevation which avoided inadvertent perforation of sinus membrane[7].

In 1994, Summer introduced the transcrestal osteotomy technique of indirect sinus lift. The original concept of this technique uses a set of osteotomes of various diameters to create a "green-stick fracture" by hand tapping force in the vertical direction. Thus it lifts the membrane by tapping motion to create a "tent"[6].

The antral membrane balloon elevation (AMBE) is a minimally invasive procedure first performed by Muronoi in 2003[8] to elevate the Schneiderian membrane gradually while optimally maintaining its integrity. This technique is relatively safe with less postoperative bleeding or discomfort[8].

A newer technique used for the indirect sinus lift is the hydraulic pressure technique proposed by Emmanouil G. Sotirakis et al. in 2005, which facilitates detachment of the sinus membrane through injection and aspiration of a fluid into the subsinosal area through the crestal osteotomy created by sequential drilling, followed by placement of a suitable graft material in sub-Schneiderian space[9]. This technique is advantageous over all the other methods of sinus lift as it is minimally invasive and has greater precision[5].

In all the above techniques, the sub-schneiderian space created, that would both act as a scaffold and help in Osseo induction as well. The most effective graft material of choice after the autograft is the sticky bone graft which is a combination of platelet rich fibrin derived from the patient's venous blood and bone particles[10].

The ideal choice of investigation for a sinus lift surgery is the cone beam computed tomography (CBCT), as it gives a three dimensional volumetric imaging with a considerably less exposure to radiation, unlike conventional computed tomography[11,12]. Due to complex anatomy of maxillary sinus[13] and adjacent structures[14] and for proper treatment planning, IOPA, OPG and CBCT were used.

In our study, a minimally invasive crestal approach sinus lift surgery with hydraulic pressure technique was done in patients who had reduced residual alveolar ridge height, inadequate for implant placement. Sticky bone graft prepared using autologous bone mixed with freshly prepared autologous PRF and xenograft was used to fill the subsinosal space created by sinus lift procedure, followed by immediate implant placement. CBCTs were used for diagnosis, treatment planning and preoperative assessment and for a follow up at 6 months post operatively to compare the changes in bone height and bone density to confirm the success of this recent technique.

AIM AND OBJECTIVES

AIM

Prospective evaluation of ridge augmentation in the posterior maxilla following hydraulic pressure indirect sinus lift in combination with sticky bone graft and immediate placement of endosseous implants with the help of Cone Beam Computed Tomography.

OBJECTIVE

1. To evaluate the efficacy of the crestal approach hydraulic pressure sinus lift.
2. To assess the intraoperative feasibility and ease of the sinus floor elevation by crestal approach hydraulic pressure sinus lift.
3. To estimate the effectiveness of sticky bone when used as a subsinosal filling material after crestal approach hydraulic sinus lift.
4. And to confirm the outcome of the procedure.

REVIEW OF LITERATURE

A classification for the treatment of edentulous posterior maxilla based on the amount of bone available between the floor of the antrum and the crest of the alveolar ridge was given by Misch in 1987[15]. According to which, SA1 (12 mm) is an adequate vertical bone for implants and no manipulation of sinus is required. SA2 (0-2 mm) is less than the ideal height of bone and may require surgical correction. SA3 (5-10 mm) requires sinus augmentation after which implants can be installed immediately. In SA4 (< 5 mm) implants can be placed only after a sufficient healing period for graft maturation.

The changes in the function of the maxillary sinus after a lateral sinus lift procedure done for implant insertion was studied by Nicolaas M et al (1997)[16]. In about 85 patients, 29 sinuses had perforations during the procedure. But none of the patient experienced wound dehiscence or loss of bone particles through the nose. 1 patient had a change in the voice resonance post operatively. 2 patients developed sub-acute maxillary sinusitis. The occurrence of postoperative chronic sinusitis appears to be limited only to patients who had a predisposition for this condition pre operatively. None of the other patients developed chronic sinusitis.

A comparative study between three procedures, the lateral antrostomy as a two-step procedure, the lateral antrostomy as a one-step procedure and the osteotome technique with a crestal approach was done by Nicola U. Zitzmann et al (1998)[17]. Crestal approach are recommended, when more than 6 mm of residual bone height is present and an increase of about 3 to 4 mm is expected. In cases of more advanced resorption a one-step or two-step lateral antrostomy is performed which is technically demanding with advantage to place implants with the elevated schneiderian membrane visibly. when an average increase in bone height of 3 to 4 mm needed, the osteotome procedure technique found to be suitable for elevating the antral

membrane. Where resorption is more advanced, a lateral antrostomy procedure is required for the sake of ending up with a sufficient bone height for adequate implant length. Clinical results and the histologic evaluation demonstrate that Bio-Oss is a useful scaffold for bone regeneration. It has the advantages of being stable and having an osseoconductive property that allows for direct contact with newly formed bone. The resorptive process of the Bio-Oss appears to proceed slowly, enough to provide sufficient time for bone maturation.

In a comparative study Paul A. Fugazzotto, James Vlassis et al (1998)[18] performed 222 sinus augmentation procedures using one of three techniques: crestal approach (28 patients); lateral approach (110 patients); or lateral approach with simultaneous implant placement (84 patients). Here a sinus augmentation was deemed successful if sufficient bone was generated to allow placement of an implant of at least 11 mm in length entirely in the bone. All 28 of the crestal approach sinus augmentations were successful, while 97.3% of the lateral approach and 97.5% of the lateral approach with simultaneous implant placement after sinus augmentations were successful. The study concluded that crestal approach was the most successful method for sinus augmentation for implant placement.

The incidence, height and location of antral septa and their clinical implications were reported by Gerald Krennmair et al (1999)[15]. Antral septa constitute partly congenital and partly acquired structures; congenital septa are referred to as primary septa. These primary septa develop in all the regions of the sinus and they evolve during the growth of middle third of face. The pneumatization of sinus and resorption of alveolar ridge at different rates due to the variations in the tooth loss pattern leads to the septa formation. A primary septum poses a major challenge for any type of surgery involving the maxillary sinus as it is more

pronounced. Secondary septae poses problems in sinus lift surgeries where the floor is elevated with bone grafts after infracturing the facial antral wall. Septa are More common and shorter in edentulous atrophic maxillae than in dentate maxillae. CT scanning is the best method for detecting the sinus septae. Panoramic radiography has less sensitivity compared to CT scanning to detect sinus septa.

A technique in which a calibrated trephine bur with a 3mm external diameter was used to initially prepare the sinus lift site followed by using an osteotome to collapse a core of posterior maxillary alveolar bone by gentle malleting forces to elevate the sinus membrane before placing an immediate implant was presented by Paul A. Fugazzotto et al (2002)[19]. So this technique will lessen the possibility of imploding of the bone core into the sinus as malleting forces need not be as high as used in the traditional summer's technique. This utilization of a combined trephine and osteotome allows a comparatively atraumatic implosion of autogenous alveolar bone and thus apical displacement of the floor of sinus, in preparation for placement of immediate implant.

The elevation of the maxillary sinus floor using hydraulic pressure was proposed Emmanouil G. Sotirakis et al (2005)[9]. It is similar to Summer's technique and uses a specific sequence of osteotomes to deepen and widen the osteotomy site and in-fracture the floor of sinus. Sinus floor elevation was achieved by injecting normal saline under hydraulic pressure beneath the membrane with a syringe. Thus, simultaneous detachment and elevation of the membrane was achieved. It was first done on hen's eggs, then human cadavers and finally on patients. After determining the required hydraulic force required to elevate the sinus by invitro trials, 11 clinical cases were performed, and 13 implants were placed in the elevated and grafted sinuses. There were no implant losses in any of the clinical cases. This technique

combines the advantages of the Caldwell-Luc window approach that allows the placement of high bone graft volume and the ease of the osteotome technique.

Leon Chen et al (2005)[20] retrospectively evaluated 1,100 patients who received 1,557 implants by a minimally invasive hydraulic sinus condensing technique. Sinus burs and condensers of increasing width were used with pliable atraumatic bone grafting mixture and hydraulic pressure from a surgical handpiece. The results showed that 8 implants failed and 14 required longer healing periods in patients with alveolar ridge heights varying between <1 to 5 mm. They suggested that hydraulic sinus lift is a predictable alternative for prosthetic rehabilitation of maxillary posteriors in the presence of anatomical restrictions to implant placement.

The incidence of Paroxysmal Positional Vertigo (PPV) that occurred during Summer's method of osteotome sinus floor elevation was reported by Michele Di Girolamo, Bianca Napolitano et al (2005)[21]. They investigated the correlation between PPV and the intraoperative trauma induced by the percussive and vibratory forces on the maxilla during the osteotome sinus floor elevation for implant placement. It was hypothesized that the surgical trauma and the pressure exerted by the mallets leads to the detachment of otoliths in the utricular macula. The patient head position (hyperextended and tilted opposite to the side where the surgeon is working) favors these free-floating otoliths to enter the posterior semicircular canal on the side of implant surgery. The symptoms of PPV are very unpleasant and stressful for the patient and it could be solved by Epley re-positioning maneuver.

The ENT assessment that has to be done for patients who require sinus lift surgery for implant placement was proposed by L. Pignataro et al (2008)[22]. They proposed that the treatment planning for sinus lift should include the careful

preoperative identification of any conditions contraindicating the procedure. If any naso-sinusal disease is suspected, a clinical assessment which should include nasal endoscopy, a computed tomography of the maxillofacial region, particularly the ostio-meatal complex should be done. This first step, i.e., preventive-diagnostic step should be done to detect contraindications to a sinus lift, whereas the next (preventive-therapeutic) step is aimed at correcting contraindications such as phlogistic-infective diseases, middle meatal anatomical structural impairments and benign naso-sinusal neoplasms, the correction of which will restore the physiological drainage and ventilation of sinus.

The success and survival rates of implants placed by Summer's osteotome technique based on peri-implant soft tissue parameters was analysed by Bjarni E. Pjetursson et al (2009)[23], marginal bone and the patient-centered outcome by comparing with the traditional lateral window technique. 252 dental implants were inserted in 181 patients. In addition to the clinical examination, a visual analogue scale was used to analyze the perception of the patients about the procedure. According to the most important parameter, the residual bone height, there was a success rate of 91.3% for sites with 4mm residual bone height and 90% for sites with 5mm, compared to that of 100% in sites with bone height of >5mm. Soft tissue parameters including pocket probing depth, probing attachment level, bleeding on probing and marginal bone levels did not yield any difference between the osteotome-installed and the conventionally placed implants. More than 90% of the patients were satisfied with the procedure and reported that, if necessary, they would undergo the therapy again. Thus it was concluded that the osteotome technique was a reliable method in the posterior maxilla, especially at sites with a relatively flat sinus floor and 5mm or more of preoperative residual bone height.

In their study Ziv Mazor, Robert A et al (2009)[24] assessed the efficacy of PRF as the sole filling material in a lateral sinus lift with immediate implant placement, using radiologic and histological evaluation. Choukroun's method was used to derive the platelet-rich fibrin (PRF). It was reported that PRF releases numerous growth factors like transforming growth factor, platelet-derived growth factor, vascular endothelial growth factor and matrix glycoprotein for at least 7 days when evaluated in vitro. From a radiologic and histological perspective, 6 months after surgery, it was concluded that the use of PRF as the sole filling material during a sinus lift and implantation helped to stabilize a high volume of natural bone regeneration in the sub sinus cavity even up to the tip of the implants.

It was proposed by Lars-Åke Johansson et al (2010)[25] that mere lifting of the sinus membrane by implants protruding into the cavity of sinus allows the establishment of a void for blood clot and formation of new bone. They evaluated bone formation after using a perforated, hollow hydroxyapatite space-maintaining device of 12 mm diameter. 3 patients requiring implant rehabilitation with subantral height of 1–2 mm was selected. The device and bone formation was evaluated by CBCT, 6 months after the procedure. The implant sites were drilled with a trephine to get a specimen of the bone from the device and evaluated histologically which revealed bone formation inside device. After implant installation, the sinus membrane near the device was evaluated endoscopically. Bone formation was found in all three patients around the device. All the implants were stable and there was no marginal bone loss after 1 year of loading. It was concluded that hydroxyapatite space-maintaining device can be used effectively in sinus lift surgery.

A study to evaluate the outcome of the use of bone grafts harvested from adjacent site during maxillary sinus floor elevation and simultaneous implant

placement was conducted by Lars-Åke Johansson, Sten Isaksson et al (2010)[26]. In one group, a 'bone trap' was used to collect the bone debris during drilling for implant preparation, in the other group, a 'bone scraper' was used to collect autologous bone from the zygomatic buttress. It was found that harvesting of particulate bone chips from the zygomatic buttress is a reliable technique. They concluded that bone grafts can be locally collected near maxillary sinus lift procedure site to enable successful placement and loading of implants.

In a retrospective study Yifat Manor et al (2010)[27] assessed the incidence of late signs and symptoms such as maxillary sinusitis after sinus lift surgery in 137 patients, 12 – 80 months after surgery and correlated them with predisposing factors. It was aided with a questionnaire, clinical and radiographic examination. Intraoperative complications recorded were excessive bleeding and sinus membrane perforation. Immediate postoperative complications recorded were infection of the graft, acute sinusitis, and implant failure. Late postoperative complications were identified by imaging and with the help of otolaryngologist. They have found that the occurrence of postoperative chronic sinusitis occurred in the patients with history of preoperative sinusitis and thick mucosa, despite control of the disease. And it was also found that intraoperative surgical complications have negligible effect. So, the patients presenting with preoperative sinusitis should be followed-up regularly and prompt treatment should be administered when the patient has symptoms of sinusitis.

D.Rickert, S.Sauerbiern et al (2011)[28] assessed whether any differences in formation of bone after maxillary sinus lift surgery with bovine bone mineral (Bio-oss) mixed with Autogenous bone or Autogenous stem cells in patients requiring bilateral sinus augmentation for implant placement. They histologically evaluated the percentage of new bone formed after three months. It was detected that Mesenchymal

stem cells seeded on Bio-oss particles induce the formation of a sufficient new bone volume in the subsinosal space created by the sinus lift surgery to enable the placement of implants in the appropriate time frame compared with that of applying either autogenous bone alone or a mixture of Bio-oss and Autogenous bone.

A Controlled Hydrostatic Sinus Elevation procedure was explained by Daniel W. K. Kao et al (2011)[29]. An osteotomy hole is created using the traditional method. A Luer-Loc cannula with tapered plug-in end of 2 mm diameter is placed in the osteotomy hole and pressed snugly. There must be an air tight interface between the bone and cannula to prevent any lateral leak of the saline solution used for the sinus lift. The isotonic saline fluid is pushed slowly and this gentle pressure will cause the elevation of Schneiderian membrane through the hydrostatic pressure delivered from the hand-activated pump. The pressure sensor meter will monitor the pressure. The hydrostatic pressure is under the control of surgeon and can be constantly monitored by the pressure meter which will prevent the surgeon from delivering excess pressure that might perforate the membrane. The controlled hydrostatic sinus lift procedure allows smooth, evenly applied force through gentle fluid pressure to elevate the Schneiderian membrane.

A flapless, CBCT-guided transcrestal sinus floor elevation technique with immediate implant placement was evaluated by Jan Fornell et al (2011)[30.] Here the preoperative CBCTs were taken using titanium screws as markers and during the surgery the titanium screws are removed and a tissue punch was used to create a hole in the soft tissue through which the transcrestal osteotomy was preceded. No flap was raised for the surgery. They concluded that flapless crestal sinus lift procedures guided by preoperative CBCTs can be performed successfully for implant placement.

Successful loading and healing of implants with increase in bone height in the range of 2.6 – 8.9 mm was achieved.

A histological and clinical evaluation of maxillary sinus lift using fresh frozen bone chips in presence of sinus cyst was reported by Alessandro Acocella et al (2012)[31]. Maxillary antral cyst is a common benign pathology that contraindicates sinus lift surgery according to many authors. In the bioptic specimen evaluated post operatively, there was no sign of inflammatory cells and newly-formed bone in contact with the existing bone along with active bone remodeling was found. The pre-existent bone was covered fully by newly-formed bone and it was well organized in numerous mature lamellae and was concluded that the presence of pseudocysts in the maxillary sinus is not an absolute contraindication for maxillary sinus augmentation surgery for implant rehabilitation.

The effectiveness of Water Lift System and its capability to reduce the risk of schneiderian membrane perforation in the sinus membrane elevation surgery was evaluated by Dae Y. Kim et al (2012)[32]. 70 sinus lift surgeries were performed using aqua lifter by lateral or crestal approach. Out of 66 cases done by crestal approach, sinus membrane perforation occurred in only 2 cases (during elevation of the membrane by excessive hydraulic pressure). It was concluded that aqua Lift System deserves to be considered as a sinus elevation surgical Autogenous, owing to its feature of less membrane perforations due to controlled administration of hydraulic pressure.

A comparatively evaluated the effectiveness of traditional and the transcrestal sinus floor elevation with a minimally invasive smart lift procedure was done by Leonardo Trombelli et al (2012)[33]. A Guide Drill was used to create a pilot hole,

where the Smart Lift Drill was subsequently inserted producing a bone core up to the sinus floor. The bone was malleted to infracture the floor by means of a calibrated Elevator. The limited invasiveness of the technique was reflected on the low Visual Analogue Scale scores for pain/discomfort and also by the limited use of rescue analgesics during the first week following the procedure. The results showed that this technique provides a predictable elevation of the maxillary sinus floor with lesser post-surgical complications.

M. Arasawa, Y. Oda et al (2012)[34] conducted a study to establish an objective method for evaluation of bone volume changes quantitatively after sinus augmentation that was done by lateral window technique. 11 sinuses in 9 patients were examined by CT images taken before the procedure and 3 months and at least 1 year after sinus lift surgery. With the help of 3D digital subtraction technique, images of the augmented bone were extracted and the bone volumes were calculated from voxel numbers. The mean augmented bone volumes at 3 months and 1 year post operative were 2.46 cm^3 and 1.85 cm^3 respectively. Loss of augmented bone was found in all patients except one. These correlations indicated that bone resorption progressed with time after sinus augmentation procedure. The method used by the author for the analysis helps in visualization of augmented bone and assessment of bone volume changes objectively.

The migration of dental implants into the maxillary sinus in regions where sinus lift surgery was performed without placing bone graft was evaluated by Pablo Galindo-Moreno et al (2012)[35]. Using cone beam computed tomography, 14 patients in whom the implant was migrated were included for the study. This migration of implant into the sinus can result from lack of primary stability, nasal and intrasinosal pressure, autoimmune reaction of the body to implant and improper distribution of

occlusal load. It was concluded that patient selection and appropriate treatment planning, application of the appropriate sinus lift procedure are important aspects that should be addressed to lessen the risk of implant migration.

The Prevention and Treatment of Postoperative Infections after Sinus lift surgery explained the Tiziano Testori et al (2012)[36]. High implant survival can be achieved by proper decision making with regard to implant surfaces, preferably textured and the choice of graft materials. As prevention is better than treatment, certain things are to be followed that will help to reduce the occurance of the postoperative infections which includes, careful assessment of medical history, proper patient selection who has a healthy maxillary sinus, a pre operative CT scan to identify any preexisting pathology, a smoking cessation protocol especially in case of heavy smokers, preventive rehabilitation of periodontal and endodontic diseases, adequate antibiotic prophylaxis, preoperative disinfection of skin with an antiseptic solution, mouth rinses with autogenous bone, use of infection-control protocol and sterile draping, prevention of salivary contamination of the bone graft, control of hemostasis, prevention of bone overheating, irrigate the surgical field with sterile autogenous solution, keep the surgical time as short as possible, postoperative autogenous rinses at regular intervals, appropriate postoperative pharmacological therapy and follow up.

The height of membrane elevation and perforation rates between the trans crestal balloon technique and a conventional osteotome technique in cadavers were compared by Hsun-Liang Chan et al (2013)[8] aided by cone beam computed tomography. They randomly assigned one side of each cadaver to both techniques and they endoscopically autogenous the elevation procedure and the occurrence of sinus perforation intraoperatively. The sinus floor was elevated until either 15 mm was

reached or until a perforation occurred. It was found that the amount of residual alveolar bone was not related to the incidence of perforation and the height of sinus elevation. The thickness of the sinus membrane played a significant role in the rate of incidence of perforations.

Three different lateral sinus lift procedures concerning new bone formation was compared by Lars ake Johansson et al (2013)[37] using micro computed tomography. The three different procedures are 1) replacing the bone window but without any kind of bone graft, 2) using a collagen membrane in the osteotomy site but without bone graft, and 3) replacing the site with Autogenous bone graft. 7 months post operative micro CT revealed excellent bone to implant contact in all three groups. But regarding the formation of lateral sinus wall, a completely ossified bone wall was consistently regenerated in the group where Autogenous bone was used.

A review was done by D. Shiva Kumar et al (2013)[38] to determine the effectiveness of maxillary sinus lift without bone grafts. According to them, maxillary sinus lift without placing a bone graft, allowing blood clot to form in the subsinosal space was considered cost effective, less time consuming and associated with lower morbidity since there is no need of harvesting bone. They have concluded that implant survival depends on factors like quality of the bone in that region, intraoral hygiene status, stage at which the implant is installed implant surface, length and diameter, prosthetic considerations, systemic health condition of the patient rather than on the presence or absence of a graft material.

Giovanni Franceschetti et al (2014)[39] evaluated the relevance between smoking rate and its impact on transcrestal sinus lift done with a minimally invasive

procedure. Factors such as penetration of implant into sinus, residual alveolar bone height, extent of sinus lift were assessed on periapical radiographs immediately after the surgery and 6 months post operatively. It was found that smoking status of the patient did not significantly have any impact on the 6-month radiographic outcomes. There was a similar low occurance of intra and postoperative complications in both smokers and non smokers. It was concluded that smoking has negligible effect on the outcomes of sinus elevation procedure.

The relationship between rhinosinusitis and sinus lift dental implantation was retrospectively analysed by Gurkan Kayabasoglu et al (2014)[40] retrospectively analysed. Patients were evaluated with a conventional radiographic examination, a satisfaction questionnaire and nasal endoscopic examination, for sinus pathology postoperatively. It was found that an iatrogenic small membrane perforation does not seem to be related to the occurance of postoperative sinusitis in normal patients, but large perforations of the membrane have higher chances of resulting in the dispersion of graft material into the maxillary sinus leading to sinusitis. Other factors that could lead to the post operative maxillary sinusitis are obstruction of the ostium caused due to postoperative swelling of the sinus mucosa, airflow blockage due to decreased intrasinus volume, impaired mucosal activity due to mucosal lacerations, implant extension and exposure.

The posterior maxillae for anatomical consideration during sinus augmentation surgery was evaluated by Ji-Eun Lee et al (2014)[13]. The Schneiderian membrane's thickness varies with individuals, but on an average 0.3-0.8mm in fresh, unfixed cadavers without sinus disease. A study with CBCT has shown that the schneiderian membrane thickness varies with individuals from 0.16 to 34.61 mm and it is thicker in thick gingival biotype and thinner in females. A thicker membrane has been noted

adjacent to restored teeth and teeth with periodontal and endodontic lesions. Inflammation or allergy and smoking are correlated with higher mucosal thickness. It has been found that the thickness of the schneiderian membrane increase significantly by about 6.7mm after sinus augmentation surgery and the swelling gradually disappears three weeks later.

It was proposed by V. Nimigean et al (2014)[41] that the reduction in the subantral bone height after removal of a tooth can be due to various factors like ischaemia, local inflammation, functional unload and pressure. They gave three subantral classes based on the distance from the antral floor to the alveolar crest in an edentulous site. Class I is minimum of 10 mm bone height, that allows placement of an endosseous implant with a minimum bone width of 5 mm. Class II is bone height of 5–10 mm, which requires a sinus lifting with a minimum bone width of 5 mm, or when the bone width is only 2.5–5 mm it may also necessitate osseous augmentation, which has to be performed before implant placement. Class III is bone height of 0–5 mm, which may Autogenous the sinus lifting followed by a healing period for graft maturation and delayed implant placement.

A simplified transalveolar hydraulic sinus lift technique that was minimally invasive using calcium phosphosilicate putty (CPS) was retrospectively evaluated by Udatta Kher, Andreas L. Ioannou et al (2014)[42]. The technique is based on the use of hydraulic pressure with the help of a viscous bone graft material which acts as an incompressible fluid. The osteotomy was done similar to the Summer's technique with a mild modification, in which the drilling was stopped 1 mm short of the estimated height of the sinus floor. A periapical X-ray was done to verify the position of the drill in relation to the sinus floor. The osteotomy was then widened using the sequential drills. A small quantity of approximately 0.2cm^3 CPS was delivered in the

osteotomy site using a narrow-tipped cartridge to act as a cushion while tapping the sinus floor and a concave osteotome with depth markings and a mallet were used to carefully fracture the floor of the sinus. 21 patients consecutively treated with this technique were evaluated, which included 28 tapered implants placed in posterior maxilla with < 6 mm of residual bone height radiographically (cone beam volumetric tomographs). There were no sinus membrane perforations noted and no post operative sinusitis like symptoms were reported by the patients. The mean gain in bone height was 10.31 ± 2.46 mm. All implants integrated with 100% success rate and were loaded with cement-retained prostheses. It is concluded that this technique is a simple, efficacious, minimally invasive approach for sinus elevation that can be recommended for sites with at least 3 mm of residual height.

The method of preparing and using Concentrated Growth Factors (CGF) and Sticky Bone and the benefits associated with their use was reported by Dong-Seok Sohn et al (2015)[10]. They have illustrated 3 cases: 1) Comparison of CGF membrane and collagen membrane in 2 sites in the same patient who required implant rehabilitation, but had horizontal bone defect in the edentulous site, 2) Three-Dimensional Ridge Augmentation using Sticky bone with/ without Titanium Mesh, 3) Minimally Invasive sinus Augmentation using Sticky Bone and Tunnel Technique. The study stated that first generation platelet concentrates like platelet rich plasma (PRP) and plasma rich in growth factor (PRGF) require artificial additives like anticoagulants and thrombin or calcium chloride to initiate fibrin polymerization before usage in the surgical site. They can be used as substitutes for the traditional barrier membrane. They also compared the efficacy of “sticky bone” (fabricating growth factors-enriched bone graft matrix) in this study. Sticky bone is prepared by obtaining the autologous fibrin glue from the test tube centrifuged with the venous

blood and mixing it with particulate bone powder and allowing for a polymerization period of 5-10 minutes to obtain the yellow coloured sticky bone. Sticky bone provides stabilization of graft in the sinus cavity and thus accelerates tissue healing. It has other significant properties like moldability, fibrin interconnection that minimizes the tissue ingrowth, lack of biochemical additives which makes it a better bone graft alternative compared to the other traditional and modern materials.

The midterm clinical outcomes of sinus augmentation, implant placement and provisional restoration of single implant supported crowns in relation to healing time was evaluated Lang et al (2015)[43]. They proposed that the timing of sinus augmentation and implant placement will have lesser effect on the implant survival, but the time of implant loading has a higher impact on the implant survival. The results showed that implants that were loaded immediately regardless of the timing of the sinus elevation showed greater failure rates than implants that were loaded after an appropriate interval after sinus augmentation or those that were loaded immediately in sites that did not require a sinus lift procedure.

The correlation between sinus membrane thickness and perforation rates during transcrestal sinus lift was studied by Shih-Cheng Wen et al (2015)[44] based on CBCT data. The mean thickness of the Schneiderian membrane was 1.78 to 1.99 mm. It was found that there was a significant correlation between membrane thickness and perforation rate. The perforation rate was high in both the extremes of the thickness of the membrane ($\geq$ 3 mm and $\leq$ 0.5 mm). Sinus membrane thickness between $\geq$1 and <2 mm had lowest perforation rate. It was lowest when the thickness was 1.5–2 mm.

The change in bone height (BH) after lifting the sinus membrane and placing xenograft and the outcome of implants installed after the healing period was studied

by F. Younes, A. Eghbali et al (2016)[45]. In this study, 57 patients treated with sinus lift surgery by lateral window approach followed by implant placement were re-evaluated using periapical radiographs to assess the changes in bone height after the sinus was augmented and the marginal bone loss. After an average healing period of 4 months, Baseline BH, BH during surgery and final BH were 3.87mm, 13.75mm, and 13.11mm which favored to conclude that, irrespective of the initial native bone height, sinus lifting can be done. A bone condensing implant could be used in the early healing phase after lifting the sinus membrane with successful clinical outcomes based on the parameters like implant survival and bone adaptation.

The clinical outcomes of implants that were placed within the maxillary sinus that has a perforated sinus membrane by the lateral window approach was retrospectively evaluated by Gwang-Seok Kim et al (2016)[46]. Elevation of the Schneiderian membrane is a very delicate procedure, thus the mucosa perforation occurs frequently of about 10 – 55%. This direct communication leads to the graft material getting scattered into the sinus space, which in turn can lead to infection or sinusitis. Repair using resorbable collagen membrane is a reliable and predictable technique. Thus, repair of perforated maxillary sinus using resorbable collagen membrane is a reliable and predictable technique.

A CT guided sinus lift procedure in cadavers and explained the minimally invasive technique called “radiological sinus lift” using sinus endoscopy was described by Jean-Francois Matern et al (2016)[47]. Approach is done through the canine eminence by manual drilling in the alveolus, instead of creating a window in the lateral aspect of the maxillary sinus itself. An inner curved obturator was fabricated and the subsinosal bone is compressed through the opening and an inner window was created in the maxillary alveolar recess. Hydrodissection using diluted

iodinated contrast medium was performed. This less invasive experimental study provides an interventional radiological alternative to the traditional lateral window approach and is equally successful. It has a lower morbidity and is less time consuming.

The recent trends in sinus augmentation surgery focusing on bone grafting and surgical considerations in atrophic posterior maxilla was described by Mahmoud Al-Dajani et al (2016)[12]. It is suggested that comprehensive assessment of septa, sinus pathology and quality and quantity of bone using CBCT is essential for placing implants in the posterior maxilla. With a residual alveolar height of <5 mm, the implants survival rate decreases substantially. Lateral window technique can increase the bone height to >9 mm, while in indirect approach it is about 3 to 9 mm. The perforation of the sinus membrane increases the risk of sinusitis or infection.

The clinical, radiographic and histologic outcomes when a highly purified xenogenic bone was used as grafting material in maxillary sinus elevation procedure was studied by Renzo Guarnieri et al (2016)[48]. Owing to the refinement in the sinus lift surgical technique over the past two decades, the predictable placement of implants in atrophic maxilla regenerated with xenografts became simpler. In all the postoperative histological sections, there was no evidence of acute inflammatory infiltrate or foreign body granulomatous tissue, as the material does not provoke any adverse immunologic response. The graft has mostly been reabsorbed after 6 months and was replaced by vital bone and there was complete integration of the residual xenograft particles to vital bone.

T.L.M.R. dos Anjos et al (2016)[49] conducted a study to compare implant stability after maxillary sinus floor elevation using small or large-sized particles of

Bio-Oss. Ten partially edentulous patients who required bilateral maxillary sinus floor augmentation were included in the study. Primary implant stability was recorded immediately after implant placement using resonance frequency analysis and a torque controller. After six months, the implant stability was recorded again. The results indicate that the size of particles (small and large) did not influence implant stability after a maxillary sinus augmentation surgery. Indeed both the particle types presented optimal osteoconductive properties.

The effect of maxillary sinus width on the outcomes of crestal approach sinus lift with implant placement was investigated by Xiaofei Zheng et al (2016)[50] based on CBCT. It is postulated that the dimension of the maxillary sinus cavity will have an impact on the graft resorption and remodeling. Furthermore, the support provided by the medial and lateral sinus wall may affect the morphology of the graft bone materials placed in the augmented sinus. And it was concluded that, a better support for the elevated membrane and the graft bone can be acquired with short lateral–medial distance in sinus. In a wider sinus, graft material is more likely to collapse due to the lack of enough support.

The immediate implant insertion simultaneously with sinus augmentation in freshly extracted sockets was innovated by Yaqian Chen et al (2017)[51]. Implants were inserted after transcrestal sinus floor augmentation immediately after tooth extraction. The change of mucosal thickness, occurance of rhinosinusitis, marginal bone loss, pocket depth and sulcus bleeding index were checked through radiographic measurement and clinical examination. But after the healing period, the thickness of the sinus mucosa returned to presurgical measurements. No statistical significant difference occurred in marginal bone loss and depth of pocket and bleeding index. It

was concluded that it is advantageous to combine both transcrestal sinus floor elevation and immediate implant placement following extraction.

The probability of devitalization of the adjacent teeth after maxillary sinus floor elevation surgery was retrospectively assessed by Florian Beck et al (2018)[52]. The radiographs of the region at different time points taken after a sinus elevation surgery were compared and changes in the radiographic status of adjacent teeth like, formation of a periapical lesion were assessed. It was found that tooth devitalization is an extremely rare complication after a sinus lift surgery and the probability of tooth devitalization is $\leq 0.7\%$.

The survival of implants placed in augmented sinuses on a medium- to long-term basis was systematically reviewed by Georgios N. Antonoglou et al (2018)[53] and they also identified the factors influencing implant survival rate such as bone grafts, surgical technique and timing of implant placement. Implants in augmented sinuses have high survival rates. Both direct and indirect maxillary sinus elevation have a low occurance of manageable complications.

MATERIALS AND METHODS

The study was conducted at the Department of Oral and Maxillofacial Surgery, Sri Ramakrishna Dental College & Hospital over a period of 18 months. Patients with complaints of missing upper (maxillary) posterior tooth and willing to undergo prosthetic rehabilitation with implant were selected for the study.

Selection criteria:

Patients with maxillary alveolar bone height of 3-7 mm in the planned implant site were selected for the study.

Inclusion criteria:

Patients between age of 24 to 64 years of age with good oral hygiene, medical status of ASA I, II, no long-term medication history, healthy maxillary sinus.

Exclusion criteria:

Patients with poor oral hygiene, smokers, history of previous maxillary sinus surgery, history of sinusitis or sinus pathology, previous history of implant failure, chronic intake of medication that affects bone healing (chronic steroid regimen, oral or iv bisphosphonates, etc), active periodontal disease or periapical pathology of the adjacent tooth, history of other systemic diseases that would contraindicate the surgical procedure were excluded.

Patient evaluation:

All the selected patients underwent routine clinical examination with an appropriate case history, blood investigations, model analysis, bone mapping and preliminary radiographic examination using Radio Visio Graph (RVG) and Orthopantomogram (OPG) (FIGURE 1). The patients with alveolar bone height of 3 –

7 mm were subjected to higher investigation with Cone Beam Computed Tomography (CBCT) (FIGURE 2). The following parameters were assessed using the CBCT

- The initial height of the native subsinosal bone in the centre of the area selected for implant placement (in mm)
- Bone densities in the subsinosal alveolar bone (in Hounsfield Units (HU))
- Rule out any pathologies of the sinus that would contraindicate the procedure

All the patients participated in the study were explained about the necessity of sinus lift surgery and the possible complications of the procedure. Patients were motivated for post operative follow up. The study was cleared by the institutional ethical committee and the patients were explained about the necessity of the sinus lift procedure and its possible complications and an Informed consent specific to the procedure was obtained from the patients. 20 patients were screened, and 5 patients were selected for the study based on the inclusion and exclusion criteria.

Procedure:

1. All the patients qualified for the procedure, were premedicated with a loading dose of Amoxicillin/clavulanate potassium (625 mg) administered 1 hour prior to the surgery.
2. Under aseptic and sterile conditions, local anesthesia was administered. A crestal incision was placed, after the precision drill using a partially limiting design surgical stent (FIGURE 6) and a mucoperiosteal flap was elevated (FIGURE 7). The instruments and equipment's used are attached in the annexure (FIGURE 3 & 4).

3. All the instructions given by the manufacturer for osteotomy were followed. The osteotomy was initiated from the crest of the ridge with a 2 mm pilot drill at 1,000 rpm stopping 1 mm short of floor of the sinus using a stopper provided in the kit.

4. The osteotomy was widened sequentially to the desired width with the drill sequence, using the same length stoppers at 400 to 800 rpm with Osstem sinus kit (FIGURE 8). The bone particles in the flutes of the drill bits were collected (FIGURE 9) and stored to be used as autogenous graft.

5. The final drill was made with a rounded and inversely concave end special drill bit with stopper which safely pushes the sinus membrane at a speed of 50 – 100 rpm through the remaining bone.

6. Valsalva maneuver was done to test the integrity of the membrane (If perforated – abort the procedure and reschedule the appointment after 6 to 8 weeks). Depth gauge fitted with stopper was used to test the mobility of the membrane (FIGURE 11).

7. The hydraulic membrane lifter, a plastic tubing along with the syringe was tightly adapted to the entrance of the osteotomy to achieve an air-tight seal (FIGURE 12). Sterile saline solution (approximately 1.5cc) was pushed slowly that causes atraumatic elevation of the sinus floor. The whole of the injected solution was retrieved back by aspiration which ensures safe elevation. This push and pull of the solution were repeated several times until the required elevation of sinus membrane.

8. On confirming the required height of elevation of sinus membrane (FIGURE 13), adequate amount of Sticky bone graft (autologous bone graft obtained from the osteotomy site mixed with freshly prepared autologous platelet rich fibrin derived

from the patient's venous blood that was centrifuged at 3000rpm for 10minutes and bone particles) was packed through the osteotomy opening into the subsinosal space (FIGURE 14).

9. Intra operative RVG was taken, to ensure adequate elevation of Schneiderian membrane and to visualize dome shaped elevated space after packing (FIGURE 16).

10. The planned implant was installed in the prepared osteotomy and the cover screw was placed. Primary closure of the flap was done. Along with the Postoperative instructions, antibiotics, analgesics and Chlorhexidine mouthwash were prescribed.

A radiographic investigation using OPG was taken in all the patients postoperatively to confirm the presence of adequate graft material around the implant in the acquired subsinosal space (FIGURE 17). Periodic follow-ups were done every month until 6 months with periapical radiographs. A CBCT was taken 6 months postoperatively, to evaluate the objective of the study (FIGURE 18). All the implants will be loaded 6 months post operatively according to the protocol. The recorded patient details and measurements were submitted for statistical evaluation.

FIGURE 1: PRE OPERATIVE OPG

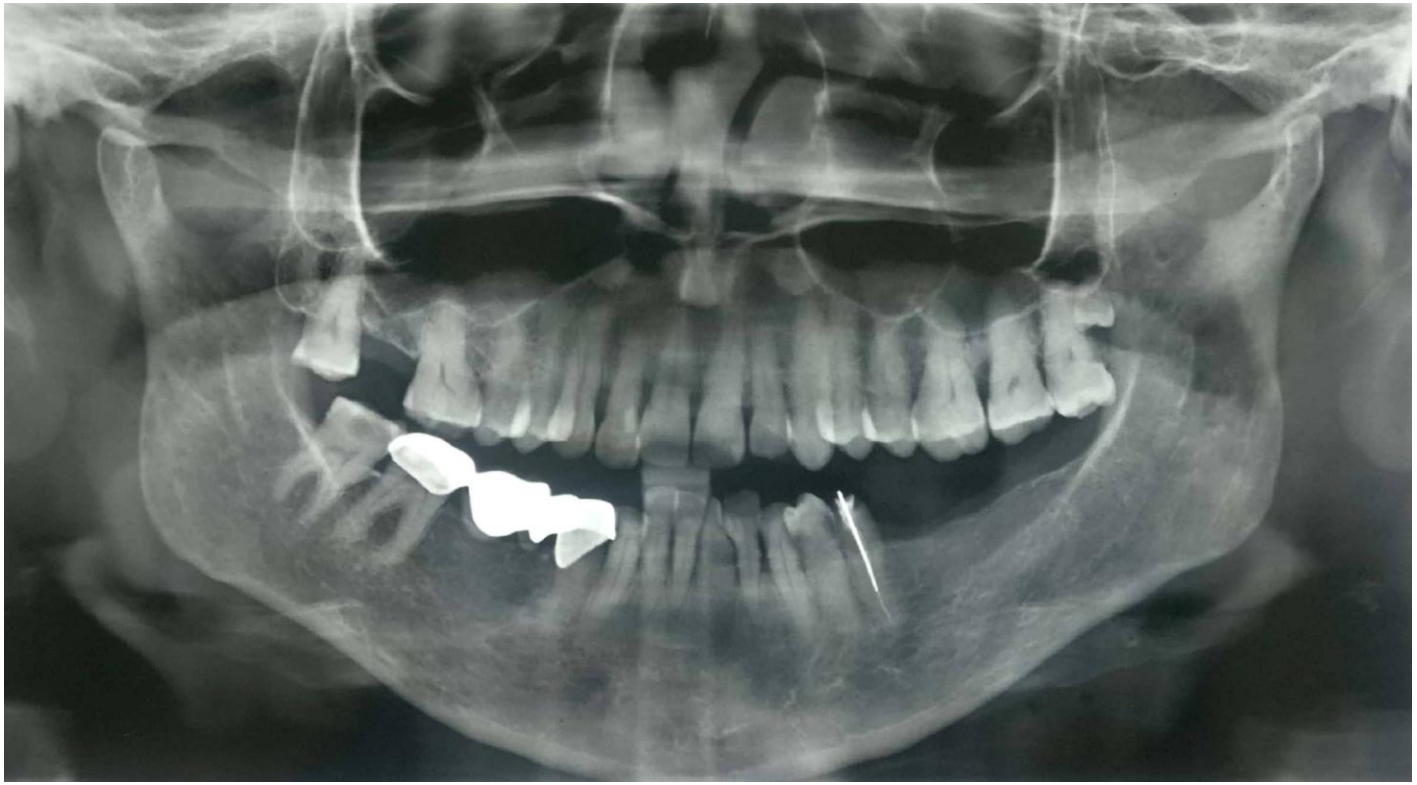


FIGURE 2: PRE OPERATIVE CBCT

Figure 2a: Sagittal View

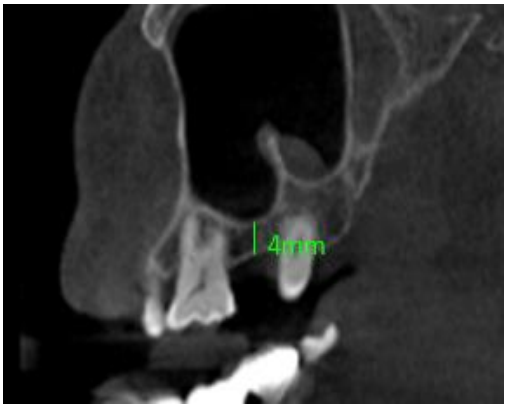


Figure 2b: Coronal View

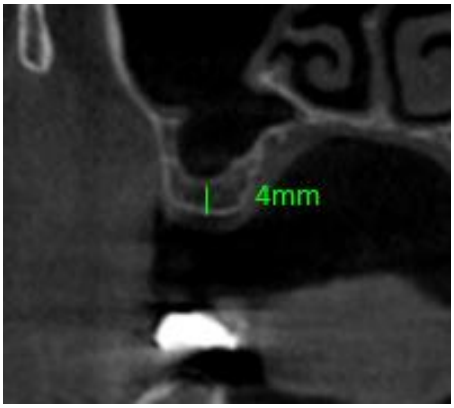


Figure 2c: Axial View

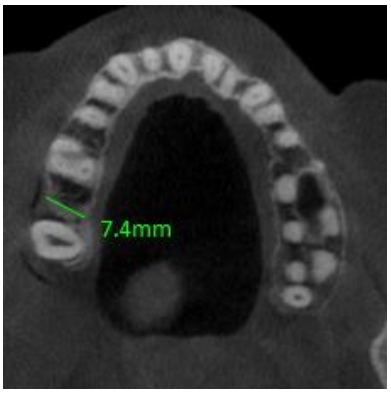


FIGURE 3: Hiossen Crestal Approach Sinus Kit by Osstem
The second and third row constitutes the sequential stoppers

FIGURE 4: Osstem Implants – Taper Kit

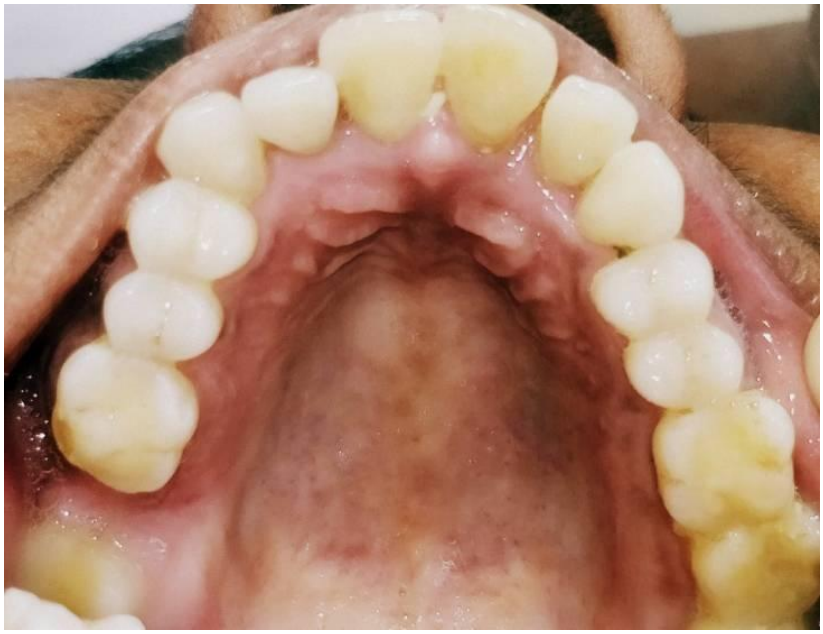


FIGURE 5: Pre operative maxillary occlusal view

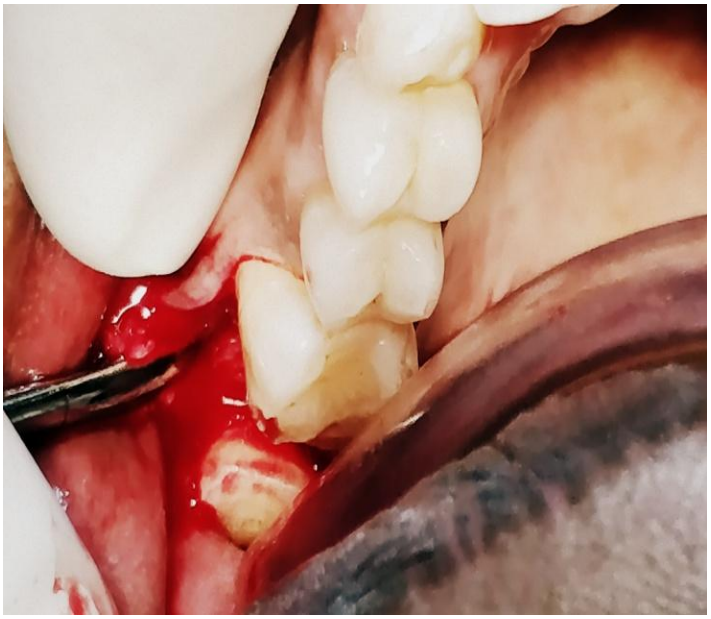


FIGURE 6: Elevation of full thickness mucoperiosteal flap

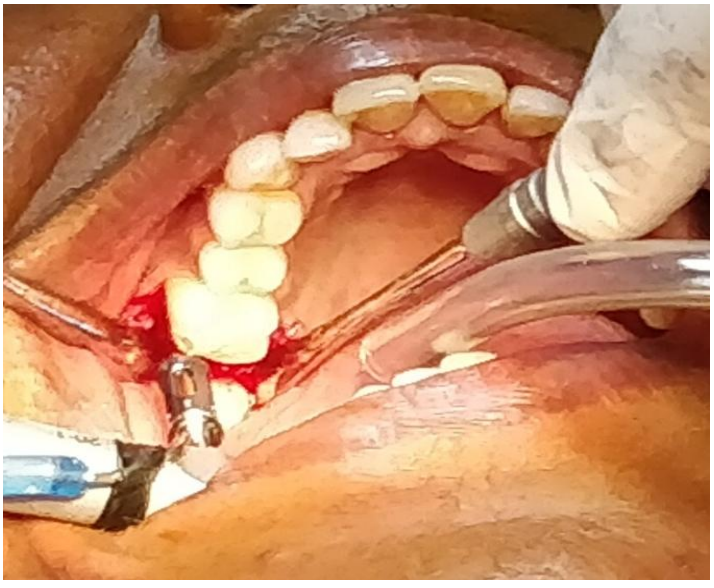


FIGURE 7: Drilling of osteotomy with the round ended drills with desired stoppers

FIGURE 8: Bone collected in the flutes of the drill and the stopper that can be used for sticky bone preperation

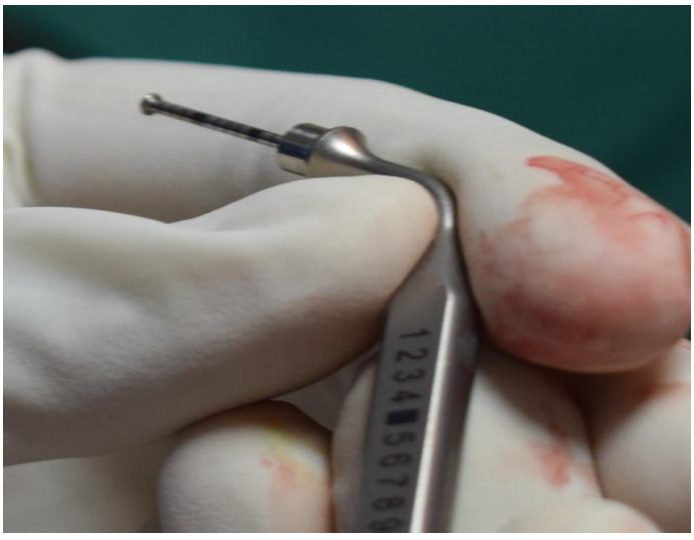


FIGURE 9: Measuring gauge with graduations and a blunt end that prevents perforation of the membrane while checking for its detachment. It is designed for the attachment of stoppers also.

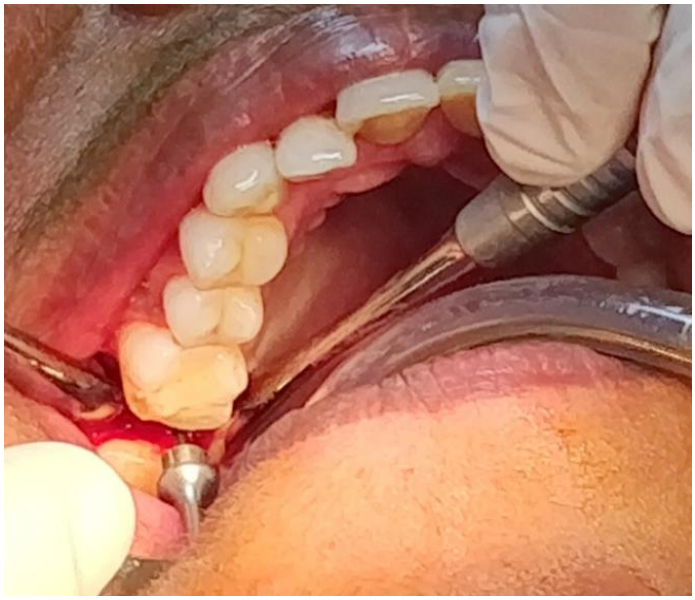


FIGURE 10: Measuring gauge used in the osteotomized hole to check the adequacy of depth

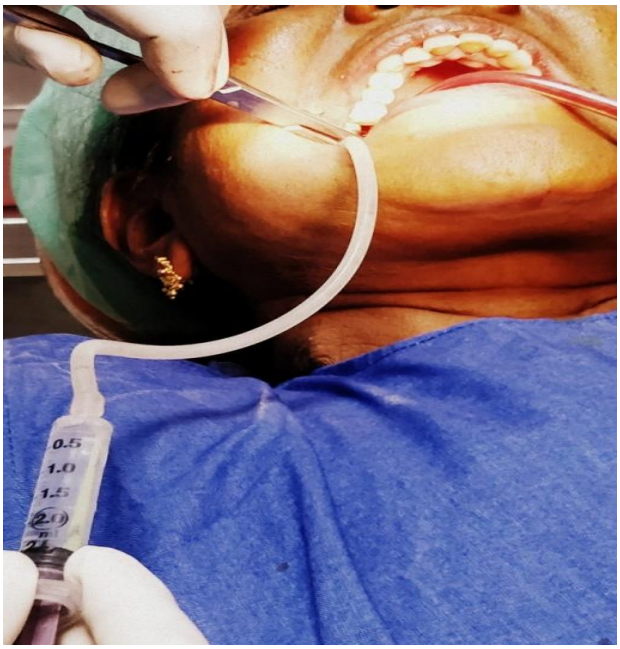


FIGURE 11: Hydraulic lifter with plastic tubing and syringe containing sterile saline solution

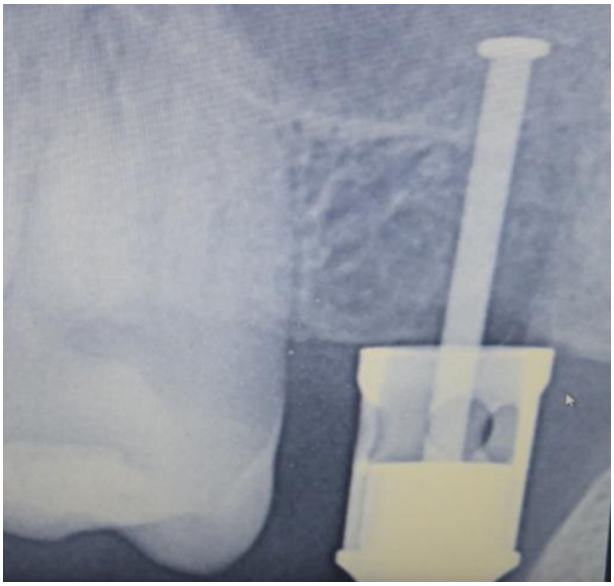


FIGURE 12: Measuring gauge with the appropriate stopper to check the detachment of schneiderian membrane from the bony floor of sinus

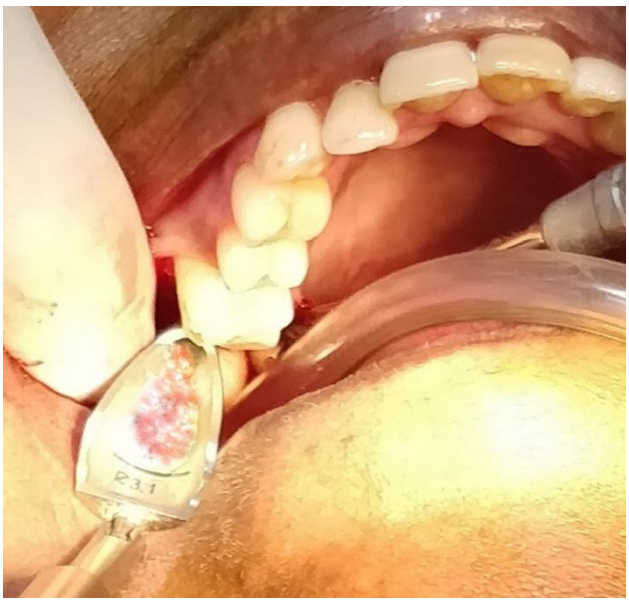


FIGURE 13: Bone carrier with sticky bony graft inserted into the osteotomy.

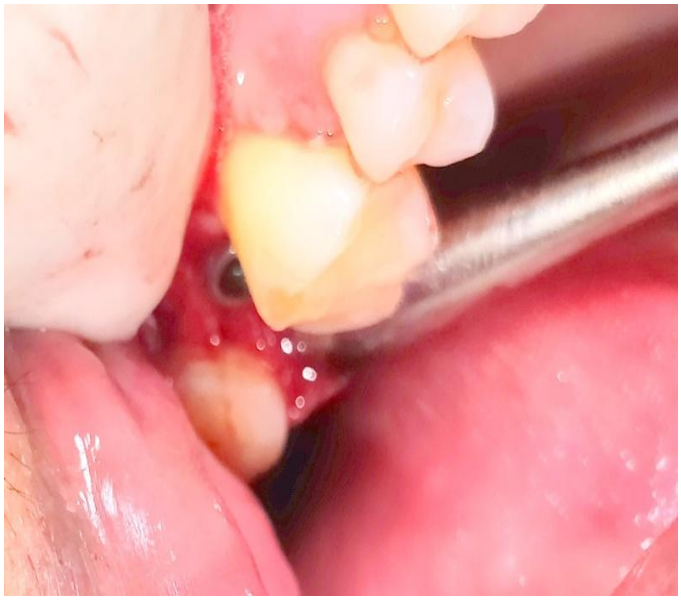


FIGURE 14: Implant placed in the desired site

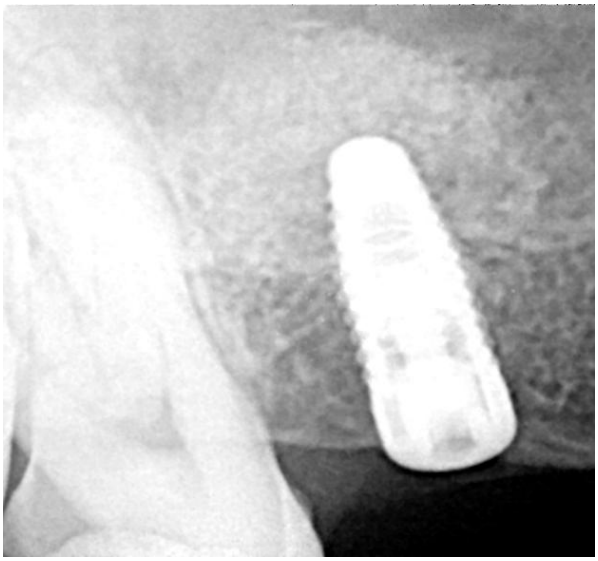


FIGURE 15: Intra operative RVG after the placement of implant

FIGURE 16: POST OPERATIVE OPG

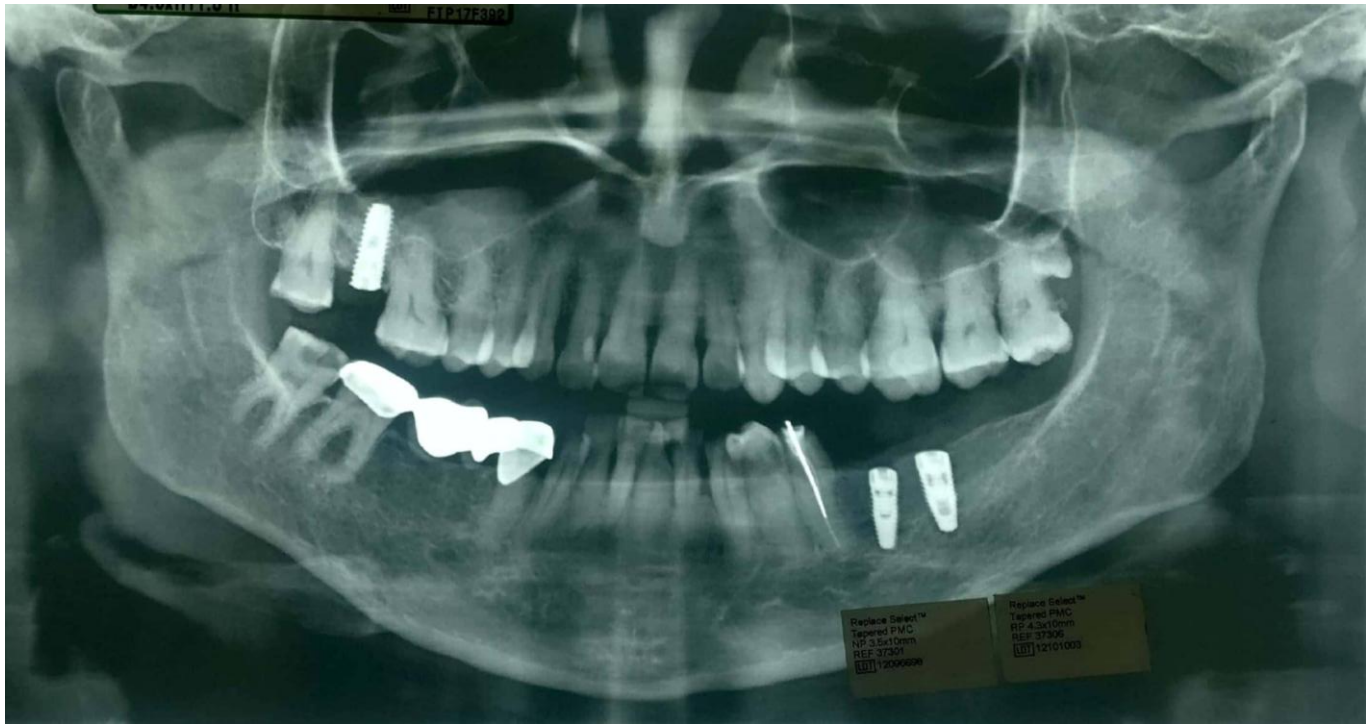


FIGURE 17: POST OPERATIVE CBCT

Figure 17a: Sagittal View

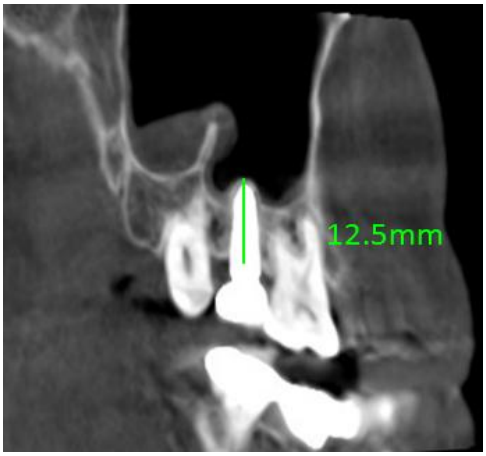


Figure 17b: Coronal View

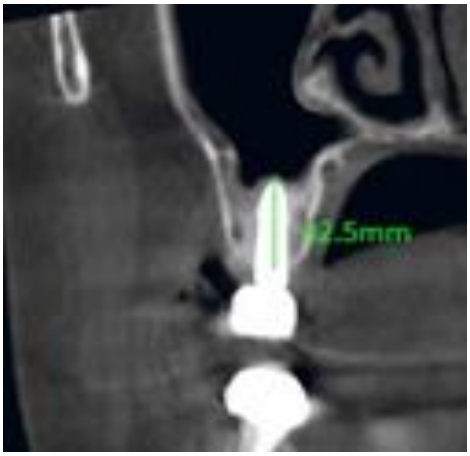
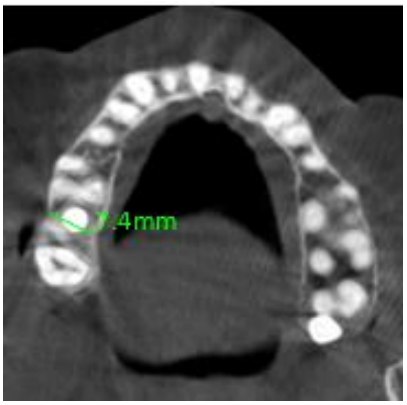


Figure 17c: Axial View



RESULTS

In our study, 5 patients (2 males and 3 females) requiring sinus lift surgery for implant placement due to reduced residual alveolar bone height in the subsinosal region were treated with hydraulic pressure indirect sinus lift and the created subsinosal space was packed with sticky bone graft.

All the 5 patients were first evaluated with an OPG and RVG to rule out the major exclusion criterion and then a OPG, CBCT was done for further assessment and treatment planning. The subsinosal bone height in the chosen patients ranged from 4 – 7 mm with a mean of 5.8mm. The density of the bone in the same regions were in the range of 654 – 854 HU with a mean of 814 HU. The amount of saline used to lift the membrane ranged from 0.5 – 1.5cc. The average volume of graft packed is 0.9 cc.

None of the patients had any complications like membrane perforation, expulsion of graft into the sinus, sinusitis, displacement of implant into the subsinosal space created, obstruction of the ostium, graft or implant failure, wound dehiscence, hemosinus, damage or devitalization of adjacent teeth.

During the follow up period, OPG was used to assess the healing process and the implant survival. After 6^{th} post operative month, OPG, CBCT investigation was done to assess height and density of the bone in the subsinosal region. None of the patients had bone loss around the implant or any implant migration, in 2 patients post operative bone density with CBCT could not be assessed due to their non-availability. There was adequate bone covering the apical end of the implant in all the cases in the range of 1 to 3.2 mm with an average of 1.74 mm. The subsinosal bone height recorded post operatively ranged from 12.5 – 14.7 mm with a mean of 12.8mm.

The data collected was compiled in Microsoft excel sheet and transferred to version 20 SPSS software. The data recorded is normally distributed therefore parametric analysis was used.

A P value of < 0.05 was considered significant. Kolmogorov-Smirnov test and Shapiro-Wilk test was applied to the continuous variables for testing the normality distribution. Tests showed that the measurements follow normal distribution. Therefore, the results were statistically analyzed by the parametric method, Student's paired 't' test.

The statistical results are as follows:

The average diameter of the implants used in the study was 4.09 ± 0.44 mm and the average length of implant was 10.9 ± 1.34 mm. the average age of the patient treated was 43.4 ± 16.5 years of which 40% were males and 60% were females.

The pre-operative bone height had a mean value of 5.8 ± 1.3 mm with a mean difference of -7mm therefore it is statistically significant compared to the post operative average bone height of 12.8 ± 1.9 mm ($P < 0.05$) (TABLE 02).

The pre-operative bone density has a mean value of 814 ± 25.2 HU with a mean difference of -27 HU and there is no statistical significance as the post operative bone density has a mean value of 841.83 ± 117.4 HU ($P > 0.05$) (TABLE 02).

Statistical Tests and Assumptions:

TABLE 01: Tests of Normality

	Kolmogorov-Smirnov			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Presurgical Bone Height(mm)	.223	6	.200	.908	6	.421
Bone Density(HU)	.178	6	.200	.927	6	.559
Pre op bone density (HU)	.362	6	.014	.791	6	.049
Post Op height(mm)	.205	6	.200	.961	6	.830

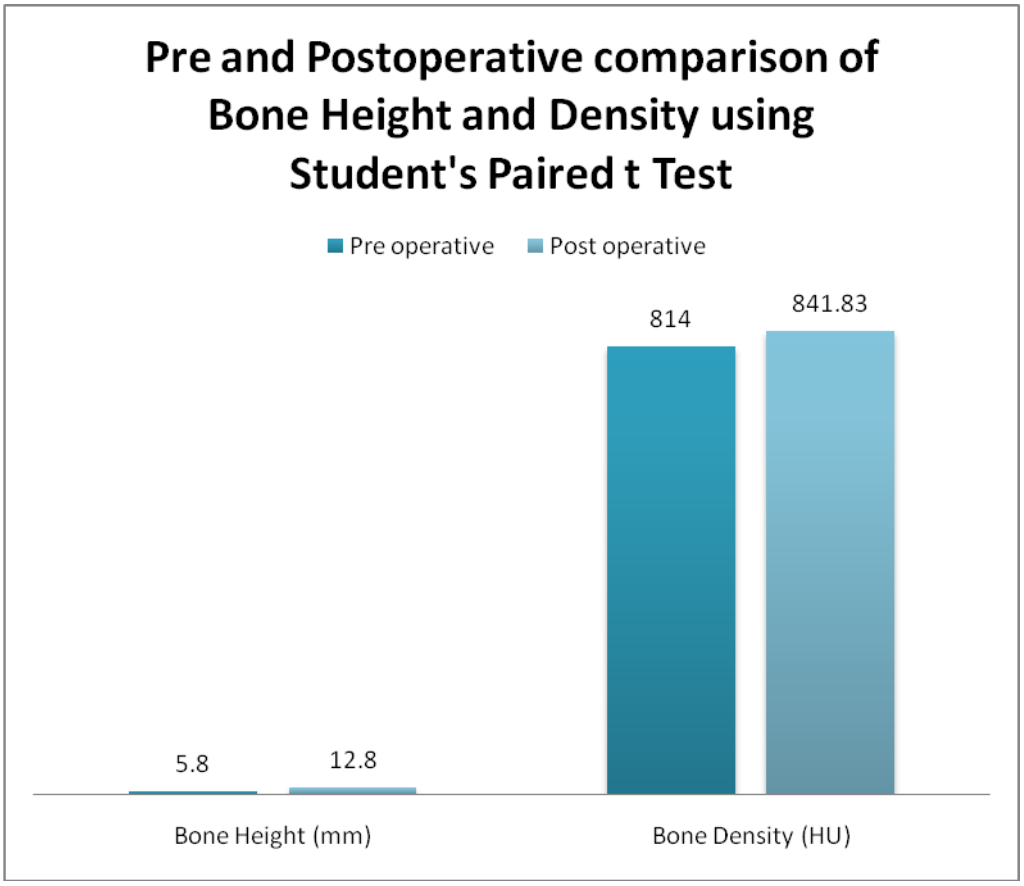
P value > 0.05

TABLE 02: Pre and post surgical comparison based on Bone height and bone density using student's paired 't' test.

	Mean	S. D	Mean difference	95% Confidence Interval of the Difference		t	P value
				Lower	Upper		
Pre Op Bone Height (mm)	5.8	1.3	-7	-8.7	-5.24	-11.06	0.001
Post Op Bone height(mm)	12.8	1.9					
Pre op Bone density (HU)	814	25.2	-27	-147	93	-0.624	0.566
Post op Bone Density(HU)	841.83	117.4					

P value < 0.05 - statistically significant

GRAPH 01: Mean Pre and Post surgical comparison based on Bone height and bone density using students paired t test.



Many patients with edentulous posterior maxilla present with inadequate vertical bone height between the floor of the maxillary sinus and the alveolar ridge crest, making it inhospitable to place an implant and achieve primary stability necessary for a long-term successful implant. So this poses a great challenge for placement of implants in the posterior maxilla. When such a condition exists, sinus or residual bone augmentation is indicated. The maxillary sinus augmentation is aimed to induce new bone formation in the subsinosal space and to provide adequate bone through osteogenesis for implant placement[3].

Whenever there is a patient with edentulous alveolar ridge in the posterior maxilla with reduced residual alveolar ridge height inadequate for an implant placement (i.e., less than 10mm), a sinus lift surgery should be opted for a long-term success of implants. As the bone quality is usually D3 or D4 in this region, opting short implants won't be successful. The other option is the Zygomatic implants, which have anatomical constrains, post-operative morbidity, cost, prosthodontic planning and level of expertise to create the outcome successful. Maxillary sinus augmentation is the most commonly practiced minimally invasive method in the recent years to increase the vertical bone height of the alveolus in the edentulous maxillary posterior region, thus making it hospitable for a desired size of implant.

The common indications for sinus augmentation[5] are (i) Severely atrophic maxilla with no history of sinus pathology, (ii) Poor bone quality and quantity in the posterior maxilla. The contra indications are (i) Recent radiation therapy in maxilla, (ii) Uncontrolled systemic diseases such as diabetes mellitus, (iii) Acute/chronic maxillary sinusitis, (iv) Psychosis, Heavy smoking and Alcohol abuse, (v) Severe allergic rhinitis and Oroantral fistula, (vi) Tumor or large cyst in the maxillary sinus.

There are various techniques advocated for maxillary sinus augmentation surgery like, Lateral Window Approach[37], Lateral Window Approach using Piezoelectric device[7], Transcrestal Osteotome Technique (Summer's technique)[54] Antral Membrane Balloon Elevation[8], Crestal Approach Hydraulic Sinus Lift[45].

In 1975 Dr. Hilt Tatum[6] attempted the first sinus lift surgery through lateral window approach. This technique involved raising a mucoperiosteal flap on the buccal aspect of the alveolus and creates a bone window on the lateral wall of the maxilla. A green stick fracture is made on the bony window and the osteotomized bone is gently elevated inward to lift the sinus membrane along with the bone. This elevated floor with the bone will now form a tent, below which a suitable graft can be placed. The main drawback with this technique is that it desires delayed implant loading.

The most common complication in a lateral sinus lift surgery is the Schneiderian membrane perforation. Devorah Schwartz-Arad et al[55] evaluated 70 patients who underwent 81 lateral window sinus elevation procedures and found that 44% of patients had perforation of the Schneiderian membrane trans-operatively. Usually perforations primarily happen, during the preparation of the window or during the elevation of the Schneiderian membrane. Inversion of the bone plate and elevation of the sinus membrane would be difficult in the presence of any septa[56]. Boyne and James[57] recommended cutting the septa for graft to be placed all over the floor. Secondarily, the Perforations can occur during graft condensation. Vlassis et al[19] classified sinus membrane perforations into three classes, Class I perforations occur at any point along the most apical wall of the prepared sinus window. Class II perforations occur along the lateral or crestal aspects of the prepared sinus window and is further subdivided according to their relative position to the most mesial, distal

or crestal extension of underlying sinus. Class III perforations occur at any location within the body of the prepared sinus window. For a class I and class IIA, a collagen membrane is sufficient. For class IIB and class III, a bio-resorbable synthetic membrane is used[18].

Membrane perforations can lead to acute or chronic sinus infection, bleeding, swelling, wound dehiscence and graft material loss. The integrity of membrane is essential for the stability of graft, by avoiding leakage and migration of the grafted material and additionally permitting adequate vascularization for healing. The crestal approach techniques like Summer's, balloon sinus lift have about 10%[8] chances of perforations. In our study, none of the patients had sinus membrane perforation complications following hydraulic pressure indirect sinus lift procedure.

Other complications include expulsion of the graft material into the sinus, infection, trauma to adjacent teeth or other vital structures. Elian et al[2], found that the height of maxillary artery is 16 mm superior to the alveolar ridge crest. When there is extreme resorption of alveolar ridge the lateral window may interfere with the maxillary artery leading to excessive bleeding.

Postoperative Complications include pain, swelling, wound dehiscence, acute sinusitis, flap necrosis, hemosinus, hematoma, paresthesia, implant failure, osteomyelitis, orbital cellulitis, cavernous sinus thrombosis[2]. None of these complications were encountered in our study.

The Summer's technique requires a minimum alveolar ridge width of only 3 mm that can be widened progressively with wider osteotomes. Whereas, transalveolar sinus elevation with twist drills instead of osteotomes require wider bone and a minimum of 1mm of bone on buccal and lingual side of the implant. The original

Summer's technique required between 7 and 10 mm of bone between the bone crest and floor of the sinus. Later, Rosen et al[54] reported that the implant success rate is highest in cases where the preoperative vertical bone height was greater than 5 mm. Bjarni E. Pjetursson et al[23] compared the survival rates of implants placed with crestal and lateral approach. They concluded that the crestal approach technique was more reliable especially at sites with a relatively flat sinus floor and 3mm or more of preoperative residual bone height.

Michele Di Girolamo, Bianca Napolitano et al[21] reported the incidence of Paroxysmal positional vertigo (PPV) and ridge fracture that occurs during Summer's method of osteotome sinus floor elevation. They hypothesized that the pressure exerted by the mallet leads to the detachment of otoliths in the utricular macula that leads to PPV. To overcome this disadvantage Lalo et al[34] proposed drilling with a stopper which also diminished the sinus membrane perforation by an osteotome. Tilotta et al[58] reported a surgical procedure where he used a trephine bur and stopper for drilling before using an osteotome.

Transalveolar osteotomy with the recent advances and bone grafting technique for implant placement are less time consuming and atraumatic. Antral Membrane Balloon Elevation (AMBE) technique, introduced by Muronoi et al[8] involves the preparation of the osteotomy, through which a Micro-mini sinus lift balloon was inserted into the sinus cavity and inflated. This results in atraumatic elevation of the sinus membrane from the bony floor. But it has certain disadvantages like occasional tearing of membrane if the balloon is inflated too fast. The balloon may burst and rupture the antral lining which makes the maxillary sinus more prone to infection.

A more recent advancement is the use of hydraulic pressure, attempted first by Emmanouil G. Sotirakis et al[9] to elevate the sinus membrane for implant placement. In this technique the sinus lift is performed through the same osteotomy that is done for the implant placement. The osteotomy is done with round ended drills and sequential stoppers provided by the manufacturer (Hiossen Crestal Approach Sinus kit by Osstem). The osteotomy to the required implant width is done with sequential drilling; keeping the length 1mm short of the sinus floor and finally the last one millimeter of the osteotomy is breached at a much slower speed (100 rpm). A circular conical bony lid is formed at the floor of the sinus owing to its inversely concave and blunt design of the drill. This bone lid safely pushes the sinus membrane away from the drill. Then the hydraulic membrane lifter tube should be tightly adapted to the entrance of the osteotomy and sterile saline solution (approximately 1.5cc) filled in a syringe is pushed slowly through the tube into the osteotomy to achieve hydrodissection of sinus membrane from the bony floor. This push and pull of the fluid is repeated 2 times to efficiently raise the sinus floor. The subsinosal space created is then filled with a suitable graft material and the planned implant is placed.

Jean-Francois Matern et al[47] attempted a different method of hydraulic sinus lift in which they made the approach to the sinus floor through a tunneled osteotomy from the lateral aspect of the alveolus rather than on the lateral aspect of the sinus itself. Though it is a less invasive alternative to the traditional lateral window approach, it is equally time consuming. A study conducted by Leonardo Trombelli et al[33] compared the traditional lateral window approach and crestal approach hydraulic sinus lift. They have concluded that crestal approach hydraulic sinus lift is more effective due to its predictable sinus elevation with less post operative morbidity and less time consumption. Esposito et al[59] found in a review that if residual alveolar bone

height is 3-6 mm, a crestal approach to lift the sinus lining and placing 8mm implants may result in better implant stability than a lateral window approach to place implants at least 10 mm long. Nkenke et al[60] suggested that the sinus membrane elevation is limited to an average of 3.0 ± 0.8 mm using the osteotome technique. In our study, we achieved an average of 8.5mm increase in bone height and we were able to place an implant of 11.5mm long successfully.

Though readily available and cost effective, intra oral periapical radiography has geometrical and anatomical limitations. Lack of standardization between serial radiographs and inability to assess the bucco-lingual width of the sinus or the thickness of the buccal wall of the sinus makes it unreliable[2].

Orthopantomogram (OPG) on the other hand, offers an overall view of the dentoalveolar structures in a single image with limited radiation dose. The OPG has a drawback of superimposition of structures which can result in failure of identification of any septa within the maxillary sinus. A septum missed in diagnosis due to overlap of structures can lead to a sinus perforation due to error in treatment planning. Also, the bone quality can be under or over estimated with an OPG. Shoaleh Shahidi et al[61] Compared CBCT with OPG in measuring bone height in the mandible and found that for each single unit of increase in the horizontal distance of the alveolar crest to the mandibular canal, dental panoramic radiographs showed 0.87 unit of overestimation.

Conventional tomography produces one cross-sectional image at a time which is limited to a narrow region, and it causes more radiation exposure to the patient[2].

The above limitations and the advent of newer modalities led us to choose CBCT as the mode of investigation for our study. S.Girish Rao et al[12] Compared the use of OPG and CBCT for a sinus lift surgery and reported that CBCT provided more

information about the implant site with regards to the osseous morphology such as knife edge ridges, cortical irregularities, developmental variations, density of the trabecular bone and post-extraction irregularities in addition to the amount of bone available for implant placement. Amin Rahpeyma et al[62] quoted the factors to be assessed in a CBCT for a sinus lift surgery other than bone height and width such as thickness of the lateral maxillary sinus wall, presence of alveolar antral artery, irregularity of sinus floor, intimacy of membrane to adjacent teeth roots and estimation of the graft volume needed. In our study, CBCT provided an improved diagnosis and thus increased the confidence in treatment planning. Other investigations like periapical radiography and OPG had been used as adjuncts intra-operatively during the surgery and for a post operative follow up.

Over the past few decades, a variety of bone grafts had been tried in sinus floor elevation. When choosing a bone graft material for sinus floor elevation, the clinicians should take the following factors into consideration: 1) Incorporate xenografts or alloplasts if one wants to visualize the amount of bone placed in the sinus or when space maintenance is required 2) Utilize xenografts for slower resorption rate compared to allseografts 3) Combine matrix materials with biologics if one desires to enhance the quality of the bone formed in a shorter time period[2].

Autogenous bone grafts have advantage of osteogenic potential i.e., “the formation of new bone by viable cells such as osteoblasts derived from graft itself”. Lars ake Johansson et al[26] compared the use of collagen and Autogenous bone graft in the lateral sinus window approach. 7 months post operative micro CT revealed a completely ossified bone wall that was consistently regenerated in the group where Autogenous bone was used. But there is difficulty in stabilizing the blocks in the sinus and there is a need for a second surgery where the bone grafts are harvested. In our

technique, the well-grounded autogenous bone particles collected in the drill flutes are used. Xenografts taken from other species like bovines or equines have osteoconductive property. They are more commonly used in sinus floor elevation procedures owing to its radiopacity, which allows better visualization on radiographs. Histological analyses by Ewers et al[63] show that they have a very slow resorption rate and can be present after many years. But it can be advantageous when space maintenance is required.

E. S. Tadjoedin et al[64] studied the performance of Bio-Oss bone particles as bone substitutes in sinus augmentation histomorphometrically on the 5th post operative month and noticed presence of tartrate-resistant acid phosphatase-positive multinucleated osteoclasts in the resorption lacunae, indicating that bone remodeling was very active. The percentage of graft in surface contact with bone remained stable at about 35% in all the patients. Tingting Pei et al[65] compared the radiodensities of PRF and bio-Oss bone particles when used in extraction socket using CBCT. At the 8th post operative month, the bone mineral density in the samples where bio-oss was used was approximately 840 HU which is almost similar to the bone density noticed in the sinus augmented regions in our study which is 841.43±117.4 HU.

A combination of autogenous bone material collected in the drill flutes from the osteotomy site, xenograft bone particles and platelet rich fibrin derived from the patient's intravenous blood had been used in our study to reap out the osteogenic, fast resorbing potential of the autograft; radio opaque, space maintaining potential of the xenograft and the slow release of growth factors acquired from the platelet rich fibrin.

Approximate amount of graft material that is required during a hydraulic sinus lift procedure are as follows[66]: 3mm (0.4cc), 4mm (0.5cc), 5mm (0.7cc) and 6mm

(0.9cc). In our study, the volume of graft materials placed were 4mm (0.5cc), 4.8mm (0.5cc), 5.5mm (1cc), 6.7mm (1cc), 7mm (1.5cc). The average volume of graft packed is 0.9cc for an average of 7mm increase in height.

In our study 5 patients who required sinus lift surgery for implant placement were treated with hydraulic pressure indirect sinus lift. Sticky bone graft was used for filling the subsinosal space followed by immediate implant placement. OPGs were used to assess the healing process during follow ups. Implants were loaded 6^{th} month post operatively. The pre and post operative bone height and bone density were evaluated statistically. There was adequate bone covering the apical end of the implant in all the cases in the range of 1 to 3.2 mm with an average of 1.74 mm. There was a highly significant difference in the bone height with p value = 0.001 (< 0.05) when the pre operative bone heights (Mean – 5.8mm) and post operative bone heights (Mean – 12.8mm) were compared statistically. The immediate postoperative bone height was measured with an IOPA so the progressive variation in bone density post operatively could not be assessed. The preoperative (Mean – 814±25.2HU) and postoperative (Mean – 841.43±117.4HU) bone densities measured from the CBCT showed no statistical significance (p value > 0.05).

Advantages of hydraulic pressure indirect sinus lift technique are lesser post operative morbidity as it is minimally invasive, decreased chair-time, better patient comfort as it does not require large flap elevation, retraction or creation of buccal bony window and it does not require high technical expertise. There were no incidents of perforations and any perforation could be easily identified by Valsalva maneuver or by saline aspiration. There was adequate bone covering the apical end of the implant in all the cases as evident from post operative CBCT. Sticky bone graft is an ideal

choice of subsinosal graft material with increased moldability, graft stabilization and faster healing.

Limitation of our study is that we need a larger sample size study and a long-term study to evaluate the changes in the bone formed following prosthetic loading. An immediate post operative CBCT would have led us to assess the three-dimensional grafted bone volume changes.

SUMMARY AND CONCLUSION

To summarize, the study was conducted to evaluate the efficacy and the intraoperative feasibility of the crestal approach hydraulic pressure sinus lift with sticky bone graft as a subsinosal filling material. There was no occurrence of any intra or post-operative complications. The grafted bone material height and density was good, and adequate bone covering the apical end of the implant achieved in all the cases.

To conclude, Hydraulic pressure indirect sinus lift with sticky bone graft is a more reliable technique with predictable outcomes for the elevation of schneiderian membrane and simultaneous implant placement. It is a fast and simple technique that enables elevation of the sinus floor with no occurrence of perforation of schneiderian membrane and allows simultaneous placement of the implant.

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ANNEXURE I

SRI RAMAKRISHNA DENTAL COLLEGE & HOSPITAL

(Educational Service : SNR Sons Charitable Trust)

Affiliated to the Tamilnadu Dr. M.G.R. Medical University, Chennai,
Recognised by Dental Council of India, New Delhi

INSTITUTIONAL ETHICAL COMMITTEE

TO WHOMSOEVER IT MAY CONCERN

This is to certify that the study titled " PROSPECTIVE EVALUATION OF RIDGE AUGMENTATION IN THE POSTERIOR MAXILLA BY HYDRAULIC PRESSURE INDIRECT SINUS LIFT METHOD" to be done by **DR. A. PREETHI** (2016-2019 Batch) in the Department of ***Oral and Maxillofacial Surgery*** under the guidance of ***DR. R. KANNAN, M.D.S.*** **PROFESSOR** is approved by the Institutional Ethical Committee.

DATE : 20.12.2016
PLACE: COIMBATORE

DR. V. PRABHAKAR, M.D.S.
Member Secretary

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ANNEXURES

ANNEXURE II

SRI RAMAKRISHNA DENTAL COLLEGE AND HOSPITAL, COIMBATORE

CASE RECORD

Patient Name: ` Age: Sex:

Occupation: Phone No:

Address:

Chief Complaint:

History of Presenting Illness:

Past Medical History:

Past Dental History:

Personal History:

General Examination:

BP: Pulse: RBS:

Local Examination:

Extra oral Examination:

Facial Symmetry:

TMJ:

Lymph Nodes:

Mouth Opening:

Intraoral Examination:

Oral Mucous Membrane: Wasting Diseases:

Calculus: Stains:

Mobility: Restorations:

Caries: Rehabilitations:

Missing Teeth: Period of Edentulousness:

Occlusion:

Edentulous Area:

Number:

Location:

Size of the edentulous area:

Interocclusal Clearance:

Mesiodistal Width:

Buccolingual width:

Radiographic Investigations:

OPG:

CBCT:

Diagnosis:

Treatment Plan:

Medication prescribed on the day of surgery:

LA administered:

Amount of saline solution injected and withdrawn:

Volume of graft material placed:

Type of implant:

Type of graft:

Post operative Medications:

BONE MEASUREMENTS:

Preoperative:

- Initial height of the native subsinosal bone at centre of the area to be augmented(in mm) -
- Preoperative bone density in the subsinosal alveolar bone (in HU) -

Postoperative:

- Height of the subsinosal bone at implant site in the centre of augmented area (in mm) -
- Postoperative bone density in the subsinosal alveolar bone (in HU) -

ANNEXURE III

SRI RAMAKRISHNA DENTAL COLLEGE AND HOSPITAL, COIMBATORE

ORAL AND MAXILLOFACIAL SURGERY

INFORMED CONSENT

I (Name) _____ age_____ years, hereby authorize and request the performance of dental services for myself.

I understand that there is not enough natural jaw bone for placement of the proposed implant and that a procedure called a sinus lift is planned. I have been told that this procedure is more complicated than the usual implant placement and involves opening the sinus cavity in my upper jaw through the toothless region of jaw and placing a bone graft in order to provide support for the implant. I have been told that this graft could be specially prepared bone or bone substitute. I have been given information about the anesthetics and the other medications to be administered during the course of the treatment. My doctor explained to me that there are certain potential risk sequalae and complications in any surgical procedure such as post-operative discomfort, swelling, infection(including sinus infection) that may require additional treatment or may prolong or alter the proposed treatment plan in favour of my health. He/She also explained me that factors such as smoking, alcoholism, diabetes and certain drugs may adversely affect the healing process. I am informed that it is absolutely necessary to report for periodic examinations.

By signing this form, I am freely giving my consent to authorize Dr. _____ and/or all associates involved in rendering any services he/she deems necessary and advisable to treat my dental conditions, I am solely responsible for the opted procedure without shifting any blame or complaint towards them.

Signature of the Patient: Signature of the Doctor:

Address and phone number: Date:

ஸ்ரீ ராமகிருஷ்ணா பல் மருத்துவக் கல்லூரி, கோயமுத்தூர்

முகம் மற்றும் தாடை அறுவை சிகிச்சை பிரிவு

தெரிவிக்கப்படும் தகவல்களுக்கான ஒப்புதல் படிவம்

நான் (பெயர்) ……..... வயது …….....

இதன் மூலம் எனக்கு தேவையான பல் மருத்துவ சிகிச்சைகளைப் பற்றி அறிந்து அதை அளிக்குமாறு வேண்டுகிறேன்.

என் மேல்த்தாடை எலும்பு குறைவாக இருப்பதையும், இம்ப்லான்ட் வைப்பதற்கு சைனஸ் அறுவை சிகிச்சை தேவை என்பதையும் நான் அறிந்தேன். நரம்பு மரப்பு ஊசி மூலம் செய்யப்படும் இந்த சிகிச்சை முறை பற்றியும், இதனால் பின் விளைவுகள் சில நேரிடலாம் என்பதையும் மருத்துவர் எடுத்துரைத்தார். சிகிச்சையின் போது செயற்கை எலும்பு சைனஸினுள் வைக்கப்படும் என்பதையும் தெரிவித்தனர். புகை பிடித்தல், மது அருந்துதல், சர்க்கரை போன்ற நோய்களால் செய்த சிகிச்சையில் பாதிப்பு உண்டாகலாம் என்று எடுத்துரைத்தனர்.

இப்படிவத்தில் கையொப்பம் இடுவதின் மூலம் Dr……..க்கு எனக்கு சிகிச்சை அளிக்க முழு ஒப்புதல் அளிக்கிறேன். எந்த பின் விளைவுகளுக்கும் மருத்துவரோ, மருத்துவ உதவியாளர்களோ, மருத்துவமனையோ அல்லது நிர்வாகமோ பொறுப்பில்லை என்பதை ஏற்றுக்கொள்கிறேன்.

கையொப்பம் : மருத்துவர் கையொப்பம்:

முகவரி & தொலைபேசி எண்: நாள் :

ANNEXURE IV

ARMAMENTARIUM

Diagnostic instruments:

- Mouth mirror
- Shepherd's crook probe

Materials for PRF preparation:

- 20ml syringes for PRF (Platelet Rich Fibrin) preparation
- 15ml test tubes
- Remi R8C laboratory centrifuge machine
- Giestlich Bio-Oss spongeous bone substitute (1-2mm particles)

Materials for local anesthesia:

- 26 gauge needle and 2ml unolok syringe for local anesthesia
- Lignocaine hydrochloride 2% with adrenaline bitartrate 1:80,000

Instruments and materials for surgery:

- Cheek retractor
- Bard Parker blade handle no.3 & No.15 surgical blade
- Suction tip
- Sterile gauze
- Bite block
- Molt's no.9 periosteal elevator
- Howarth's periosteal elevator
- Austin's retractor

- Kidney tray and sterile cups
- Nobel biocare Physio-dispenser
- Nobel biocare Contra-angled latch-type hand piece
- 0.9% sodium chloride solution
- HIOSSEN Crestal Approach Sinus (CAS) Kit from Osstem
- Osstem Implant surgical kit and Implants
- Halstead’s mosquito artery forceps
- 5ml syringe for hydraulic sinus lift
- Needle holder
- Adam’s tissue holding forceps – toothed and non-toothed
- 3-0 vicryl suture material
- Suture cutting scissors

ANNEXURE V

RADIOLOGICAL ANALYSIS (PRE OPERATIVE AND POST OPERATIVE)

Patients Name	Age	Sex	Tooth Number	Pre surgical			Implant Size (mm)	Post surgical		
				Bone Height (mm)	Bone Width (mm)	Bone Density (HU)		Bone Height (mm)	Bone Density (HU)	Periapical bone height(mm)
Mr.PK	24	M	16	7	6.5	854	4.5 X 11.5	14.7	1008	3.2
Mrs.RL	63	F	16	5.51	7.6	654	4.3 X 11.5	13	782	1.5
Mr.KK	34	M	16	6.7	5	803	3.75 X 11.5	13.3	893	1.8
Mrs.PM	38	F	27	4.94	5.5	793	4 X 8.5	9.7	737	1.2
Mrs.TA	58	F	17	4	7.4	825	4.5 X 11.5	12.5	847	1

PATIENT AND IMPLANT DETAILS

	N	Minimum	Maximum	Mean	S. D
Diameter of implant	5	3.5	4.5	4.09	0.44
Length of implant	5	8.5	11.5	10.9	1.34
Age	5	24	63	43.4	16.5
Sex	Male	40%			
	Female	60%			

GLOSSARY

CBCT	Cone Beam Computed Tomography
PRF	Platelet Rich Fibrin
OPG	Orthopantomogram
RVG	Radio Visuo Graph
AMBE	Antral Membrane Balloon Elevation
CAS kit	Crestal Approach Sinus Kit
mm	Millimeter
HU	Hounsfield Units
rpm	Rotations Per Minute
cc	Cubic Centimeter
SA	Sub Antral
CPS	Calcium Phospho Silicate
BH	Bone Height
CGF	Concentrated Growth Factor
PRGF	Plasma Rich In Growth Factor
PRP	Platelet Rich Plasma
PPV	Paroxysmal Positional Vertigo