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CASE REPORT

Subantral sinus augmentation using hydraulic lift system and alloplastic phosphosilicate putty followed by simultaneous implant placement for the rehabilitation of an atrophic posterior maxilla: A case report

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ABSTRACT

Background: Tooth extraction is generally accompanied by bone remodeling and pneumatization of the maxillary sinus in the posterior region of the maxilla, which can result in a reduction in the height and width of the bone and compromise the placement of the implant. However, this anatomic deficiency can be restored through maxillary sinus elevation. Among the various surgical methods used, the indirect sinus floor elevation technique is relatively less invasive and less complex.
Aim: Herein, we present the case of a 58-year-old partially edentulous female who underwent rehabilitation of the right maxillary molar region using the indirect sinus floor elevation technique. The hydraulic lift system was used followed by immediate implant placement.
Relevance for Patients: This technique incorporates the advantages of both the lateral wall and crestal approaches for sinus elevation and is associated with a lower incidence of sinus membrane perforation and minimum bone loss.

1. Introduction

Tooth loss is generally accompanied by a physiological reduction and remodeling of the alveolar bone [1]. In addition, the absence of occlusal forces, which activate the bone remodeling process and cause pressure thresholdregulated bone atrophy, can result in a reduction in the height and width of the surrounding bone [2]. An increase in osteoclast activity in the periosteum at the floor of the sinus can lead to the development of an enlarged sinus [3,4]. The placement of an implant in the edentulous posterior maxillary region might prove challenging due to the pneumatization of the sinus**,** which can adversely affect the clinical outcome [5]. After tooth extraction, the height and width of the alveolar bone are generally reduced by 1–2 mm and 4–5 mm, respectively [6]. Significant bone loss occurs within 1 year of tooth extraction, with maximum loss observed during the first 3 months after the extraction; thereafter, the bone loss continues throughout life [6]. Both vertical and horizontal alveolar bone resorption occurs at the same rate after tooth extraction in the posterior part of the maxilla, thereby triggering the pneumatization of the sinus [7] and limiting the vertical distance between the alveolar ridge and floor of the maxillary sinus [8]. Furthermore, advanced periodontal disease impairs the residual alveolar bone support required for implant placement [9]. Several factors such as heredity, craniofacial configuration, nasal mucous membrane pneumatization, sinus surgeries, growth hormones, bone density, and sinus pressure can affect pneumatization [10]. Approaches such as

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sinus augmentation and bone augmentation have been used to overcome the problems related to implant placement in regions with insufficient vertical bone height.

A sinus lift is performed by grafting additional bone into the sinus in order to increase the bone height and aid in implant placement. According to Pommer *et al*., the height and width of bone required for implant placement should be at least 10 mm and 3–4 mm, respectively [11]. Although maxillary sinus elevation was first developed by Boyne in the 1960s, it was first published in 1980 by Boyne and James who reported the elevation of the sinus floor in patients with larger pneumatized sinus cavities in preparation for blade implants [12].

A variety of sinus lift procedures such as the lateral window approach/direct sinus lift [13-15], transcrestal approach/indirect sinus lift [16,17], smart lift technique, piezoelectric surgery, hydraulic sinus lift technique [18], and balloon elevation technique have been developed. Among them, the direct sinus lift and indirect sinus lift techniques are most commonly used. The direct technique was first introduced by Tatum in 1977, wherein the sinus was accessed through the lateral sinus wall; alternatively, in the indirect technique, the crestal approach with an osteotome and a surgical mallet was used [13]. The less invasive indirect approach takes precedence over the direct approach [19]. The smart lift technique requires the use of drills and osteotomes are used for the transcrestal approach. In recent years, piezoelectric instruments have been used to open the window of the lateral wall; however, the risk of perforation remains.

Before proceeding with sinus grafting, knowledge about the anatomy of the maxillary sinus, the various surgical procedures used, and the rate of success associated with each of these techniques are essential. According to a study by Misch [20], the indirect sinus augmentation technique is indicated when the height of the sub antral bone is 8 mm, 1-stage direct augmentation with implants is indicated when the bone height is 5–8 mm, and the 2-stage direct augmentation technique is indicated when the bone height is <5 mm. Complications occur when filling materials dislodge into the sinus cavity [21] due to perforation of the Schneiderian membrane during instrumentation or by the implant, which can result in sinusitis [22]. Proper case selection and preparation of the anatomical site can overcome these problems. The Schneiderian membrane is a mucous membrane that covers the inner part of the maxillary sinus and is approximately 1 mm in thickness. It is important to consider the properties of this membrane to reduce the complication rate and patient morbidity [23].

This clinical report describes the rehabilitation of the dimensions of the vertical bone in the posterior region of the maxilla using the indirect sinus lift technique using hydraulic pressure to lift the floor of the maxillary sinus; this was then followed by the immediate placement of the implant. The Hiossen's Crestal Approach Sinus Kit (CAS-KIT-Osstem Korea) consisting of safe side/end-cutting drills and vertical stoppers was used along with hydraulic pressure for membrane elevation. This technique is less invasive, less time-consuming, and associated with fewer post-operative complications. The CAS drills improve the convenience and safety of the surgical procedure and aid in the careful lifting of the membrane owing to the precise cutting techniques and the formation of conical bone chips, which help in lifting the sinus membrane safely without causing any damage. According to Misch, grafting with delayed implant placement is advisable when the thickness of the bone between the crest of the ridge and the maxillary sinus is <5 mm [22]. However, in the current study, the use of the hydraulic lift system and the alloplastic phosphosilicate putty resulted in a sinus lift of 8 mm and an even distribution of the graft material; hence, immediate implant placement was performed.

2. Case Presentation

A 58-year-old partially edentulous female visited the Department of Prosthodontics and Implantology to replace her missing teeth. Intraoral examination revealed a partially edentulous arch with missing teeth #17, #36, and #37 (Figure 1A). Orthopantamograph (OPG) examination revealed a vertically deficient ridge in the #17 region and a distomolar located distal to tooth #28 (Figure 1B). Cone-Beam computed tomography revealed that the available bone height from the alveolar crest to the sinus floor was 4 mm and the width at the alveolar crest was 8.9 mm in the #17 region (Figure 1C). The patient presented with the SA-4 classification (<5 mm of bone between the crest of the ridge and the floor of the maxillary sinus), based on the classification proposed by Misch [22]

The treatment options were explained to the patient after comprehensive history taking and thorough clinical and

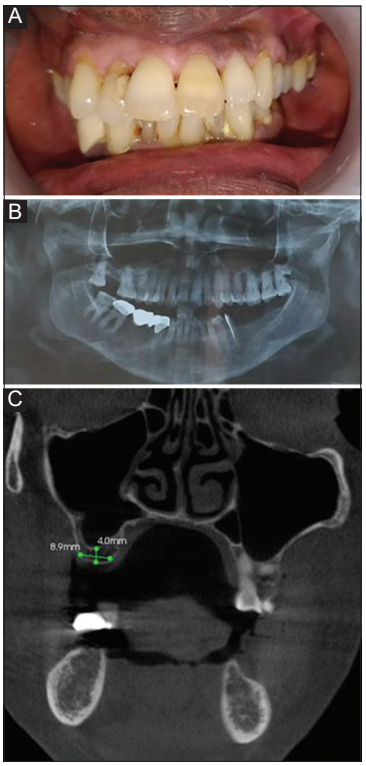

Figure 1. Clinical (A) and radiographic (B, C) images of the oral cavity of the patient. A. Clinical picture of the patient. B. Pre-operative orthopantamograph. C. CBCT view of the #17 region.

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radiographic examinations. The crestal approach for sinus lift along with hydraulic pressure was adopted using the CAS KIT (Figure 2). This was followed by immediate implant placement (Osstem) in the #17 region.

A local anesthetic was administered using the block technique and a crestal incision extending from the distolingual line angle of tooth #16 to the mesiolingual line angle of tooth #18 was made; this was followed by the elevation of a full-thickness mucoperiosteal flap (Figure 3A). The osteotomy site was prepared using a 2.0 guide drill followed by a 2.2 twist drill at 1000–1500 rpm, which was safely advanced 2 mm short of the sinus membrane using the vertical stopper system. Subsequently, a series of osteotomies were performed using the 2.8, 3.3, and 3.8 mm CAS drills at 400–600 rpm. Owing to the inverse conical drill design of the CASKIT, conical-shaped bone chips were generated between the cutting blades during the drilling process, which created an auto lifting force that aided in the elevation of the membrane (Figure 3B and C). The detachment of the sinus membrane was assessed with the help of a depth gauge consisting of an atraumatic tip and a stopper system (Figure 3D and E). Then, a hydraulic lifter connected to a 1.0-ml syringe and filled with saline solution was used to elevate the membrane (Figure 4A and B). The hydraulic lifter was inserted and stabilized, and the saline solution was slowly infused; this process was repeated until the required elevation was achieved. In general, 0.2–0.3 cc of saline is sufficient to lift the membrane by 3 mm, which can be observed radiographically, as shown in Figure 5. The graft material (nova bone putty; Osteogenics Biomedical; Figure 6A), which is a viscoelastic calcium phosphosilicate alloplastic putty, was placed at the prepared implant site using a bone carrier (Figure 6B) and condensed with a bone condenser (Figure 6C). A bone spreader was used to evenly distribute the graft and further elevate the sinus. The sinus was elevated up to a height of 8 mm, and the Osteem implant (4.5 × 11 mm; Osstem, Korea) was placed in position. Subsequently, the cover screw was placed over it, the flap was repositioned, and the site was closed with sutures (Figure 6D and E).

The patient was instructed to keep the head in an elevated position during sleep and cautioned that nasal bleeding may occur. In addition, she was advised to avoid drinking through a straw, sneezing, coughing, smoking, sucking, flying in a pressured aircraft, lifting weights, and pulling the lips to examine the sutures, which could disturb the blood clot and prolong the healing process. She was instructed to swallow the saliva instead of spitting it and was warned that it might have a slight reddish discoloration due to the presence of blood. A liquid diet was recommended for 2 days, followed by a soft diet for 2 weeks. Prophylactic antibiotics were prescribed for 5 days post-surgery.

Conventional implant placement was performed in the #36 and #37 region after the administration of the local anesthetic agent (Figure 7A-E). After 5 months of healing [24], an OPG was taken to assess bone formation; an 11 mm gain in vertical height from the crest of the ridge to the floor of the sinus was observed (Figure 8). A punch cut was made to expose the implants in the #17, #36, and #37 regions, followed by the fixing of the closed tray impression copings to the implants (Figure 9A and B). Closed tray impressions were made for both the maxillary and mandibular arches. A metal-ceramic screw-retained prosthesis was placed onto the implant and

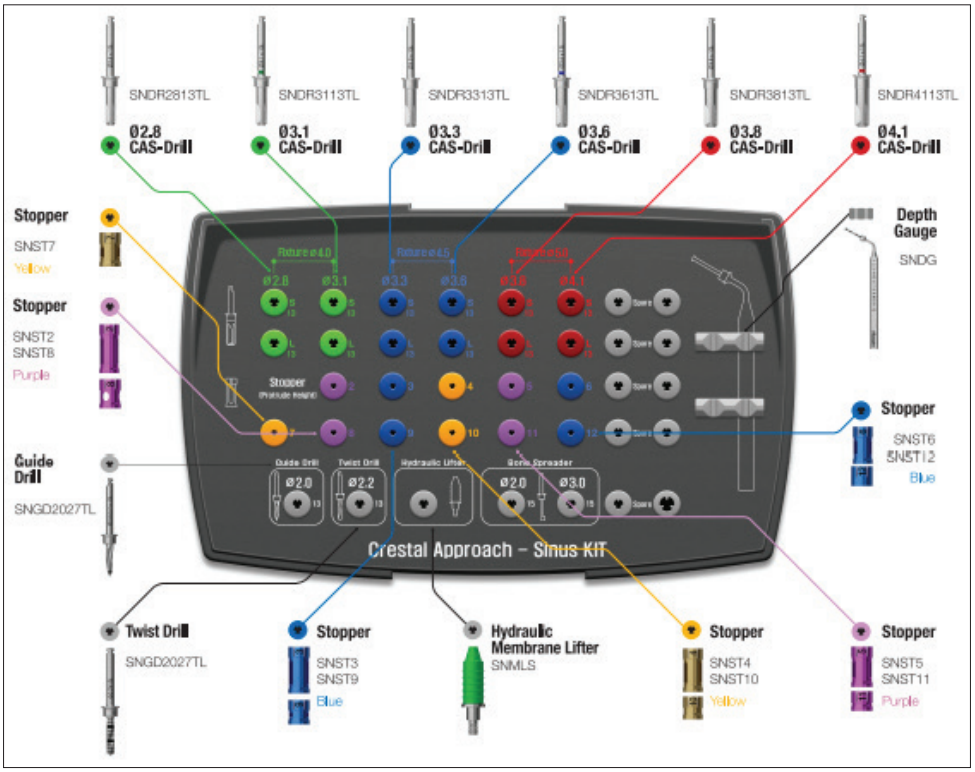

Figure 2. The Crestal Approach-Sinus kit (CAS-KIT).

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tightened to a torque value of 20 Ncm; the screw access channels were filled with composite resin restorations in relation to tooth #17, 36, and 37 (Figure 10A and B).

The patient was recalled after 2 months for review and the results were found to be satisfactory.

3. Discussion

The elevation of the Schneiderian membrane without causing any perforation is essential during the sinus lift procedure. The factors that must be taken into consideration during sinus elevation include the following: the anatomy of the maxillary sinus, the force required for membrane detachment, the angulation of the instrumentation, and the elasticity and deformation capacity of the sinus membrane [25]. Berengo *et al*. reported that the anatomical structure of the sinus and the properties of the Schneiderian membrane are correlated with the maximum achievable elevation [26]. In another study, Peleg *et al*. reported that the survival rate of implants placed immediately in grafted maxillary sinuses with <5 mm of bone remaining was 97.9% [27]. Rosen *et al*. reported a significant drop in the survival rates of implants from 96% to 85.7%, in cases where the height of the residual alveolar bone was <4 mm. The bone height from the alveolar ridge to the floor of the sinus has been reported as the most important factor that affects implant survival [28]. Several authors have reported elevations of up to

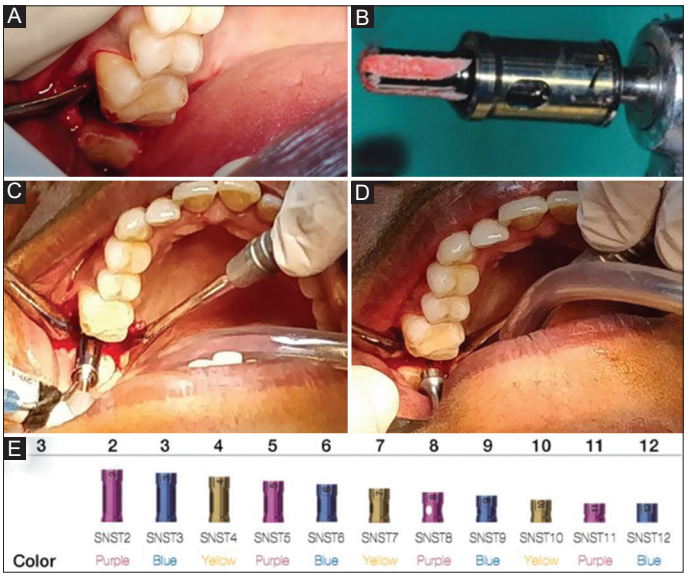

Figure 3. Site preparation and surgical procedures in tooth #17 region. A. Flap elevation in tooth #17 region. B and C. The CAS drills used on the patient. D. Accessing the detachment of the sinus membrane using a depth gauge. E The stopper system used in this study.

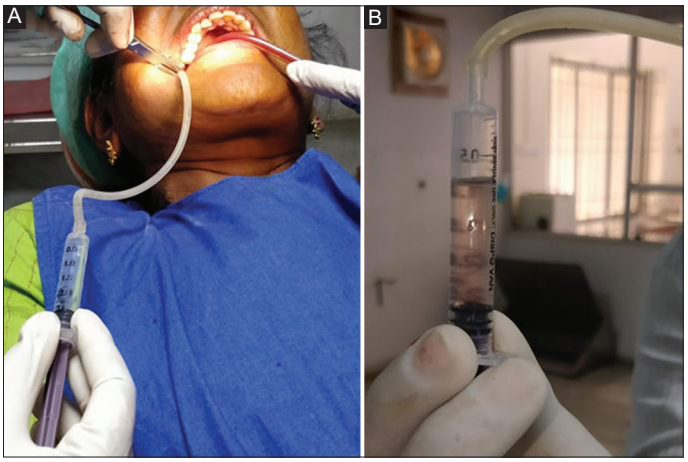

Figure 4. Images of the hydraulic lifter system (A and B) used on the patient.

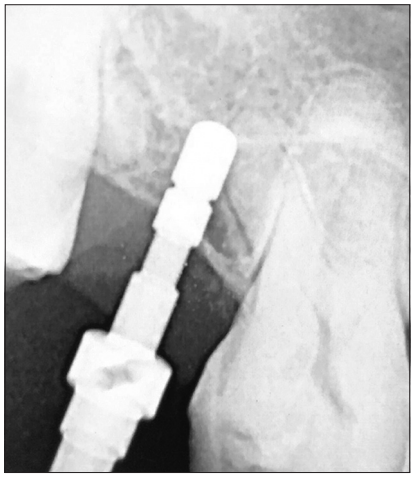

Figure 5. Radiographic evaluation of the depth.

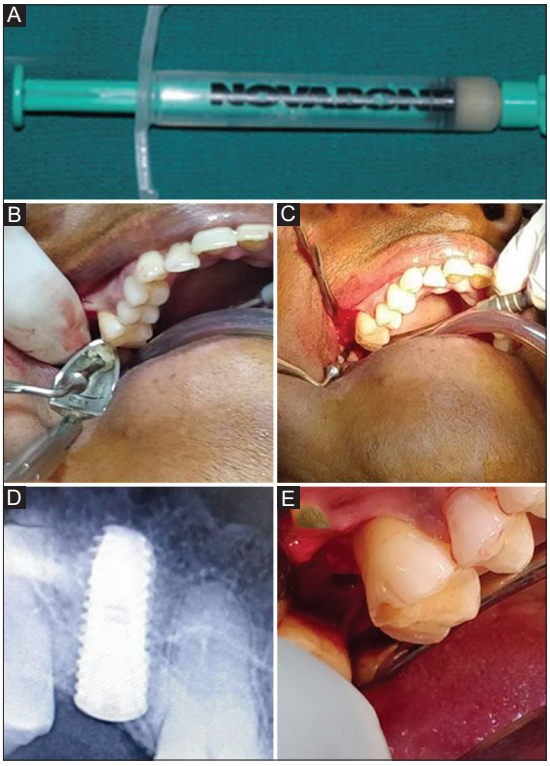

Figure 6. Placement of the graft material and the implant. A. Nova bone putty (bone graft). B. The bone carrier with the graft material. C. Bone condenser. D. Radiographic view after implant placement. E. Clinical view after implant placement.

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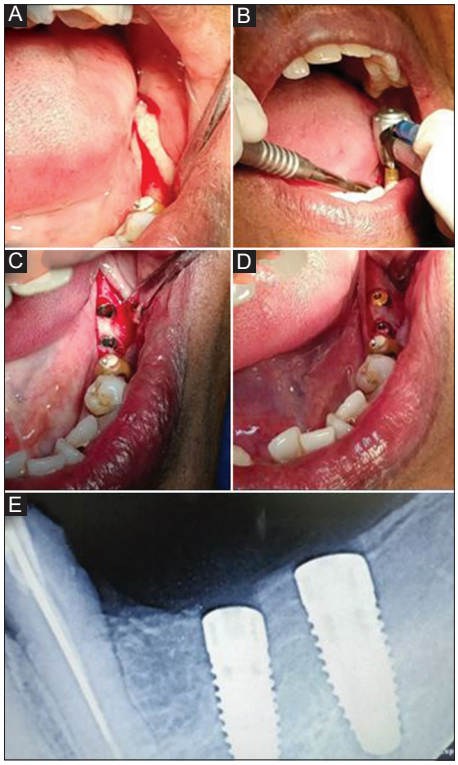

Figure 7. Conventional implant placement in the #36 and #37 region. A. Flap elevation. B. Implant site preparation. C. Implant placement. D. Cover screws were placed in position. E. Radiographic view of the implants.

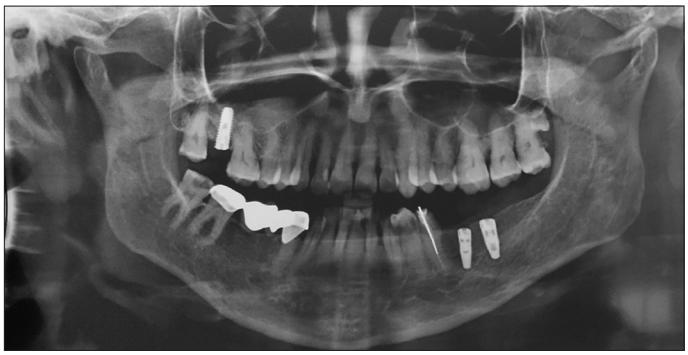

Figure 8. Post-operative orthopantamograph. An 11 mm gain in vertical height from the crest of the ridge to the floor of the sinus was observed.

2.5–8.6 mm in the sinus membrane using the crestal approach [29-33]. However, this approach cannot be executed in all cases due to the perforation of the Schneiderian membrane, inadequate primary stability of the implant, and displacement of the implant into the sinus cavity. Perforation of the membrane may result in postoperative sinusitis or the migration of the graft into the sinus [34,35]. Hiossen's CASKIT improves the ease and predictability of the sinus lift procedure by combining the advantage of both the lateral window approach and the crestal approach. This minimally invasive technique minimizes crestal bone loss, whereas traditional procedures are associated with the risk of Schneiderian membrane perforation. The CAS drill tip can be used to perform sinus surgery

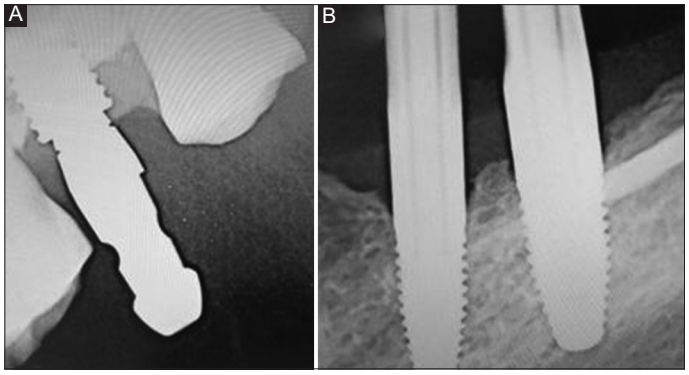

Figure 9. Radiographic evaluation of the fit of the impression copings in the maxilla (A) and mandible (B).

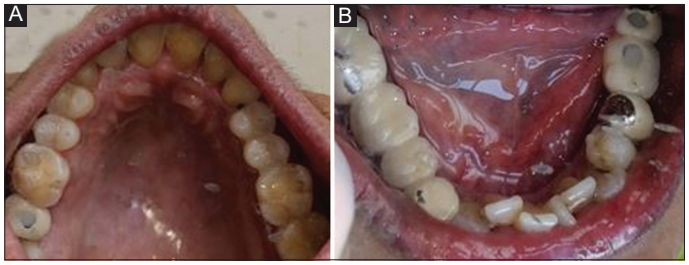

Figure 10. Screw retained prosthesis in relation to tooth #17 (A) and teeth #36 and #37 (B).

regardless of whether the floor of the sinus is flat, inclined, or has a septum. Membrane perforation and excessive drill penetration can be prevented using the unique stopper system. This method aids in achieving simultaneous detachment and the elevation of the membrane without perforation. However, it is indicated only when a minimum residual height of 4–6 mm is available; nonetheless, up to 2–10 mm of sinus elevation has been reported with this method.

Safe end/side-cutting burs were used to push the small conical bone chips from the sinus floor into the sinus during the final drilling process. The use of various vertical stops allows for the preparation of the site 1–2 mm below the sinus floor. The final osteotomy is performed by switching the vertical stopper a little deeper through the floor of the sinus and pushing a small tapered piece of bone into the sinus. Finally, the hydraulic lift elevates the sinus membrane. The bone graft material can be continuously introduced via osteotomy, using a condenser and a rotary bone spreader, and evenly distributed. The implant is placed after the desired bone height is achieved through augmentation.

The patient in the present study presented with a bone height of 4 mm in the right maxillary posterior region. The sinus floor was elevated up to 8 mm for the placement of an Osteem implant (length, 11 mm; diameter, 4.5 mm). One of the limitations of this technique is that it is a blind procedure; hence, the probability of making an error exists.

4. Conclusion

The use of the CASKIT for lifting the sinus combines the benefits of high-volume bone placement using the lateral window approach

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with the simplicity of the crestal approach, without any fear of membrane perforation. In addition, it minimizes crestal bone loss (up to 0.5 mm during the first 6 months) because drilling with an atraumatic tip enables the harvesting of the autogenous bone [36,37]. Hence, an adequate understanding of this noninvasive technique and its possible complications during sinus augmentation surgery, and adherence to a clear surgical plan can aid the dental surgeon in performing a safe and predictable sinus augmentation surgery.

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Conflict of Interest

The authors declare no conflict of interest.

Author Contributions

1. Dr. Cathryn Beryl Padma Felix- Diagnosis, direct patient contact, performing the treatment procedure, writing the report
2. Dr. Anjana Kurien- Contributed to patient care and writing of the report
3. Dr. Ashwin Devanarayanan- Guided the treatment procedure
4. Dr. Deepak Kumar.B- Contributed to witing of the report
5. Dr. Thirumurthy V.R-Contributed to witing of the report
6. Dr. Bindhoo Y.A-Contributed to witing of the report and Gramatical correction

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