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Minimally Invasive Lateral Approach through Circular Window with a Diameter of 5 to 6 mm for Maxillary Sinus Floor Elevation with Simultaneous Implant Placement: Retrospective Study

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Abstract: The aims of this study were to propose a minimally invasive lateral approach technique for maxillary sinus floor elevation (MSFE) with simultaneous implant placement and to evaluate the surgical outcome and complications of this technique. This study reviewed 49 surgeries of MSFE with simultaneous implant placement (n = 83) using a minimally invasive lateral approach. A circular shape window with a diameter of 5 to 6 mm and an area of 20–30 mm^2 was made on the lateral wall of the maxillary sinus. After elevation of the Schneiderian membrane, the xenograft was used for bone grafting. The MSFE was possible with a minimum-sized window in 47 of 49 cases. For the remaining 2 cases, MSFE with a minimum-sized window was failed. In one case, it was expanded to be more than 30 mm^2 to repair the membrane perforation. In another case, MSFE was performed by forming two minimum-sized windows. Post-operative bleeding after MSFE occurred in one anticoagulant-treated patient. There was no failed implant during the follow-up period (mean 22 months). A minimally invasive lateral approach through a small circular window with a diameter of 5 to 6 mm is a feasible and safe technique for MSFE with simultaneous implant placement.

Keywords: maxillary sinus floor elevation; minimal invasive lateral approach; lateral window; window size

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1. Introduction

Dental implant treatment is needed to restore the function and aesthetics of an edentulous patient. Adequate quality and quantity of bone are necessary for the proper placement of the dental implant. After extraction of maxillary posterior teeth, bone atrophy and maxillary sinus pneumatization gradually progress. Thus, insufficient bone for implant placement is frequently observed for a maxillary posterior alveolar bone [1]. For such cases, a maxillary sinus floor elevation (MSFE) can be considered to place the dental implant. The Schneiderian membrane which is located on the maxillary sinus cavity can be elevated and bone-grafting materials can be used to fill in the space between the elevated membrane and the maxillary sinus floor. This concept of MSFE was introduced by Tatum in 1977 [2]. Since then, various advanced techniques have been developed and progressed. A MSFE can be performed with a lateral or a crestal approach according to the method of accessing the Schneiderian membrane.

With the crestal approach, the sinus floor is elevated through the site of implant installation. The Schneiderian membrane is elevated by graft material filling or hydraulic pressure. This technique has shown successful results in many cases when the height of the alveolar bone is more than 5 mm [3,4]. A major disadvantage of the crestal approach is the lack of direct visibility of the maxillary sinus cavity. Unlike the crestal approach, the lateral

approach needs the lateral window for better access and visibility into the sinus cavity. The Schneiderian membrane can be seen and evaluated through the lateral window. It can then be carefully detached and elevated from the sinus cavity. The graft material is filled into the space between the sinus floor and the elevated membrane. The lateral approach may be preferred when the alveolar bone height is less than 6 mm and/or when the crestal approach is difficult to perform. The lateral approach is a more invasive technique than the crestal approach because osteotomy should be performed for the formation of a lateral window. However, this technique has benefits as it is possible to directly observe and manipulate the Schneiderian membrane.

A minimally invasive lateral approach is a technique that allows sinus bone augmentation with reduced window size. Various surgical techniques have been proposed to reduce the size of the lateral window. A slim-linear shape of the lateral window for a lateral approach with a simultaneous bone-added osteotome technique has been introduced to decrease the size of the lateral window while maintaining proper access to the instrument [5,6]. Adawi, Hengjeerajaras et al. (2019) have proposed a vertically oval shape window (4×8 mm^2) for a single implant and a horizontally oval shape window (10×5 mm^2) for multiple implants [7]. There was no difference in the obtained augmented bone height when the height of the window was 4 mm or 8 mm [8]. Two mini windows with a height of 5–6 mm in a horizontally oval shape (total size of 52 mm^2) have demonstrated similar results to a conventional window technique [9]. It has been suggested that a minimally invasive lateral sinus elevation with a window size of about 3–5 mm in height can result in a favorable patient morbidity [10]. Baldini, D'Elia et al. (2017) have compared a small window (6×6 mm^2) with a large one (8×10 mm^2) and found that the small window can result in less postoperative discomfort [11]. In a retrospective study, Lu, Xu et al. (2018) have used a small window (35 mm^2) and a large one (47 mm^2) and demonstrated no significant difference in terms of implant survival, augmented bone stability, or postoperative complication [12]. Although a reduced window dimension has demonstrated clinical success, reported minimally invasive lateral windows to differ in size, shape, and position. Thus, it is necessary to evaluate the ideal width, height, shape, and location of the osteotomy site.

In the present study, a circular shape window with a diameter of 5 to 6 mm (an area of 20–30 mm^2) was made on the lateral wall of the maxillary sinus for a minimally invasive lateral approach. After elevation of the Schneiderian membrane, the xenograft was used for MSFE. This retrospective study reviewed 49 surgeries of MSFE with simultaneous implant placement using a minimally invasive lateral approach from a single institution. The aims of this study were to propose a minimally invasive lateral approach technique (circular window with a diameter of 5 to 6 mm) for MSFE, and to evaluate the surgical outcome and complications of this technique. The null hypothesis was that the minimally invasive lateral approach technique is associated with a higher membrane perforation incidence than conventional lateral approach MSFE.

2. Methods

2.1. Patient Selection

A total of 43 patients with 49 surgeries of MSFE in combination with simultaneous implant placement were retrospectively evaluated. All surgeries were performed in the department of dentistry at Gangneung Asan Hospital between May 2017 and December 2019. This clinical study was approved by the Institutional Review Board (IRB) of Gangneung Asan Hospital (IRB No: 2021-02-001).

The mean age of patients was 60.8 years with ranged from 35 to 77 years (27 men and 22 women). Preoperative evaluation with a panoramic radiograph was performed regarding residual bone height, structural deviation, and pathogenesis in the maxillary sinus. The inclusion criteria were as follows: (1) patients in need of fixed implant rehabilitation for edentulous posterior maxilla; (2) patients were categorized as American Society of Anesthesiology physical status I–III; (3) no previous surgery or radiation treatment on

the maxillary sinus. A total of 59 minimally invasive lateral approaches for MSFE with simultaneous implant placement were tried between May 2017 and December 2019. Among 59 surgeries, 10 surgeries were excluded by following exclusion criteria: (1) patients with more than 7 mm of residual bone height in the maxillary posterior area; (2) patients with less than 8 months follow-up period; (3) presence of inflammatory or pathologic lesions in the maxillary sinus (Figure 1).

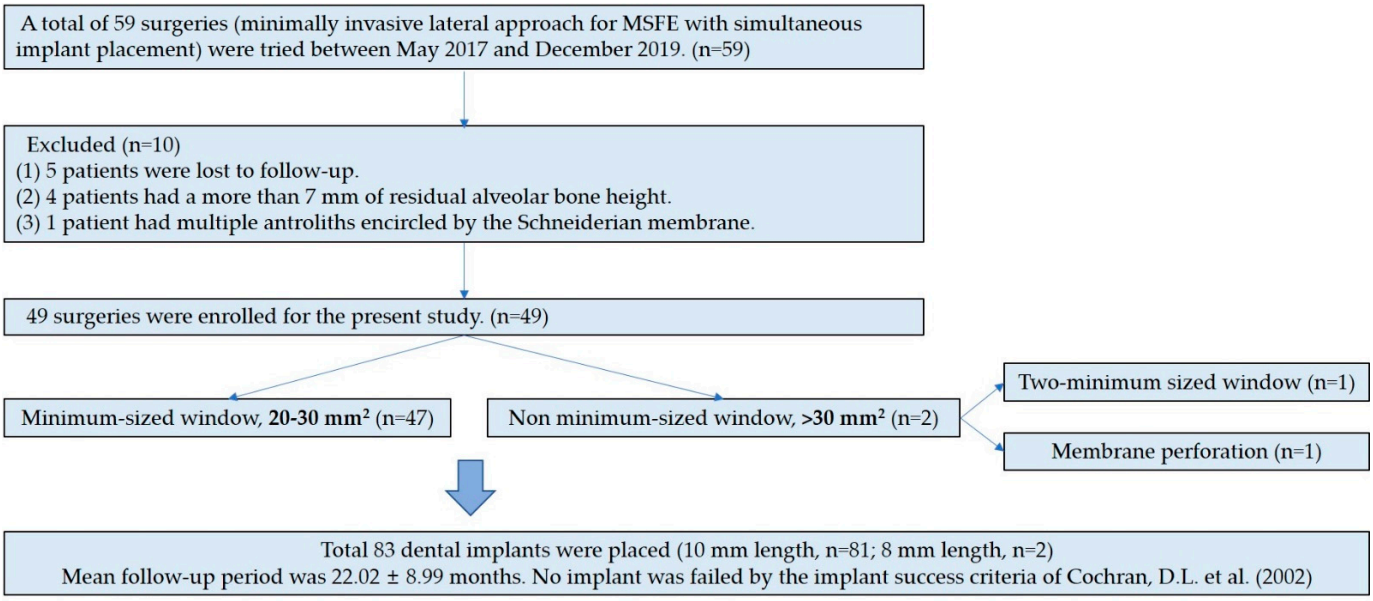
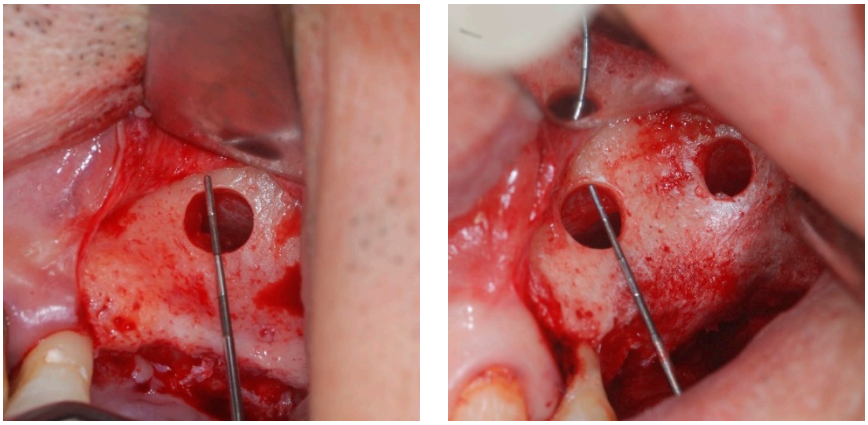


Figure 1. Flow diagram of patient participation.

Past medical history and current medications were checked from a preoperative patient questionnaire and medical records. Anticoagulant-treated patients with ischemic heart disease, heart failure, valvular heart disease, peripheral artery disease, arrhythmia, and/or cerebrovascular accident were included in this study. These patients were generally maintained their anticoagulation treatment during the pre- and post-operative period. Medical consultation was conducted if abnormal results of blood examination were found in a recent laboratory test and/or if a patient requested an interruption of their anticoagulation treatment due to concern about postoperative bleeding. The anticoagulation treatment was interrupted or changed according to the results of medical consultations. When the anticoagulation treatment was maintained, the possibility of post-operative bleeding was explained to the patients before surgery. When prophylaxis of endocarditis was required, prophylactic antibiotics were applied orally or intravenously.

2.2. Surgical Protocol

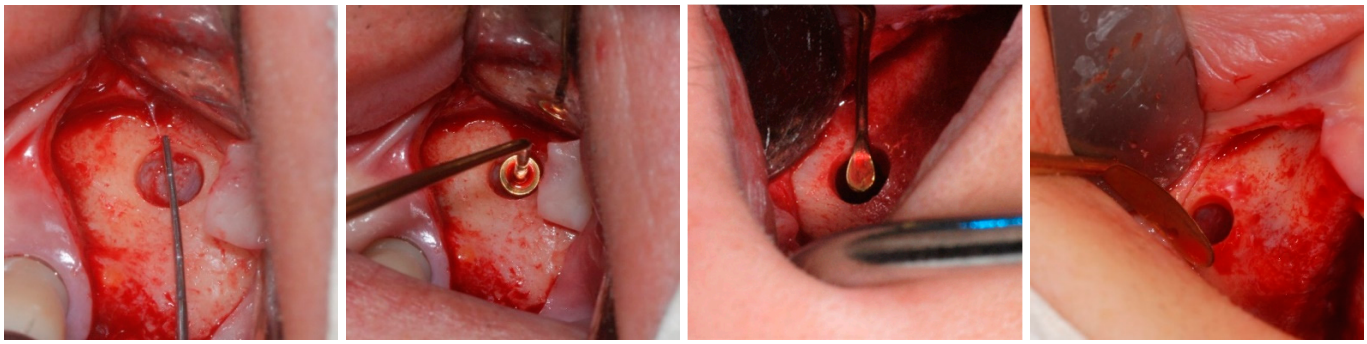
Local anesthesia was applied using 2% lidocaine with 1:100,000 epinephrine. A full thickness mucoperiosteal flap was elevated after crestal and vertical incisions to expose the alveolar bone and the lateral wall of the maxillary sinus. The vertical incision was designed to be more than 5 mm mesial from the margin of the lateral window to prevent exposure of lateral window even after wound dehiscence. A lateral minimum-sized window with a diameter of 5 to 6 mm (area of 20 to 30 mm^2) was created for sinus floor elevation (Figure 2a). If maintaining the small round window was difficult due to restriction of instrument access, the size of the lateral window could be increased to be more than 30 mm^2 or a second window (20 to 30 mm^2) could be made in the posterior position parallel to the first window (Figure 2b).



(**a**) (**b**)

Figure 2. (**a**) Elevated Schneiderian membrane was observed through a minimum-sized lateral window (circular shape with a diameter of 5–6 mm); (**b**) Two minimum-sized lateral windows with a diameter of 5–6 mm were made for proper elevation of Schneiderian membrane.

A low-speed straight handpiece with a diamond round bur (RA SL 801-029, Komet, Lemgo, Germany) was used to form a round window on the lateral wall of the maxillary sinus. About a 5 mm dimension round hole was initially made to expose the Schneiderian membrane (Figure 3a). The membrane was detached around the window margin using a dome-shaped sinus elevation instrument (REF XSE1L, Dentium, Seoul, Korea) (Figure 3b). If the instrument access was restricted, the window was enlarged gradually until the diameter was 6 mm. The diameter of the round window was measured with a dental probe having a scale of 3 mm and the final diameter was confirmed to be less than 6 mm.



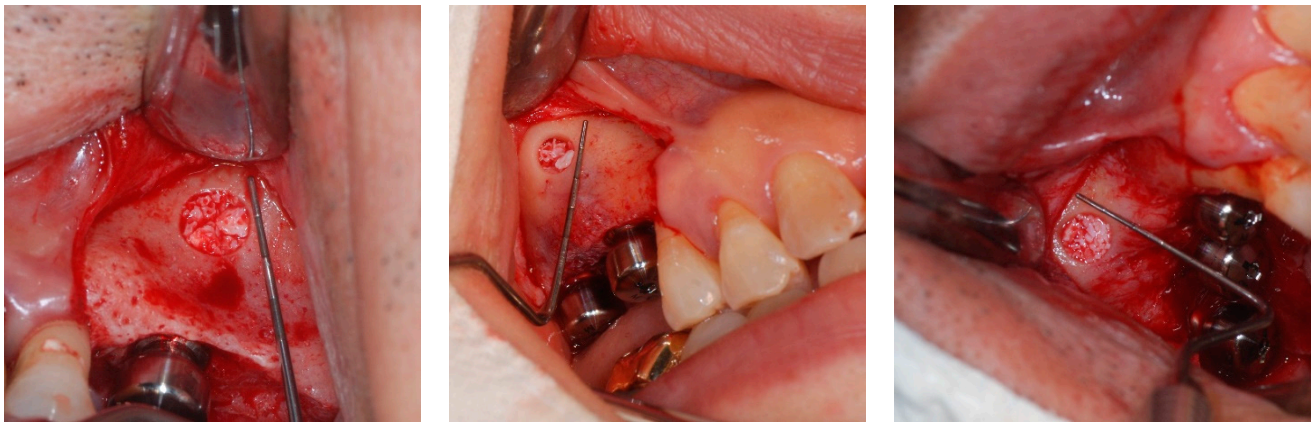
(**a**) (**b**) (**c**) (**d**)

Figure 3. (**a**) Schneiderian membrane observed through a minimum-sized lateral window with a diameter of 5 mm; (**b**) Membrane detachment using a dome-shaped sinus elevation instrument; (**c**) Membrane elevation using a blunt-edged sinus elevation instrument; (**d**) Elevated membrane is visible with a long shank blunt-edged sinus elevation instrument.

Detachment of the membrane toward the upper portion of the window was almost limited. Thus, the upper border of the window was positioned at 10 to 12 mm vertically from the alveolar crest considering the length of the implant to be placed. Detachment of the membrane toward the anterior direction from the anterior border of the window was also partially limited. Therefore, a minimum-sized lateral window was positioned at the most anterior part of the lateral wall of the maxillary sinus or at the most anterior part of the required bone-grafting area. Elevation of the Schneiderian membrane was proceeded in a lateral to medial direction via the sinus floor, gradually facing backwards. Among sinus elevation instruments, REF XSE2L was used as the main instrument for membrane elevation (Figure 3c). REF XSE4L was used as a supportive instrument at the medial wall and the posterior region of the maxillary sinus cavity for membrane elevation

(Figure 3d). The Schneiderian membrane was detached from sinus walls by keeping instrumentation in contact with the bony floor. Membrane elevation was finished so that the membrane was horizontally elevated to the height of the upper margin of the lateral window (Figure 2a). If the Schneiderian membrane was perforated, the lateral window was enlarged to be more than 30 mm^2. It was then repaired by covering it with an absorbable porcine collagen membrane (BioGide®, Geistlich Pharma AG, Wolhuser, Switzerland). After membrane elevation, sequential drilling was performed on the alveolar bone for implant placement. Before implant installation, an anorganic bovine bone (ABB; Bio-OSS®; Geistlich Pharma AG, Wolhunsen, Switzerland) with 1–2 mm particle-size was grafted for sinus floor elevation through a minimum-sized lateral window using a surgical curette. Some cases showed insufficient amounts of bone grafts on the most distal part of the bone graft area. This was solved by vertically augmenting the graft material through the transalveolar drilling site of the implant.

After bone augmentation, a dental implant of an internal connection system (Implantium, Dentium, Korea) or an external connection system (USII, OSSTEM, Seoul, Korea) was installed depending on the prosthetic plan. No barrier membrane was placed to cover the minimum-sized lateral window in most patients (Figure 4). After managing the lateral window, the connection of healing abutment was decided for the implant fixture considering the initial stability and the interocclusal distance of the implant. All surgical procedures were performed by one identical clinician. Prosthetic treatment was started after a healing period of about 4–5 months.



(**a**) (**b**) (**c**)

Figure 4. Minimum-sized lateral window without a barrier membrane was observed during maxillary sinus floor elevation with simultaneous (**a**) single or (**b**,**c**) multiple implant placement (anorganic bovine bone filled in sinus cavity).

2.3. Clinical Outcome Evaluations

The lateral window was formed with a diameter of 5 to 6 mm with a circular shape. The calculated area of the lateral window was about 20 to 30 mm^2. The conventional approach was defined as more than 30 mm^2 for the size of the lateral window. Panoramic radiographs are taken before surgery, immediately after surgery, after prosthetic restoration, and annually thereafter until the final observation. The period from bone graft to final observation was different for each patient.

Surgical complications include intraoperative membrane perforation and postoperative bleeding (prolonged bleeding over a period of 24 h). Criteria for dental implant success were the same as those proposed previously [13]: (1) absence of implant mobility, (2) absence of continuous radiolucency around the implant, and (3) absence of persistent or irreversible pain and infection.

3. Results

A total of 49 MSFE surgeries with simultaneous implant placement were performed in the present study. MSFE with a minimum-sized window was possible for 47 of 49 surgeries. For the remaining two surgeries, MSFE with a minimum-sized window failed. In one case, it was expanded to be more than 30 mm^2 to repair the membrane perforation. In another case, MSFE was performed by forming two minimum-sized windows (Table 1).

Table 1. The frequency of a non-minimum sized window, a membrane perforation, and a post-operative bleeding according to implant position.

Implant Position	Number of MSFE	Minimum Sized Window 20–30 mm^2	Non-Minimum Sized Window >30 mm^2	Membrane Perforation	Post-Operative Bleeding	Irregular Sinus Floor
#6	13	12	1	1	0	4
#7	8	8	0	0	1	5
#5, 6	4	4	0	0	0	0
#6, 7	18	18	0	0	0	7
#4, 5, 6	1	1	0	0	0	0
#5, 6, 7	5	4	1	0	0	1
Total	49	47	2	1	1	17

#4, maxillary first premolar; #5, maxillary second premolar; #6, maxillary first molar; #7, maxillary second molar.

Among these 49 MSFE surgeries, a total of 83 implants were simultaneously placed. The mean number of placed implants was 1.69 and the mean follow-up period was 22.02 ± 8.99 months. There was no failed implant during the follow-up period.

In the present study, a total of 15 MSFE surgeries were performed for patients who had received an anticoagulation treatment. Among them, 13 MSFE surgeries were performed with maintaining of anticoagulation treatment while two MSFE surgeries were performed with interruption or change of anticoagulation treatment. Post-operative bleeding after MSFE occurred in one patient who received a combination treatment of warfarin and aspirin. The nasal bleeding occurred the day after surgery. It ceased within two days without any hemostatic treatment.

4. Discussion

In the present study, a minimally invasive lateral approach for MSFE with simultaneous implant placement was tried in 49 surgeries. Among all surgeries, 47 were successfully performed by maintaining a minimum-sized (20–30 mm^2) lateral window. However, two surgeries failed to maintain a minimum-sized window due to perforation of the Schneiderian membrane (1 case) or limitation of instrument access (1 case).

In this study, most surgeries successfully maintained a window size of 20 to 30 mm^2 which was relatively small compared to other studies (Table 2). One study has used a small-sized lateral window using a bone scraper with an average window size of 55 mm^2 [14]. A "Mini-lateral window" for minimally invasive surgery with an average window size of 52.3 ± 11.4 mm^2 has been introduced [9]. The average window size in another study was 69.71 ± 26.24 mm^2, and the smallest was 35.75 mm^2 [15]. Baldini, D'Elia et al. (2017) have made a small-sized window with an average size of 30.9 ± 4.4 mm^2 and a large-sized window with an average size of 73.7 ± 10.1 mm^2 [11]. Lu, Xu et al. (2018) have made a small-sized window with an average size of 35.25 ± 9.19 mm^2 and a large-sized window with an average size of 47.49 ± 8.27 mm^2 [12].

The MSFE using a minimum-sized lateral window has several advantages in the following aspects. If the size of a lateral window is decreased, detachment of the periosteum from maxillary bone can be reduced. Thus, trauma to a patient can also be minimized. Less detachment of the periosteum will result in fewer postoperative periosteal reactions, which will reduce postoperative swelling, pain, and bleeding [16]. A split randomized clinical study has compared the visual analogue scale of post-operative discomfort between small and large windows for 16 patients needing bilateral sinus floor elevation. It was found that

the small window approach showed significantly less discomfort than the large window approach [11].

Table 2. Literature review of lateral window size and shape in maxillary sinus floor elevation.

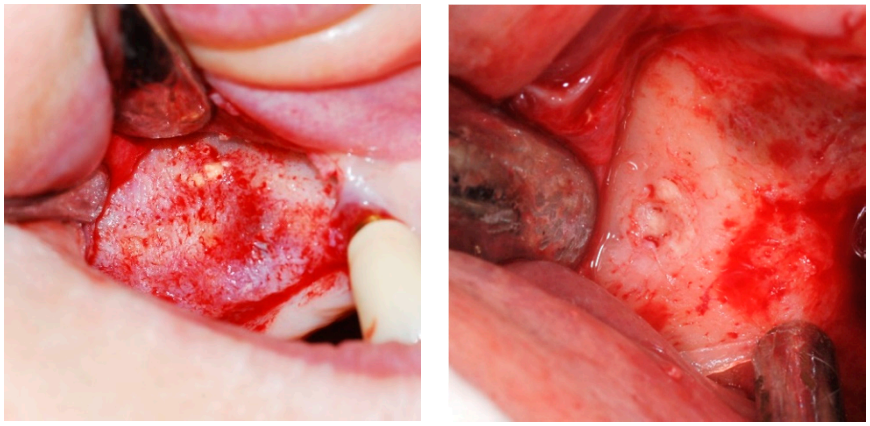
	Number of Surgery	Average Window Size and Shape	Average Number of Implant Placement	Timing of Implant Placement	Incidence of Sinus Perforation
Present study. 2021	49	20~30 mm^2 except 2 surgeries (circular shape)	1.69	Simultaneous	2.0%
Shunsuke Kawakami et al., 2019	20	SW, 48.7 mm^2 LW, 98.3 mm^2	-	Delayed (6 months)	SW 16.7% LW 16.7%
Yu and Qiu 2017	20	SW, 81.66 mm^2 (two ovoid window) LW, 118.04 mm^2 one ovoid window)	SW 3.00 LW 3.22	Delayed (6 months)	SW 9.1% LW 0.0%
Avila-Ortiz, Wang et al., 2012	23	69.71 mm^2 (square shape)	-	Delayed (6 months)	21.70%
Baldini, D'Elia et al., 2017	32	SW, 30.9 mm^2 LW, 73.7 mm^2	SW 2.12 LW 2.06	Delayed 6 month)	SW 18.8% LW 25.0%
Lu, Xu et al., 2018	49	SW, 35.25 mm^2 LW, 47.49 mm^2	SW 1.32 LW 1.46	Simultaneous	SW 8.0% LW 4.2%
Pariente, Dada et al., 2014	15	52.3 mm^2 (ellipsoidal shape)	-	Delayed (6 months)	13.3%

SW, small window; LW, large window.

When the window size is reduced, the amount of graft material in contact with the vital bone is increased. This is advantageous in terms of bone regeneration. Regarding the bone healing process after a sinus floor elevation in a mini-pig, the proportion of new bone formation is high in the area close to the sinus wall. As the distance from the vital bone increases, new bone formation decreases gradually [17]. In a clinical study, when the window size is decreased, the amount of new bone formation is increased at six months after a sinus floor elevation [15]. Another study has presented that the small window group has a significantly higher new bone regeneration and a lower ratio of ABB than the large window group at six months after a sinus floor elevation [18].

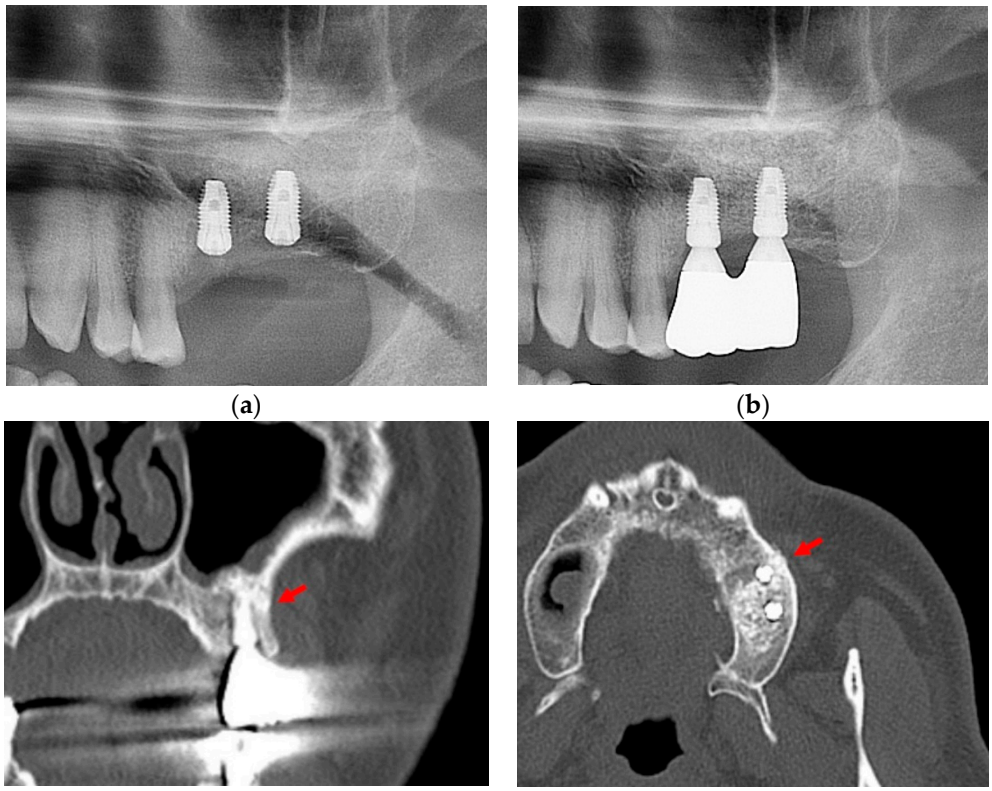
Another advantage of the minimally invasive lateral approach is that it can prevent graft material displacement, particularly in cases without using a barrier membrane. As the window where a graft material can be displaced becomes smaller, it is beneficial to maintain the graft material in the sinus cavity. In the present study, a barrier membrane for covering the lateral window was not used in most surgeries. All surgeries except two (47 surgeries) had a minimum-sized lateral window (20–30 mm^2). Figure 5a,b shows the healing state of a minimum-sized lateral window without barrier membrane at 5 and 48 months after a sinus floor elevation, respectively. The regenerated new bone and xenograft granules completely filled the lateral window, with small amounts of xenograft granules attaching to the adjacent periosteum (Figure 5a).

Figure 6 shows the axial and coronal views of computed tomography at six months after minimally invasive MSFE without using a barrier membrane. Displacement of graft material was not observed, and the osteotomy site was filled with graft material having an irregular surface. Although a barrier membrane is not utilized, reducing the lateral window size might decrease soft tissue ingrowth from the periosteum into the graft material, leading to less displacement of the graft material during the healing process [19].



(**a**) (**b**)

Figure 5. (**a**) Healing state of a minimum-sized lateral window at 5 months after the surgery. Without utilizing barrier membrane, particles of anorganic bovine bone could be observed on bone surface and periosteum; (**b**) Healing state of a minimum-sized lateral window without utilizing barrier membrane at 48 months after the surgery (anorganic bovine bone graft).



(**a**) (**b**)

(**c**) (**d**)

Figure 6. Maxillary sinus floor elevation through minimally invasive lateral approach (anorganic bovine bone graft without using barrier membrane): (**a**) panoramic radiograph immediately after maxillary sinus floor elevation; (**b**) after 6 months follow-up; (**c**) axial and (**d**) coronal view of computed tomography at 6 months after surgery. The osteotomy site was filled with graft material having an irregular surface (red arrows). Displacement of graft material was not observed.

When the window size was reduced, the possibility of encountering the intraosseous anastomosis located on the lateral wall of the maxillary sinus was also decreased. If arteries or arterioles are ruptured during surgery, maintaining a visual field becomes difficult. Thus, post-operative swelling, bleeding, and discomfort can show increases. In an imaging study

involving 58 Koreans, an artery passing through the lateral wall of the maxillary sinus was observed in about 50% of patients. The average distance from the alveolar ridge to the posterior superior alveolar artery (PSAA) was about 18–20 mm in the premolar region and about 15–17 mm in the molar region [20]. In the present study, the upper margin of the lateral window was positioned at a distance of 10 to 12 mm from the alveolar bone crest, and the anteroposterior distance of the lateral window was 5 to 6 mm. Thus, the possibility of damaging the PSAA or its dental branch is low during an osteotomy. Actually, in the present study of 49 surgeries, severe intraoperative bleeding did not occur.

The position of the minimum-sized lateral window is important for successful lateral sinus floor elevation. In the present study, the position of the window was set in relation to the outline of the maxillary sinus and the alveolar crest. The mesial boundary of the window was decided to be about 3 mm distal to the sloping anterior maxillary wall which was the most mesial border where direct instrumentation could be made [21]. The superior boundary was planned to be approximately 10–12 mm above the alveolar crest considering the inserted implant length. Because the position of the window was constant in mesial and superior boundaries, the size of the window could be minimized with a restricted extension of the distal, inferior boundary within 5 mm. If the circular-shape window with a diameter of 5 mm (area of 20 mm^2) had restricted instrumental access, it was gradually enlarged to have a diameter of 6 mm (area of 30 mm^2).

To create the lateral bony window, the present study used a diamond round bur with a diameter of 3 mm. A piezoelectric device was not chosen because of its prolonged surgery duration period [22]. There was no occurrence of membrane perforation upon the surgical phase of osteotomy utilizing a rotary instrument with careful manipulation. However, a higher risk of membrane perforation rate has been reported when utilizing conventional rotary instruments compared with piezoelectric devices [23,24]. Piezoelectric bone surgery is considered to minimize adjacent soft tissue injury that can be recommended for a minimally invasive surgical approach for MSFE [25].

As the window became smaller, the increased incidence of membrane perforation could be predicted because instrument access and visual field were restricted. However, the incidence of membrane perforation did not have a significant relationship with the window size. A systematic review reported that the overall incidence of membrane perforation during lateral approach sinus elevation was 15.7% [23]. In spite of a small window (20–30 mm^2) in the present study, the incidence of membrane perforation was only 2.0%. This incidence was lower than those (8–18%) reported in other studies using a small-sized window of approximately 30–50 mm^2 [8,11,12,18]. These other studies also showed that there was no significant difference in the incidence of membrane perforation between small and large window groups. Within careful surgical manipulation, the incidence of membrane perforation was not affected by the minimally invasive lateral approach.

Many studies have reported that membrane perforation is closely related to irregular sinus floors such as sinus septum, root protruding into the sinus, and bone exostosis [26–28]. In 49 surgeries of the present study, there was one case of membrane perforation. The frequency of membrane perforation was higher when a single implant was placed (4.8%) than when multiple implants were placed (0%). This result might be related to the fact that the ratio of irregular sinus floor was higher in the single implant group (43%) than in the group with multiple implants (29%). Among single implant placed patients, one case with membrane perforation occurring had an extensive maxillary sinus pneumatization with root protruding of the adjacent teeth. It is recommended to indirectly elevate the Schneiderian membrane in the difficult-to access area by performing an adequate membrane elevation of the adjacent easy-to-access area. For example, when the elevation of the Schneiderian membrane is difficult due to an irregular sinus floor, sufficient membrane detachment of adjacent medial and lateral sinus walls can lead to spontaneous elevation of the Schneiderian membrane on the irregular sinus floor.

In the present study, all implants were placed, and most healing abutments were connected simultaneously with minimally invasive lateral approach MSFE. Reducing

the number of total surgeries can reduce patient morbidity, which could be considered for minimally invasive management. For simultaneous implant installation with lateral approach MSFE, a gain of primary stability of placed implant might be crucial. With less than 3 mm of residual bone height, implant primary stability is unpredictable [25]. Our study included patients with a mean residual bone height of 3–4 mm, which might exhibit unpredictable primary stability of the implant. To secure sufficient primary stability, bone drilling protocol was adjusted to under-preparation of the osteotomy site less than 10% of the desired implant diameter [29]. Various methods to increase the primary stability of the implant have been proposed. Although the Summers' osteotomy technique improved primary stability with bone compaction, it could lead to unintentional bony fracture or even benign paroxysmal positional vertigo of the patient [30]. Furthermore, high interfacial pressure induced from under-preparation or Summers' osteotome might lead to the microfracture of the trabecular bone, which might compromise the marginal bone level maintenance [31]. Recently, various osseodensification drills have been introduced to increase implant primary stability with plastic deformation of the trabecular bone [32]. This technique can also be considered for minimally invasive treatment of atrophic posterior maxilla with poor bone quality.

The limitation of the present study was that there was no preoperative computed tomography evaluation before the minimally invasive lateral approach for MSFE with simultaneous implant placement. Measurement of residual bone height and maxillary sinus width, bone density evaluation from preoperative computed tomography should be needed for deciding the proper surgical approach in the implant rehabilitation of atrophic posterior maxilla [25]. Further evaluation using cone-beam computerized tomography on bony healing of osteotomy site and volumetric changes of graft material is needed.

5. Conclusions

Within the limitations of this study, a minimally invasive lateral approach through a small circular window with a diameter of 5 to 6 mm is a feasible and safe technique for MSFE with simultaneous implant placement. Our technique did not show a higher membrane perforation incidence than the conventional lateral approach MSFE of other studies.

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