



## ORIGINAL ARTICLE

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# Clinical and radiographic outcomes of reentry lateral sinus floor elevation after a complete membrane perforation

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**Abstract**

**Background:** Although small perforation of the maxillary sinus schneiderian membrane is a well-documented complication during lateral sinus floor elevation (LSFE), complete perforations larger than 10 mm often result in discontinuation of surgery. Reports on reentry LSFE and its long-term outcomes are sparse.

**Purpose:** To evaluate the long-term outcomes of reentry LSFE following complete membrane perforation to elucidate the technical details of the reentry procedure.

**Materials and methods:** We assessed the medical records of all patients receiving LSFE from 2008 to 2017 in the Department of Oral Implantology, Peking University Hospital of Stomatology. Twenty-two patients receiving reentry LSFE after complete membrane perforation were enrolled. Data were recorded using cone beam computer tomography: including the residual bone height, membrane thickness of the sinus prior to surgery ( $MT_1$ ), and before reentry ( $MT_2$ ), and height of the bone graft during the reentry procedure (HBG). Cumulative survival rate of implants (CSR), marginal bone loss (MBL), and subsequent complications were also recorded.

**Results:** From 2008 to 2017, 2023 consecutive patients (2262 sinuses) who underwent LSFE were screened. Complete membrane perforation occurred in 28 patients and resulted in discontinuation of surgery (1.2%). Twenty two patients were enrolled and received reentry LSFE within 3-6 months. Two patients undergoing the reentry procedure were suspended due to excessive membrane perforation, while the other 20 finished reentry sinus bone graft. In the reentry procedure, the HBG was  $9.73 \pm 2.67$  mm with 34 implant placements. The  $MT_1$  and  $MT_2$  were  $1.03 \pm 0.43$  and  $1.91 \pm 1.45$  mm, respectively, showing a statistically significant difference ( $P < .05$ ). After a follow-up of 2-10 years, CSR was 97.1%, and MBL was  $0.64 \pm 0.50$  mm.

**Conclusions:** The long-term outcome of reentry LSFE is predictable and reentry LSFE offers a reliable alternative following complete membrane perforation. However, the procedure is relatively sensitive and should be performed by experienced surgeons.

**KEYWORDS**

complete membrane perforation, long-term outcome, membrane thickness, re-entry, sinus floor elevation

## 1 | INTRODUCTION

Lateral sinus floor elevation (LSFE) is a reliable surgical procedure to increase bone volume in the absorbed posterior maxilla.<sup>1,2</sup> Despite the various technological advances, sinus membrane perforation remains the most common complication during LSFE.<sup>3,4</sup> Previous studies have shown when the perforations are small, the membranes can be repaired with collagen membrane coverage.<sup>5-7</sup> No significant differences were observed in terms of bone formation and implant survival rates post-repair compared to the non-perforation group.<sup>5,7</sup> However, when the perforations were larger than 10 mm (termed complete perforation),<sup>8</sup> repair of the sinus membrane is limited.<sup>5,9-11</sup> Thereafter, the operation was abandoned<sup>9-11</sup> and the prevalence of the discontinuation of LSFE due to complete membrane perforation was 1%-2% according to previous studies.<sup>5,11</sup> However, subsequent treatment after perforation of the sinus membrane remains challenging for clinicians.

Large or complete membrane perforations are a contraindication of sinus bone graft using the lateral approach.<sup>12,13</sup> While previous studies suggest the possibility of reentry following a healing period of 3-6 months,<sup>14,15</sup> lateral bone wall defects and membrane scar adhesion caused by previous surgery bring great difficulty in the second approach.<sup>15</sup> Moreover, Mardinger and colleagues showed that reentry LSFE is complex with a significantly higher incidence of membrane perforation and a lower implant survival rate compared to conventional LSFE.<sup>15</sup> To-date, subsequent treatments after complete sinus membrane perforations are rarely reported. Radiographic changes and the long-term clinical outcomes of reentry LSFE after complete membrane perforation remain unclear.

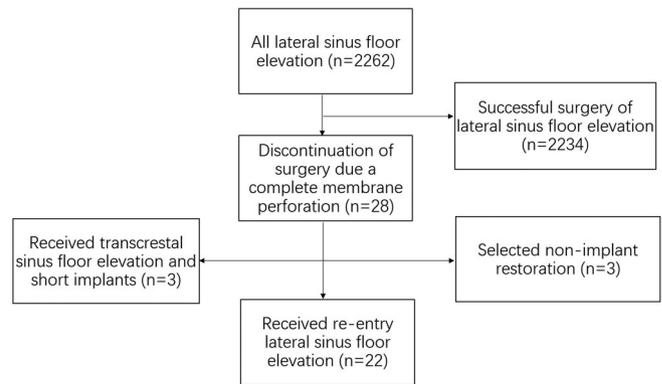
The study aimed to evaluate the long-term clinical outcomes of reentry LSFE and the radiographic changes that occur following complete membrane perforation to elucidate the technical details of the reentry procedure and the surgical outcome.

## 2 | MATERIALS AND METHODS

### 2.1 | Study design and ethical approval

Medical records of all patients who received LSFE from 2008 to 2017 in the Department of Oral Implantology, Peking University Hospital of Stomatology were analyzed. In total, 2023 consecutive patients (2262 maxillary sinus) received sinus bone graft via the lateral approach. Patients with a history of discontinued therapy caused by complete sinus membrane perforations larger than 10 mm were screened. A total of 22 patients receiving reentry LSFE were enrolled (Figure 1). Demographic information was documented and radiographic measurements were analyzed. The cumulative survival rate of the implants (CSR), marginal bone loss (MBL), and subsequent complications were also recorded and analyzed.

The study was conducted according to the principles embodied in the Helsinki Declaration for biomedical research involving human subjects. The patients received an explanation of the study and agreed to participate. The study was approved by our local ethics committee.



**FIGURE 1** Workflow of patients' enrollment

### 2.2 | Inclusion and exclusion criteria

Inclusion criteria were as follows: (a) No sinus cysts present prior to surgery; (b) initial LSFE surgery was discontinued due to complete sinus membrane perforations larger than 10 mm; (c) receiving reentry LSFE.

Exclusion criteria were as follows: (a) refused to receive the reentry procedure and selected non-implant restoration; (b) receiving transcresal sinus floor augmentation and short implants during secondary surgery.

### 2.3 | Surgical history of initial LSFE

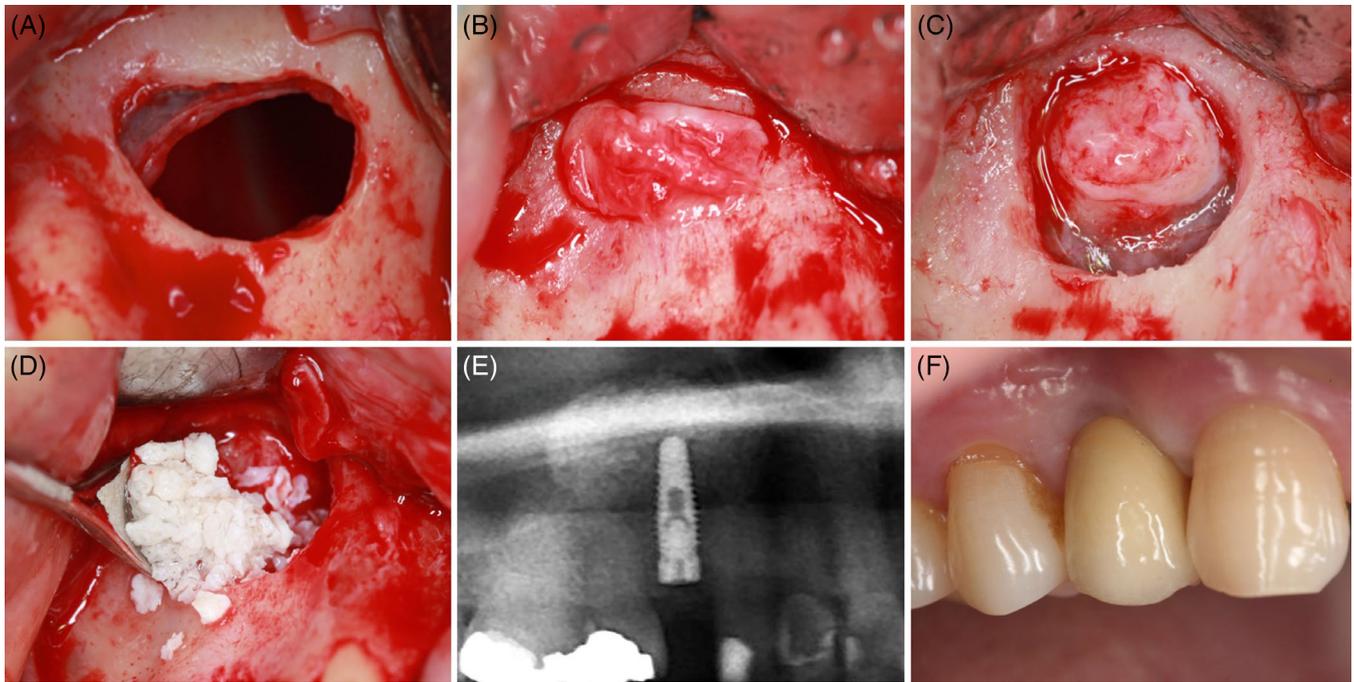
Surgery was performed under local anesthesia using the lateral approach. The window on the maxillary lateral wall was abraded by rotary burs or through piezosurgery, and the sinus membrane was dissected using blunt instruments. When the sinus membrane perforation diameter was less than 10 mm, it could be repaired delicately by covering the absorbable collagen membrane or by suture. When the diameter exceeded 10 mm, augmentation was aborted and no graft materials inserted (Figure 2A). The reflected mucoperiosteal flap was repositioned and sutured. Patients were prescribed analgesics and prophylactic antibiotics (Cefuroxime axetil tablets 500 mg/daily or in the case of allergy roxithromycin 150 mg/daily) for 3 days, and oral rinses of 0.12% chlorhexidine gluconate were performed for 7 days post-operation.

### 2.4 | Examinations prior to surgery

After 3-6 months (mean 4.3 months), patients underwent clinical and radiographic examinations. cone-beam CT (CBCT) was used to identify maxillary sinus cavity conditions, sinus membrane continuity, and the size and location of the buccal bone window from the first operation.

### 2.5 | Preoperative medications

Prophylactic oral premedication was routinely performed. Cefuroxime axetil tablets (500 mg) and ibuprofen sustained-release capsules



**FIGURE 2** Surgical and prosthetic protocol. A, Perforations exceeding 10 mm. B, 3 months later, the former window healed with scar tissue. C, A new larger window was abraded. D, The bovine bone mineral was filled into the space. E, X-rays confirmed the osseointegration of the implant. F, Single implant crown was delivered

(600 mg) were administered 1.5-1 hour prior to surgery. If patients were allergic to cefuroxime axetil, they were prescribed roxithromycin (150 mg). Patients were advised to rinse with a 0.2% chlorhexidine solution three times for 30 seconds.

## 2.6 | Reentry procedure of sinus bone graft

Surgery was performed under local anesthesia. An incision was introduced at the top of the alveolar ridge and combined with additional proximal and distal vertical incisions. Scar tissue in the original window area was dissected using a 15-blade to raise the mucoperiosteal flap and expose the former window (Figure 2B). A new larger window on the maxillary lateral wall was abraded with bur/piezosurgery, ~2 mm from the edge of the original window (Figure 2C). First, a groovy was abraded with a rotary bur until the light blue sinus membrane was seen, and then the residual bone was removed with piezosurgery insert (OT5, Mectron, Italy). The sinus membrane was then separated by a specialized elevator. The new window containing the scar tissue of the original window was lifted into the maxillary sinus cavity to form a space that was sufficient for bone grafting. The left sinus membrane was covered with platelet-rich fibrin and absorbable collagen membranes (Bio-Gide, Geistlich Pharma AG, Switzerland), and the space was filled with bone substitutes (Bio-Oss, diameter 1-2 mm; Geistlich Pharma AG) (Figure 2D). Simultaneous implant placement was performed when the residual bone height (RBH) was more than 3 mm. Otherwise, the implant placement would be delayed 6 months later. Mucoperiosteal flaps were repositioned and sutured

with 4-0 absorbable sutures (Vicryl Rapid, Ethicon, Johnson & Johnson, Livingston, UK). CBCT was performed immediately after surgery to verify the position of the bone graft and implants (Figure 2E).

## 2.7 | Postoperative management

Patients continued to take Cefuroxime Axetil tablets (250 mg twice per day for 7 days) and Tinidazole tablets (500 mg per day for 5 days) were prescribed postoperatively. Patients were advised to rinse with a 0.2% chlorhexidine solution for 7 days. Cortisone medication (dexamethasone tablets, 1.5 mg) was taken to relieve swelling and control inflammatory responses on the day of surgery and daily for 2 days postoperatively. Patients were asked to avoid physical stress and increase pressure in the sinus cavities for 2 weeks. Six months post-implant placement, periapical x-rays were recorded to verify the osseointegration of the implants. All implants were prosthetically restored (Figure 2F). Patients were followed up at 6 months, and then annually post-prosthetic loading.

## 2.8 | Measurement parameters

### 2.8.1 | Incidence of complete membrane perforations

The medical records of all patients who received LSFE from 2008 to 2017 were analyzed and filtered. All cases with a history of

discontinuation of the LSFE due to the complete membrane perforations larger than 10 mm were screened. Demographic information was documented and analyzed. The incidence of complete membrane perforations was calculated.

## 2.8.2 | Radiographic analysis

Image analysis software Planmeca Romexis (Planmeca Dental Imaging Oy, Helsinki, Finland) was used for measurements with an accuracy of 0.1 mm. Panoramic CBCT and cross-sectional views of the maxilla were reconstructed. All measurements were performed in the cross-sectional views at planned implant sites by two independent investigators. For the calibration and evaluation of intra-examiner reliability, 15 CBCT images were measured twice on two consecutive days. The mean differences were 0.04–0.09 mm/image.

### 1. Residual Bone Height (RBH)

RBH<sub>1</sub> was measured in the CBCT prior to surgery. Likewise, RBH<sub>2</sub> was measured prior to reentry (Figure 3).

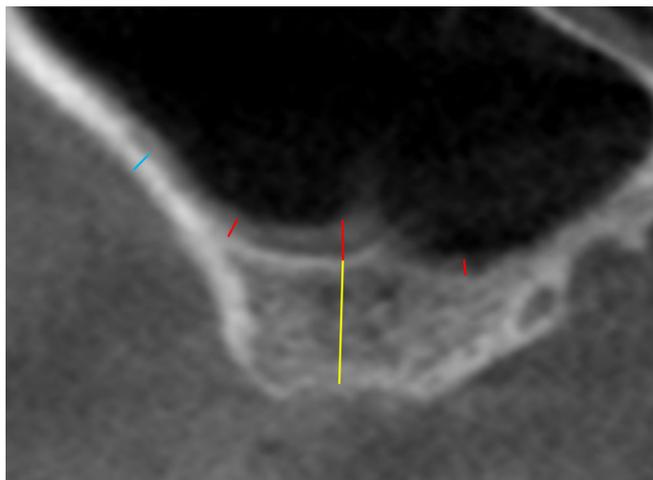
### 2. Mean sinus membrane thickness (MT)

The thickness of the membrane was measured in three points: the buccal conjunction point between the sinus floor and the buccal wall (MT<sub>b</sub>), the middle point of the sinus floor (MT<sub>m</sub>), and the palatal conjunction point between the sinus floor and the palatal plate (MT<sub>p</sub>). Measurements were perpendicular from the mucosal surface to the underlying bone plate of the sinus (Figure 3). The mean of three measurements was recorded as the mean sinus membrane thickness (MT). MT<sub>1</sub> and MT<sub>2</sub> represent the membrane thickness prior to the first and reentry LSFE.

### 3. Lateral bone thickness

Bone thickness was measured on the lateral buccal plate approximately 5 mm above the sinus floor, prior to the initial LSFE (Figure 3).

### 4. Height of the bone graft gained (HBG)



**FIGURE 3** Yellow line indicates residual bone height (RBH); red lines indicate membrane thickness at the buccal, middle, and palatal point of the sinus floor; blue line indicates lateral bone thickness 5 mm above the sinus floor

HBG represents the vertical bone grafts following reentry LSFE. Values were measured perpendicularly from the sinus floor to the top of the bone graft in the CBCT after reentry surgery.

## 2.8.3 | Complications

Intraoperative (bleeding, sinus membrane perforation) and postoperative complications (infection, acute maxillary sinusitis, wound dehiscence, or implant failing) were recorded.

## 2.8.4 | Cumulative survival rate of implants

The survival rates of the placed implants were calculated by measuring the time elapsed from implant placement to the last final follow-up visit or implant removal with an average follow-up of 5 years (ranged 2–10 years). The criteria used for successful implantation were proposed by Buser<sup>16</sup> as follows:

- The implant in its original position,
- No persistent complaints,
- No peri-implant inflammation,
- No implant loosening, and
- No peri-implant radiolucency.

## 2.8.5 | Marginal bone loss

Marginal bone loss was measured between the platform and the coronal bone-to-implant contact, which was adjusted by the actual length of the implants. Mesial and distal values were averaged to single values for each implant.

## 2.9 | Statistical analyses

All relevant data were collated into Excel 2016 (Microsoft, Redmond, Wash). Data analysis was performed using SPSS for Windows (version 22.0, Chicago, IL). Descriptive statistics were computed through the determination of the mean values, SDs, and cumulative frequencies. Paired sample *t* tests were used for the comparison of MT and RBH prior to surgery. Significance differences of less than 5% were considered statistically significant.

## 3 | RESULTS

### 3.1 | Incidence of complete membrane perforations

From 2008 to 2017, 2023 patients (2262 maxillary sinus) received sinus bone graft through the lateral approach in the Department of

Oral Implantology, Peking University Hospital of Stomatology. Twenty-eight LSFE were performed in which membrane perforations led to the cessation of surgery. The incidence of suspended sinus bone graft due to complete membrane perforation was 1.2%. Among them, 22 patients received reentry LSFE, three received transcresal sinus floor elevation with short implants, and three selected non-implant restorations (Table 1).

### 3.2 | Demographic information

Finally, 22 patients (10 males and 12 females, with an average age of 45 years old, range from 24 to 64 at the time of the first surgery) were enrolled. A total of 13 patients were right maxillary and nine were left. A total of four patients had septa at the maxillary sinus floor upon initial surgery. Among the 22 patients, ~50% had loss of a single tooth while the other ~50% had multiple teeth loss. The interval time between the two operations was 3-6 months, with an average interval of 4.3 months (Table 2).

### 3.3 | Radiographic examination and evaluation

The average residual bone height at the maxillary sinus floor of the missing tooth was  $3.83 \pm 1.14$  and  $3.73 \pm 1.36$  mm prior to primary and reentry operations, respectively ( $P = .559$ ). The mean thickness of the lateral bone wall was  $1.29 \pm 0.51$  mm. The thickness of the maxillary sinus membrane was  $1.03 \pm 0.44$  and  $1.91 \pm 1.45$  mm prior to primary and reentry operations, ( $P = .011$ ,  $P < .05$ ; Table 3, Figure 4). The height of the bone graft after reentry LSFE was  $9.73 \pm 2.67$  mm.

### 3.4 | Intraoperative and postoperative complications

During the reentry procedure, membrane perforations occurred in 4/22 patients (18%), two of them were suspended due to excessive

membrane perforation, so non-implant restoration was selected. The other two patients with membrane perforations  $\leq 5$  mm were repaired with absorbable collagen membranes (Bio-Gide). As a result, 20 patients received reentry LSFE with the simultaneous placement of 21 implants, with 13 implants receiving delayed placement according to the local anatomical conditions. Only minor postoperative edema occurred in all patients. All implants received restoration after a healing time of 6 months.

### 3.5 | Cumulative survival rate of implants

After an average follow-up of 5 years (ranged 2-10 years) and following prosthesis loading, the cumulative implant survival rates were 97.1%. A single implant was withdrawn due to peri-implantitis after 7 years of functional loading, and one new implant was inserted and the prosthesis delivered 3 months later. No other implants were lost at the final recall visit.

### 3.6 | Marginal bone loss

Excluding a single case in which the implant was removed, the mean MBL of the remaining 33 implants was  $0.64 \pm 0.50$  mm (range 0-1.4 mm) after an average follow-up of 5 years.

## 4 | DISCUSSION

Maxillary sinus mucosa perforations are the most common complication during LSFE, with a reported incidence of 7%-56%.<sup>3</sup> Despite various updates in both the surgical technique and instruments, problems remain unavoidable.<sup>6,17</sup> Previous studies showed that when the perforation was small, or less than 10 mm, the perforation could be repaired by collagen membrane coverage or by suture delicately.<sup>5,7</sup> No significant differences were observed in terms of bone formation and implant survival rates post-repair compared to the non-

**TABLE 1** Treatment following complete perforation

Treatment approaches	n
Reentry lateral sinus floor elevation	22
Transcresal sinus floor elevation and short implants	3
Non-implant restoration	3
Total	28

Male/female ratio	Mean age (range)	Site (right/left)	Septa (Y/N)	Tooth missing (single/multiple)	Mean IT (month)
10/12	44.8 (24,64)	13/9	4/18	11/11	4.3

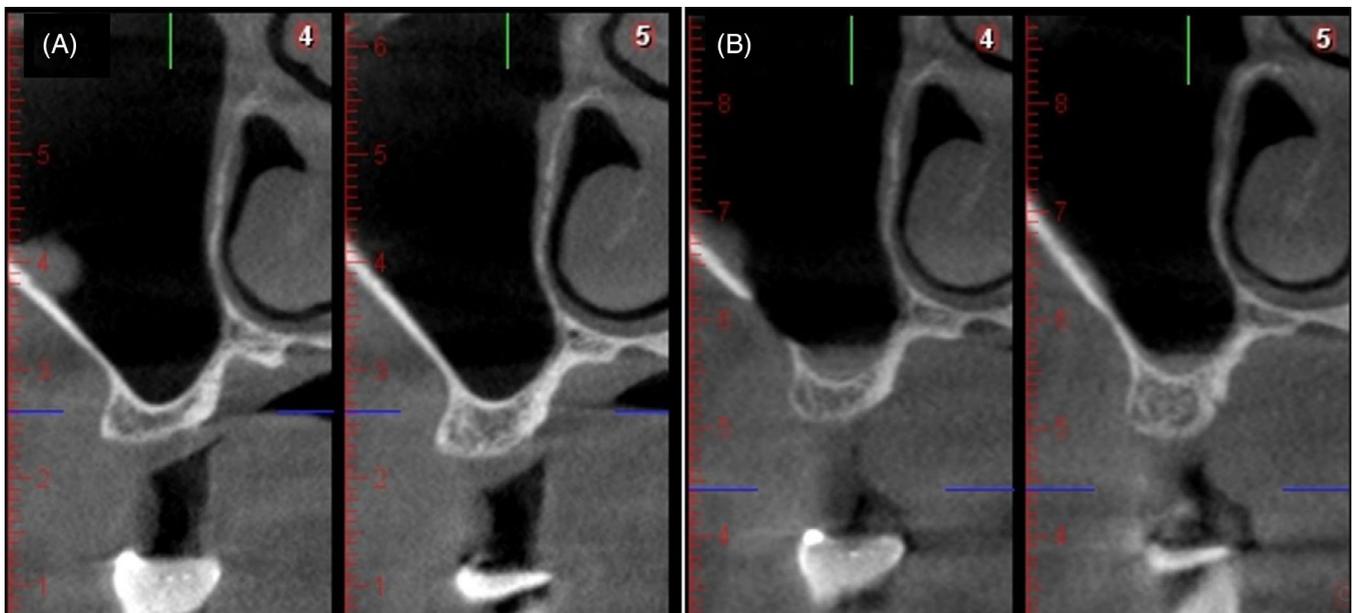
Abbreviation: IT, the time interval between initial and reentry surgery.

**TABLE 3** Radiographic changes in CBCT prior to surgery

	Prior to initial surgery	Prior to secondary surgery	P-value
RBH (mm)	$3.83 \pm 1.14$	$3.73 \pm 1.36$	.559
MT (mm)	$1.03 \pm 0.43$	$1.91 \pm 1.45$	.011

Abbreviations: RBH, residual bone height; MT, sinus membrane thickness.

**TABLE 2** Summary of the patients



**FIGURE 4** The thickness change of the sinus membrane. A, The sinus membrane prior to the initial surgery; B, membrane prior to the reentry surgery

**TABLE 4** The anatomical features prior to the initial surgery

	TM <sub>1</sub> (0-1 mm/1 mm)	Tooth missing (single/ multiple)	Septa (Y/N)	Concomitant tooth extraction (Y/N)
n = 22	12/10	11/11	4/18	9/13

Abbreviation: MT<sub>1</sub>, sinus membrane thickness prior to the initial surgery.

perforation group.<sup>5,7</sup> When the diameter of membrane perforation exceeded 10 mm, repair of the sinus membrane was limited and would increase the risks of infection and graft failure.<sup>10,18</sup> Hernandez-Alfaro et al reported that the size of the membrane perforations negatively correlated with the implant survival rate and perforations larger than 10 mm had the lowest implant survival rates (~74.14%).<sup>19</sup> So we made a decision point of perforation size that when the sinus membrane perforation is larger than 10 mm, the augmentation process should be aborted. In this study, for membrane perforations larger than 10 mm, no grafts were placed, eliminating concerns regarding infections or graft material leakage. The incidence of discontinuation due to complete perforations was 28/2262 (1.2%). The rate was comparable to those reported by Becker et al (4/201, 2%).<sup>5</sup>

Sinus membrane perforations can occur due to thin membranes,<sup>6,20</sup> operator error,<sup>8</sup> maxillary sinus contours,<sup>6</sup> the presence of septum,<sup>21</sup> and a small residual bone height.<sup>4</sup> In this study, 22 patients underwent reentry LSFE. Prior to the initial surgery, the anatomical features of the sinus were recorded (Table 4), including thin maxillary sinus mucosa (12/22), intra-maxillary sinus septum (4/22), concomitant tooth extraction (9/22), and a single-tooth gap (11/22). First, as for membrane thickness, studies have shown that the incidence of perforation is lowest when the thickness is 1-1.5 mm, and the incidence of perforation increases when the

mucosa is too thin or too thick.<sup>22</sup> Moreover, a thin mucosa shows little resistance against suture, making it impossible to repair intraoperative large perforations through simple sutures.<sup>9,23</sup> When the sinus membrane was thinner than 1 mm, special care is required when elevating the membrane from the sinus floor in cases of large perforations. Second, the existence of septum increases the risk of intraoperative mucosal perforations during the dissection of the mucosa from the septa. When a complete perforation was accompanied by the septum, we recommend that the septum should be abraded or pushed down by a diamond drill or piezo instrument to lower the risk of perforation during the reentry surgery.<sup>24</sup> In addition, the affected teeth in the surgical area are often accompanied by periapical lesions, which may lead to inflammatory reactions of the schneiderian membrane, resulting in the loss of elasticity and toughness. When an untreatable tooth with a periapical lesion is involved at the surgical site, a healing period after extraction is recommended prior to the LSFE. Finally, when the edentulous region is a single-tooth gap, window opening is generally undersized between the two adjacent root surfaces. Thus, a good field of vision and operating space are not achieved, raising the risk of complete perforation.

An undetected or unrepaired perforation can lead to the displacement of the bone graft materials, posing a risk of sinus ostium obstruction and maxillary sinusitis. Delicate techniques to repair complete membrane perforations have been performed. Sindel et al carried out simultaneous block autografts following complete perforation, in which a fixed ring block was directly added to the sinus floor with the implants. After 2 years of follow-up, the implant survival rate was 90%.<sup>11</sup> The Loma Linda pouch technique involves a slow resorbing collagen membrane with external tack fixation that results in complete membrane coverage of all internal bony, including the floor.<sup>25,26</sup> Nevertheless, complete coverage to the graft may

impede the blood supply and result in incomplete graft incorporation.<sup>8</sup> The long-term clinical results of those case series remain unclear.

A previous study showed that the healing time of the sinus membrane after removal was 10–12 weeks, and the newly formed tissue reorganization has nearly finished in 3 months.<sup>27</sup> Therefore, our original reentry operation appointment was in 3 months after the initial surgery. But in reality, some patients could not follow the exact appointments as planned, due to their personal schedule and residential locations which were thousands of kilometers far away from our hospital. After 3–6 months, 20/22 patients received successful reentry LSFE. No wound dehiscence or sinusitis occurred post-operation. All patients healed uneventfully. Due to detachment from the lateral bone wall during the initial surgery, the sinus membrane became thicker and less elastic.<sup>15,24</sup> We observed increased membrane thickness prior to reentry compared to baseline ( $1.91 \pm 1.45$  vs  $1.03 \pm 0.43$  mm). The same phenomenon was observed in the studies by Okada et al and Mardinger et al.<sup>15,24</sup> The possible mechanism could be that the sinus membrane was elevated in the initial surgery, and a stable blood clot could be formed on the sinus floor. Then the blood clot turned into granulation tissue, which differentiated into fibrous connective tissue finally, that is, the newly formed sinus membrane.<sup>27</sup> However, there was a lack of histopathological evidence. From a clinical standpoint, the thickening of the membrane in cases of previously thin membranes may lower the risk of perforation during the reentry procedure, although a less elastic and more adherent membrane can hamper the tactile feedback for the surgeon.

With regard to the surgical approach of reentry procedure, a meticulous buccal flap reflection was key to successful grafting. It has been shown that the sinus membrane was adhered to the buccal soft tissue in the area of the former window, and that direct elevation leads to a perforation or tear in the sinus membrane.<sup>15,24,28</sup> Lin et al reported a maxillary sinus lateral reentry technique that permitted a reentry LSFE following the primary maxillary lateral window approach of removing the antral pseudocyst.<sup>14</sup> Our results showed similar surgical protocols as described by Lin et al, in which the reentry lateral approach for maxillary sinus bone graft after complete perforation was both reliable and reproducible. During flap progression, the blunt and sharp separation was combined to ensure the integrity of the sinus membrane.<sup>14</sup> Subsequently, a larger window was cut by rotary bur and piezosurgery insert ~2 mm away from the edge of the original bone window with caution.<sup>14</sup> Rotary bur was used first to abrade a groovy for its high efficiency until the light blue sinus membrane was almost seen. Then the residual bone was removed by piezosurgery insert (OT5, Mectron, Italy) to reduce the risk of membrane perforation for its selective cutting capability and special insert design coated with diamonds.<sup>29</sup> Meanwhile, the larger window provided good visualization and membrane accessibility.

Despite careful manipulation of the sinus membrane, perforations occurred in four patients during the reentry procedure. Alterations in fibrosis and thickness but lower elasticity changes led to the risk of membrane perforation, and so gentle handling of the instruments should be emphasized at each step. The aforementioned space restriction in the single-tooth gap can result in a smaller window size due to

the adjacent roots of the teeth. Although the window size is not related to membrane perforation directly,<sup>30</sup> it is difficult to obtain high levels of visualization and accessibility to the membrane when attached to the inner side of the sinus with a smaller window.<sup>17</sup> Blindly reflecting the membrane also enhances the risk.

Within the four secondary-perforation cases, bone grafting was successfully performed in two patients after the proper handling of absorbable membrane coverage. Unfortunately, complete perforation occurred in the other two patients, leading to a discontinuation of bone grafting. The latter two patients selected non-implant restoration instead of bone grafting and implants. One noteworthy feature of the two cases was that all were single-tooth gaps. It is also hard to perform the third surgery due to the residual bone in the mesial-distal direction. A palatal approach has been suggested for reentry sinus bone graft.<sup>31,32</sup> Nevertheless, the operating space was limited and special care should be taken to avoid damage to the great palatine neurovascular bundle.

In this study, the average height of bone graft after reentry procedure was  $9.73 \pm 2.67$  mm (ranged 6.4–15.8 mm). Therefore, sufficient vertical dimensions were reconstructed for 10 mm or longer implants. The results demonstrated that the healed sinus membrane could be elevated to a desirable height during the reentry procedure regardless of fibrotic changes and scar formation on the membrane.

After an average of 5-year follow-up, the peri-implant MBL of 33 implants was  $0.64 \pm 0.50$  mm. A single implant was placed in the right maxillary first molar site, which was withdrawn due to peri-implantitis after 7 years of functional loading. The cumulative implant survival rates were 97.1%, which was higher than the cases with the implant and bone grafts with larger than 10 mm membrane perforations reported by Hernandez-Alfaro et al,<sup>19</sup> but comparable to the overall survival rate of the implants in the grafted maxillary sinus.<sup>33</sup> The possible reason for the failed implants may be poor oral hygiene in the patient, in which a single implant was reinserted 3 months later and restoration was delivered 5 months post-operation with improved oral hygiene control.

Although the results of our study showed that reentry LSFE are predictable, this was a retrospective study with limited patient numbers, with the surgical procedure performed by several surgeons. Further clinical studies and an improved study design are now necessary to confirm our findings.

## 5 | CONCLUSIONS

Based on this study, reentry LSFE represents a predictable alternative after complete sinus membrane perforations, and the long-term outcome of implant CSR is comparable to that of conventional LSFE. However, local anatomical conditions changes, and the surgical techniques differ from conventional LSFE, so attention should be paid to the learning curve of the clinicians.

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## CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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