Less Invasive Window Repositioning Technique for Sinus Floor Elevation: A Clinical and Radiographic Study

Kazem Khiabani, DMD, OMFS1/Mohammad Hosein Amirzade-Iranaq, DDS2,3/Ehsan Mostajeran, DMD, OMFS4

Purpose: To determine whether a less invasive window repositioning technique could provide a feasible, safe, and reliable lateral sinus augmentation. Materials and Methods: The less-invasive window repositioning technique using a piezoelectric saw was performed on adult patient candidates for lateral sinus floor elevation. The augmented bone height (primary outcome variable), bone length, and posthealing outcome variables were evaluated to determine the augmentation adequacy, safety, and reliability of this technique overall and in one- and two-implant groups with different window dimensions. Data were analyzed using descriptive statistics, chi-square test, and Pearson correlation analysis. P < .05 was considered significant. Results: A total of 50 consecutive sinus floor elevations with simultaneous placement of 66 implants (one-implant: 34, two-implant: 16) were performed on 44 subjects (72% men) with a mean age of 46.7 ± 10.3 years and followed for a mean of 13.28 ± 3.5 months. The overall, one-implant, and two-implant group mean window sizes were 31.38 ± 6.78 mm², 28.38 ± 4.2 mm², and 37.75 ± 6.88 mm², respectively. The mean overall augmented bone height and length were 12.3 ± 1.04 mm and 19.67 ± 2.01 mm, respectively. The mean window size was significantly smaller in the one-implant group versus the two-implant group (P < .001). However, there was no correlation between window size and augmented bone height (r = -0.9, P = .54) and length (r = 0.05, P = .68). The posthealing outcome variables showed perfect window integration without soft tissue ingrowth. Six sinus perforations (12%) during membrane elevation that were not related to window osteotomy were observed and were appropriately managed. Conclusion: The less-invasive window repositioning technique is feasible, safe, and reliable for appropriate sinus augmentation in height and length. The reduction of window dimension does not influence the feasibility, augmentation adequacy, and surgical safety and does not increase surgical risks or membrane perforation. The repositioned window showed proper integration. Also, sinus floor elevation through this technique is an experience-based surgery that requires delicate instruments. Int J Oral Maxillofac Implants 202 September 29. doi: 10.11607/jomi.9570. Online ahead of print.

Keywords: dental implantation, dental implants, maxillofacial surgery, oral surgery, sinus floor augmentation

The bone lid technique was introduced by Lindorf in 1974 as an osteoplastic approach to maxillary sinus surgery to preserve lateral sinus walls.1,2 This technique obviates the creation of significant bone defects caused by bone removal, prevents soft tissue ingrowth to the bone regeneration area, and results in faster bone regeneration.3-5 The window repositioning technique for sinus floor elevation includes the outfracturing of the bony window and re-closure of the lateral wall defect with the bony lid as a free bone graft on the grafted or nongrafted sinus.6,7

The new lateral sinus grafting techniques lead to less invasive, complication-free, and rapid healing procedures.8 Thus, preserving the lateral wall as a potential osteogenic source can improve bone formation, reduce healing time, protect grafting material or coagulum, prevent soft tissue ingrowth, and eliminate the need for membrane coverage. These are all significant benefits that seem to be achievable using the window repositioning technique.6,7,9,10

Despite the new trend of a less-invasive approach in conventional techniques, large windows are osteotomized for the window repositioning technique.6,7,9-14 Therefore, less-invasive window preparation can be a new approach in the window repositioning technique. It is noteworthy that few studies have investigated the outcomes and possible complications of a less-invasive approach to conventional window preparation.15,16

1Department of Oral & Maxillofacial Surgery, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.
2Department of Research, Arka Education and Clinical Research Consultants, Tehran, Iran.
3Universal Network of Interdisciplinary Research in Oral and Maxillofacial Surgery (UNIROMS), Universal Scientific Education and Research Network (USERN), Tehran, Iran.
4Department of Oral & Maxillofacial Surgery, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran.

Correspondence to: Dr Kazem Khiabani, Department of Oral & Maxillofacial Surgery, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. Email: Khiabani_ak@yahoo.com

Submitted July 5, 2021; accepted March 8, 2022.
©2022 by Quintessence Publishing Co Inc.
Similar to free bone graft, absorption and subsequent consolidation are expected for the repositioned bony window during the healing period. However, the risk of inflammation, delayed bone regeneration, infection, inflammatory resorption, dislocation, and sequestrum formation cannot be ignored. Since stable repositioning of the bony window is recommended, pediculur osteotomy, beveled osteotomy, modified osteotomy, surgical glue, membrane or platelet-rich fibrin, collagen fleece coverage, and precise osteotomy have been introduced to achieve stable window repositioning.

Despite the favorable window integration—which prevents soft tissue ingrowth and eliminates the need for membrane coverage—incomplete bone healing, which is attributed to the sinus wall thickness and initial osteotomy gap, has been reported in osteotomy lines. Rotary instruments, microsaws, and piezoelectric devices have been utilized for window osteotomy. However, safety and precision have made piezoelectric surgery more popular in recent years. Using a piezoelectric saw seems to be the most practical way to achieve a precise and rapid osteotomy to ensure window stability.

The surgical feasibility, postsurgical healing, and surgical complications of the conventional window repositioning technique have been investigated in previous studies; however, the augmentation adequacy has not yet been measured. This prospective study was conducted to determine whether the less-invasive window repositioning technique could provide a feasible, safe, and reliable method for desired lateral sinus augmentation. These will be investigated overall and in one- and two-implant groups with different window dimensions by measuring augmented bone height and length, posthealing outcomes, and surgical complications. In the present study, the effect of reducing the window size on the surgical outcome and membrane perforation, window-related variables such as wall thickness and cutting width, and surgical time are also investigated. To the authors’ knowledge, this is the first study on the less invasive window repositioning approach.

**MATERIALS AND METHODS**

To address the research purpose, the investigators designed and implemented a prospective clinical study. The study population was subjects with posterior maxillary edentulism referred to the Department of Oral & Maxillofacial Surgery at the Ahvaz Jundishapur University of Medical Sciences and a private center for sinus membrane elevations via a lateral approach from 2020 up to 2021. All the patients finished the minimum of an 8-month follow-up before June 2021.

Patients were included in the study with the fulfillment of the following items (inclusion criteria):

- > 18 years of age
- Healthy sinus cavity
- 2.5 to 6 mm of remaining bone height at the site of implant insertion, measured on a CBCT scan

Patients were excluded as study subjects in any of the following cases (exclusion criteria):

- Medically compromised patients and general contraindications for oral surgery
- Local contraindications (eg, active sinusitis, sinus pathology)
- Periapical lesion in the adjacent tooth
- Poor oral hygiene or untreated periodontitis
- Smokers (> 10 cigarettes/day)
- Drug or alcohol abuse

**Study Design**

The primary predictor variable was the less-invasive window repositioning (LIWR) technique using a piezoelectric saw for lateral sinus floor elevation (LSFE). The subjects were operated on consecutively under the same circumstances and with the same experienced surgeon (K.K.). A presurgical CBCT scan focusing on the maxillary area, with attention to a specific radiographic reference, such as the root apex of an adjacent tooth, was obtained from each patient. Repeatable measurements were performed at different times during the process and subsequent follow-ups using these references.

**Surgical Procedure**

Patients received the same prophylactic oral antibiotics and analgesics, including 1,000 mg of amoxicillin and 100 mg celecoxib 1 hour before the operation. Immediately before the procedure, the subjects rinsed their mouths for 1 minute with a 0.2% chlorhexidine mouthwash. All surgical procedures were performed under local anesthesia using lidocaine 2% with 1/100,000 epinephrine vasoconstrictor (Persocaine, DarouPakhsh).

A slightly palatal incision with one or two vertical releasing incisions was made to reflect the full-thickness mucoperiosteal flap to expose the lateral maxillary wall. The appropriate location and size of the bony window, the number and location of the implant(s), the anatomy of the sinus floor, and the height of the remaining bone, were determined using CBCT measurements and lateral wall inspection.

Using the BS1 saw insert (0.6 mm) of the piezoelectric device (Acteon) with copious irrigation, a quadrangular window 5 to 8 mm long and 4 to 6 mm high was prepped while preserving the thin bone on the membrane...
Khiabani et al

(Fig 1). The SL1 rectangular diamond insert (0.6 mm) was utilized to finalize the upper limb osteotomy until the sinus membrane became evident (Fig 2). In the early cases, the SL2 round insert (1.5 mm) was used in the corners to prepare an anchor hole for lifting the bony window. Use of the round insert was stopped to prevent gaps in the osteotomy lines. The BS1 saw was applied intermittently and carefully to finalize osteotomy of other sides of the window with the exposed membrane guide. The delicate tip of the periosteal elevator was carefully inserted under the bony window to separate it from the sinus mucosa and kept in saline-moistened gauze to be repositioned at the end of surgery. Using tactile sense and delicate sinus elevators, the sinus membrane was carefully dissected from the inferior, lateral, and medial sinus walls (Fig 3). Cases of membrane perforation were managed using extreme care while continuing membrane detachment and gently applying a piece of an absorbable membrane (Iranian Tissue Product) into the sinus cavity, where it adhered after absorption of blood.

While protecting the sinus membrane, drilling was performed. Using the delicate elevator, the sinus was partially filled with a mixture of cortical and cancellous freeze-dried bone allograft material (Iranian Tissue Product), and dental implants were inserted (BEGO Semados). The biomaterial was packed homogeneously to the window opening until the dead space was completely filled up. Finally, the bony window was repositioned at the osteotomy site and was gently pressed over the grafted window. No covering membrane was used on the window, and despite instability in some cases, no fixation was applied (Fig 4). After copious saline irrigation, the mucoperiosteal flap was watertight closed with Vicryl no. 4 resorbable suture (Supa).
Postsurgical and Follow-up Protocol

Standard postoperative instructions were provided for patients. All patients received antibiotics (1.5 g amoxicillin daily) and celecoxib (300 mg daily for 7 days). Chlorhexidine mouthwash was also prescribed twice daily for 10 days. Patients were recalled for follow-up visits at 10-, 30-, and 180-day intervals. In all cases, CBCT scans were taken 6 months after surgery before the uncovering stage. After 6 months, the mucoperiosteal flap was reflected to uncover the dental implant and expose the lateral wall of the maxillary sinus to investigate the bone window healing.

Radiographic Evaluations

The augmented bone height and length were determined to measure the sinus augmentation adequacy in two dimensions. The primary outcome variable was the augmented bone height. The augmented bone length was the secondary radiographic outcome variable.

The ratio of window length to augmented bone length was calculated to investigate the feasibility of proper sinus augmentation and the maximum possible anteroposterior sinus augmentation while reducing the window size.

To investigate the relationship between the bone depression in the osteotomy line at the implant uncoverage stage and lateral sinus wall thickness, the thickness in the center of the window to be osteotomized was measured in millimeters in preoperative CBCT. A blinded evaluator (M.H.A.I.) recorded all radiographic results on preoperative and 6-month postoperative CBCT scans.

All the CBCT images were obtained by the New Tom Giano unit (QR Verona) using high-resolution mode with a voxel size of 0.15 mm. Repeatable measurements were obtained based on reproducible radiographic reference on parasagittal images reconstructed parallel to the long axis of adjacent teeth in the region of interest, which did not have the limitation of radiographic stents for follow-up after prosthesis delivery with radiopaque references. Slice thickness was set at 1 mm. The measurements were made utilizing measurement tools of NNT Viewer software (Version 3.0) to the nearest 0.1 mm for the following measures and compared on preoperative and postoperative CBCT reconstructed images:

- Remaining bone height (RBH): Measurement of the distance (in mm) between the crest and inferior border of the sinus floor in preoperative CBCT scan along the long axis of the inserted implant in postoperative CBCT scan (Fig 5).
- 6-month bone height: Distance (in mm) between the alveolar crest and the most superior margin of the elevated radiopaque dome-shaped mass at the site of implant insertion.
- Augmented bone height (ABH): Distance (in mm) between the inferior border of the sinus floor and the most superior margin of the elevated radiopaque dome-shaped mass along the long axis of the implant.

It is noteworthy that in sinus elevations with two-implant placements, the mean ABH was calculated according to measurements along the long axis of both implants.
Augmented bone length: Distance (in mm) between the anterior and posterior points of the dome-shaped augmentation in the sagittal view while the maximum body of the implant is visible (Fig 7).

Posthealing and Intrasurgical Evaluations

Posthealing secondary outcome variables were assessed at the implant uncovering stage to investigate the lateral sinus wall healing, including bony window integration to the lateral sinus wall (Figs 8 and 9), soft tissue ingrowth in

Fig 7 Measurement of augmented bone length in postoperative CBCT scan. Measurement of distance (in mm) between the anterior and posterior points of the dome-shaped augmentation in the sagittal view while the maximum body of the implant is visible.

Fig 8 Six-month postoperative view of lateral sinus wall reconstruction at uncovering stage. Note the perfect integration of repositioned bony window to adjacent lateral sinus wall.

Fig 9 Six-month CBCT view of repositioning window site. Note the perfect integration of repositioned bony window and lateral wall corticalization.

Fig 10 Intraoperative view of the bony window repositioned over the graft material. Note the > 1.5 mm bone gap in the upper posterior corner of the repositioned window between the repositioned window and intact lateral wall, which was prepared using a piezoelectric round diamond insert in the early cases.

Fig 11 Six-month postoperative view of lateral sinus wall reconstruction at uncovering stage. Note good bony window integration to adjacent sinus lateral wall, despite continuity gap (depression) exactly at the site of initial bone gap following bony window repositioning.
Using a periodontal probe, the following intrasurgical measurements (mm) were recorded during the surgical procedure: window dimensions (length and height), window surface area (mm²), and the bone gap width in the osteotomy line after window replacement (Fig 10). The stability or instability of repositioned windows has been reported.

Also, any perioperative complications including membrane perforation, bony window fracture, nasal bleeding, infection, bony window resorption or sequestration or dislocation, and wound dehiscence were recorded. Clinical assessments of implant survival were performed during the study periods according to success criteria of the implant proposed by Cochran et al., which included the following: (1) absence of implant mobility, (2) absence of persistent pain, (3) absence of recurrent peri-implant infection, and (4) absence of continuous radiolucency around the implant.

Data Analysis
The data gathering was performed using a prepared checklist, and patients were informed about the use of their information in the study. The collected data were entered into SPSS software (IBM) version 22.0 and analyzed using descriptive statistics, chi-square test, and Pearson correlation analysis. P < .05 was considered significant.

Ethical Approval and Considerations
This study was taken from a research project with local ethical committee approval from Ahvaz Jundishapur University of Medical Sciences with the code IR.AJUMS.REC.1399.550 and the registration number IRCT20201108049312N1 from Iranian Clinical Trials. It was performed following the Helsinki Declaration. All the protocol characteristics, including procedures, goals, follow-up period, and possible complications, were explained to the patients before signing the informed written consent form, indicating their agreement to participate in the study voluntarily.

RESULTS
A total of 50 sinus augmentations (38 unilateral and 6 bilateral) with simultaneous placement of 66 implants (one-implant: 34; two-implant: 16) were performed on 44 subjects (28% women and 72% men) with a mean age of 46.7 ± 10.3 years (range: 34 to 60 years) and followed for a mean of 13.28 ± 3.5 months (8 to 18 months).

The overall, one-implant, and two-implant group window dimensions and lateral wall thicknesses are presented in Table 1. The overall mean window sizes were 31.38 ± 6.78 mm², 28.38 ± 4.21 mm², and 37.75 ± 6.88 mm², respectively. The window mean length (P < .001), height (P = .005), and size (P < .001) were significantly larger in the two-implant group than in the one-implant group. The window wall thickness difference between the two groups could not reach a significant level.

The overall one- and two-implant group augmented bone lengths are presented in Table 1. The overall mean augmented bone length was 19.67 ± 2.0 mm. There

<table>
<thead>
<tr>
<th>Variable</th>
<th>One-implant (n = 34)</th>
<th>Two-implant (n = 16)</th>
<th>Between groups P value</th>
<th>Overall (n = 50)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Window length (mm)</td>
<td>5.79 ± 0.64</td>
<td>7.25 ± 1</td>
<td>&lt; .001</td>
<td>6.26 ± 1.02</td>
</tr>
<tr>
<td>Window height (mm)</td>
<td>4.85 ± 0.35</td>
<td>5.18 ± 0.4</td>
<td>.005</td>
<td>4.96 ± 0.4</td>
</tr>
<tr>
<td>Window size (mm²)</td>
<td>28.38 ± 4.21</td>
<td>37.75 ± 6.88</td>
<td>&lt; .001</td>
<td>31.38 ± 6.78</td>
</tr>
<tr>
<td>Augmented bone height (mm)</td>
<td>12.41 ± 0.98</td>
<td>12.05 ± 1.18</td>
<td>.26</td>
<td>12.3 ± 1.04</td>
</tr>
<tr>
<td>Remained bone height (mm)</td>
<td>3.95 ± 0.83</td>
<td>3.66 ± 0.74</td>
<td>.24</td>
<td>3.86 ± 0.81</td>
</tr>
<tr>
<td>6-month bone height (mm)</td>
<td>16.4 ± 0.99</td>
<td>15.65 ± 1.37</td>
<td>.03</td>
<td>16.16 ± 1.16</td>
</tr>
<tr>
<td>Augmented bone length (mm)</td>
<td>19.72 ± 2.3</td>
<td>19.56 ± 1.26</td>
<td>.79</td>
<td>19.67 ± 2.01</td>
</tr>
<tr>
<td>Window length/augmented bone length (%)</td>
<td>29.74 ± 4.62</td>
<td>37.15 ± 5.4</td>
<td>&lt; .001</td>
<td>32.11 ± 5.96</td>
</tr>
<tr>
<td>Window wall thickness (mm)</td>
<td>1.76 ± 0.77</td>
<td>1.56 ± 0.51</td>
<td>.34</td>
<td>1.7 ± 0.69</td>
</tr>
</tbody>
</table>
was no significant difference between the two implant groups \( (P = .79) \). The ratio of window length to augmented bone length was significantly lower in favor of the implant group with the smaller window size \( (P < .001) \).

The results indicated that the window dimension did not have any significant correlation with 6-month bone height, augmented bone height, and augmented bone length \( (r = -0.11, P = .45; r = -0.9, P = .54; \text{and } r = .05, P = .68, \text{respectively}) \). The repositioned windows showed perfect integration to the lateral sinus wall without soft tissue ingrowth to the window site (Fig 8). Also, by dividing the intraoperative bone gap into \( \leq 1.5 \) mm and \( > 1.5 \) mm groups, statistical analysis revealed a significant direct correlation of bone depression at the implant uncover stage with the intraoperative \( > 1.5 \) mm bone gap \( (r = 0.917, P < .001; \text{Fig 12}) \). Bone depression at the implant uncover stage showed a nonsignificant direct correlation with window wall thickness \( (r = 0.311, P = .28) \). There was no correlation between bony window stability or instability and posthealing bone depression \( (r = 0.25, P = .84) \). Also, it did not affect window integration or postsurgical complications.

In the present study, no cases of window-related complications, wound dehiscence, or postsurgical infection were observed. Six sinus perforations (12%) during membrane elevation that were not related to window osteotomy were observed and were appropriately managed. All these cases showed similar clinical and radiologic results to nonperforated cases. All the implants survived clinically during the follow-up period.

The operation times are presented in Table 2. The overall, window osteotomy, and membrane elevation/sinus grafting mean surgical times were 41.15 \( \pm 7.23 \), 9.81 \( \pm 4.3 \), and 18.21 \( \pm 3.16 \) minutes, respectively. There was no significant difference in surgical times between the two groups with different window sizes.

### DISCUSSION

The present clinical study was designed to answer whether the less-invasive window repositioning technique is feasible, safe, and reliable for desired lateral sinus floor augmentation. Also, the clinical, radiographic, and posthealing outcomes and surgical complications of the LIWR technique were evaluated and compared to the current literature on window repositioning and less-invasive techniques of sinus floor elevation.

Measurement of augmented bone height and length as a primary and secondary radiographic outcome variable revealed the desired bone augmentation, feasibility, and reliability of this technique. Evaluation of posthealing outcome variables and surgical complications revealed similar results to published literature on window repositioning and less-invasive conventional techniques.

The new sinus grafting techniques lead to less invasive, complication-free, and rapid healing procedures. Thus, preserving the lateral sinus wall as a potential osteogenic source can improve bone formation, reduce healing time, protect grafting material or coagulum, prevent soft tissue ingrowth, and eliminate the need for membrane coverage. These are all important benefits that seem to be achievable using the window repositioning technique.

Since conventional lateral sinus floor elevation is an invasive approach, less-invasive window preparation has been considered recently. However, large windows are still osteotomized for the window repositioning technique. Therefore, less-invasive window preparation can be a new approach in this technique.
Although the window dimension is one of the key points of sinus floor elevation, there is a lack of literature on this issue. Avilá-Ortiz et al found a strong inverse correlation between window dimensions and vital bone formation. In practice, it means that the preparation of smaller windows may contribute toward faster maturation and consolidation of the grafting material. The average window areas of 69.71 mm², 59.2 mm², 36 mm², and 31.05 mm² have been reported in studies with less-invasive approaches. In the present study, the average window area was 31.38 mm², comparable with the less-invasive conventional window size from a study by Baldini et al and significantly smaller than the window dimensions reported for the previous studies of the window repositioning technique. The window areas of 200 mm², 150 mm², and 84 mm² were reported in studies by Sohn et al, Kim et al, and Tawil et al, respectively, which were approximately 2.5 to 6 times larger than the window size in the present study. However, given the mean window size of 28.38 mm² in the one-implant group, the window size difference with previous studies will be more pronounced. Although Giovannetti et al reported a possibly smaller conventional window (5 × 5 mm), their surgeries were endoscopically assisted sinus augmentation.

In the present study, only LSFEs with simultaneous implant insertion were included. The reasons for this were that (1) the implants were the radiographic outcome measurement reference and (2) a very limited number of two-stage LSFEs are performed in the authors’ clinic.

Regarding sinus augmentation adequacy assessment, the present authors believe that estimating the postoperative augmented bone volume only allows for an overall evaluation of the grafting area without focusing on the adequacy of the augmented bone surrounding the implant, which is the main goal of LSFE. Therefore, in the present study, instead of estimating the volume, sinus augmentation adequacy in two dimensions of height and length was measured based on the inserted implants. Evaluation of augmented bone height as the primary outcome variable showed an average of 12.3 ± 1.04 mm bone augmentation at 6 months, while the one-implant (with the smaller window) and two-implant groups did not show a significant difference. The augmented bone length measurement is consistent with the result of a study by Pariente et al: With a value of 19.0 ± 5.5 mm, but with a window, it was almost twice the window size of the present study.

The ratio of window length to augmented bone length was calculated to investigate the feasibility of proper sinus cavity augmentation by reducing the window size. Pariente et al reported a 72.8% ± 13.1% ratio, which is higher than the ratio of the present study (32.11% ± 5.9%). Interestingly, this ratio was significantly lower in the one-implant group compared with the two-implant group, indicating the feasibility of appropriate augmentation through a smaller window, while the augmented sinus length is similar in both groups.

Similar to free bone graft, absorption and subsequent consolidation are expected for the repositioned bony window during the healing period, although the risk of inflammation, delayed bone regeneration, infection, inflammatory resorption, dislocation, and sequestration formation cannot be ignored. Thus, stable repositioning of the bony window is recommended to ensure appropriate healing. An osteotomy with a round piezoinsert and rotary bur makes a much wider cut, resulting in an unstable repositioned window. However, a safer but slower osteotomy is expected when using a round diamond piezoinsert instead of a sharp piezosaw. The present study used a combination of saw and diamond piezoinserts for a more precise, faster, and safer osteotomy. When using the saw insert during osteotomy, higher perforation rates were reported. However, according to the protocol of the present study, less-invasive window preparation did not cause membrane perforation. Using the less invasive technique, Baldini et al and Pariente et al reported 18.7% and 13.3% perforation rates, respectively; using the window repositioning technique, Tawil et al and Giovannetti et al reported 12.8% and 10% membrane perforation rates during elevation, respectively, which is almost consistent with the present findings (12%). Regarding possible complications or clinical limitations, conservative window preparation did not restrict access to the sinus cavity or augmentation procedure, and there was no need to enlarge the window. Also, there were no window-related complications. It seems that precise osteotomy and stable window repositioning can prevent window dislocation, infection, and sequestration. However, sinus floor elevation using the LIWR technique is an experience-based procedure with a learning curve that also requires using tactile sensing and delicate instruments.

Using the repositioning windows compared with the collagen membranes in the window area has shown higher and faster bone formation in several histologic studies that indicated their osteogenic property.
Also, the repositioned bony window protects the grafted material and prevents soft tissue invasion without the risk of cross-contamination and any immunologic reaction. Despite the favorable window integration, incomplete bone healing has been reported in osteotomy lines. Using a round piezodrill, Kim et al reported posthealing shallow fissure in 50% of osteotomy lines. Using a round rotary bur, Cho et al reported 74% incomplete bone formation with a positive correlation \( r = 0.44 \) with the lateral wall thickness and recommended using a smaller round bur to reduce the osteotomy width. In contrast, Tawil et al found an association between incomplete bone healing and initial osteotomy gaps wider than 1.5 to 2 mm. In the present study, perfect bony window integration without any soft tissue invasion was observed, consistent with previous studies. However, in 34% of cases, a shallow bone depression (incomplete corticalization) was observed exactly at the site of the initial osteotomy gaps.

There was a nonsignificant correlation \( r = 0.311, P = .28 \) between sinus wall thickness and posthealing bone depression. In contrast, there was a strong positive correlation \( r = 0.917 \) between the width of the initial osteotomy gap and posthealing bone depression. Thus, when the initial bone gap was 1.5 to 2 mm, the probability of bone depression was high, which is consistent with the findings of Tawil et al. Since posthealing bone depression is directly related to the intraoperative gap width, a precise osteotomy is recommended to ensure window stability and subsequent perfect healing. Since the stability or instability of the repositioned window did not differ in terms of window integration or complications, any type of window coverage or fixation is not necessary.

Since surgical time was not reported in the previous window repositioning studies, it was compared with less-invasive conventional LSFE studies. The LIWR technique requires more time compared to the less invasive conventional technique. The reasons for this are the need for more time for window ostectomy, detachment, and subsequent repositioning at the end of surgery than simple bone removal. However, preserving the lateral wall with osteogenic potential seems to be worth the time.

According to similar findings on the height and length of the augmented sinus in different window sizes, a nonsignificant correlation between window size and augmented bone height and length \( r = -0.9, P = .54 \), and \( r = 0.05, P = .68 \), the absence of significant complications, and low sinus perforation rate, it seems that the reduction of window dimension does not affect the adequacy, reliability, and safety of sinus elevation through less invasive window preparations such as LIWR.

The present study has several strengths compared with the former window repositioning studies. This study introduces a less-invasive modification of the window repositioning technique and presents one of the least-invasive window preparations among LSFE techniques. The adequacy of sinus augmentation was evaluated in two dimensions (height and length). Also, by comparing the results of two window sizes, the effect of reducing window size on sinus augmentation adequacy and surgical safety was investigated. The surgical times of the LIWR technique, including window ostectomy, membrane elevation, and sinus grafting, were reported. Regarding study limitations, nonrandomization and the lack of a control group may affect the findings of this study. Histologic examination to assess the bone quality was not possible due to the simultaneous insertion of the implants in the LSFE stage. However, in the uncovery stage, window integration and new bone formation in the osteotomy lines were examined visually and manually. Also, the evaluation of implant survival, uncommon complications, and sinus conditions were limited to the study period.

CONCLUSIONS

According to the radiologic and posthealing outcomes, appropriate feasibility, safety, and reliability without significant complications for less-invasive window repositioning were observed. Also, within the limits of this study, the following results can be summarized:

1. Using a less invasive window repositioning technique, the appropriate sinus augmentation can be achieved in height and length.
2. The reduction of window dimension does not influence the feasibility, augmentation adequacy, or surgical safety.
3. The integration of repositioned bony windows is perfect and prevents soft tissue ingrowth.
4. Less invasive window preparation does not restrict access to the sinus cavity and does not increase surgical risks or membrane perforation.
5. Sinus floor elevation through this technique is an experience-based surgery with a learning curve that also requires delicate instrumentation.

For future studies, randomized controlled trials are recommended to compare LIWR with conventional LSFE techniques.

ACKNOWLEDGMENTS

This article is taken from research project number U-99264 and was supported by the Vice-Chancellor for Research of Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran. The authors reported no conflicts of interest related to this study.
REFERENCES