Clinical and Radiological Outcomes of Implants in Osteotome Sinus Floor Elevation with and without Grafting: A Systematic Review and a Meta-Analysis

Mei-Hua Chen, MDS¹ & Jun-Yu Shi, MDS²

¹Department of Periodontology, Shanghai Stomatology Hospital, Shanghai, China
²Department of Dental Implantation, Shanghai Ninth People’s Hospital, Shanghai Key Laboratory Stomatology, Shanghai Jiaotong University, School of Medicine, Shanghai, China

Keywords
Osteotome sinus floor elevation; survival rates; dental implants; systematic review.

Abstract

Purpose: To systematically appraise the clinical and radiological outcomes after osteotome sinus floor elevation (OSFE) with or without grafting in the published dental literature.

Methods: An electronic search was conducted using PubMed, Web of Science, and the Cochrane Central Register of Controlled Trial to identify studies after OSFE from January 1, 1994 to August 30, 2015. The primary outcome was the implant survival rates after OSFE with and without grafting materials.

Results: After search and evaluation of the literature according to the inclusion criteria, 7 studies were included in the review. The random-effect model meta-analysis based on 463 implants in patients without grafting and 415 implants in patients with grafting showed that the risk ratio difference of survival rates was 1.010 (95%CI 0.910, 1.120), which did not reach statistical significance (p = 0.99). The membrane perforation rates ranged from 0% to 10.80%. No significant difference of crestal bone loss was reported between graft and nongraft groups.

Conclusions: Based on currently available evidence, OSFE techniques with and without grafting were both predictable in the short term. In addition, survival rates of dental implants in OSFE with or without grafting did not show any significant difference in the short term.

Transalveolar sinus floor elevation (TSFE) or osteotome sinus floor elevation (OSFE), first introduced by Tatum,¹ then modified by Summers,² has proven to be a predictable procedure for implant placement in the atrophic posterior maxilla region. The technique has been widely applied in clinical practice due to its short- and long-term predictability.³⁻⁵ In comparison to the lateral approach, OSFE may be considered as less invasive, less time-consuming, and more cost-effective.⁶

Previously, many studies showed that grafting materials, including autogenous bone, allogenic bone and xenogenic bone, should be used to maintain the space below the elevated sinus membrane. These studies reported high survival rates using OSFE with simultaneous grafting.⁷⁻⁹ Subsequently, some clinicians tried to apply the TSFE procedure without any grafting materials. High success rates were reported in these studies.¹⁰⁻¹³ The osteogenic activation after sinus floor mini-fracture and the osteogenic activity of the sinus membrane may be reasons for the endo-sinus bone formation.¹⁴ The grafting protocol, which is considered as an important issue in clinical decision making, could affect the treatment cost, surgical time, loading protocol, and prosthesis selection.¹¹

A previous systematic review reported a 3-year estimated survival rate of 92.8% for OSFE; however, no conclusion could be drawn with regard to grafting materials due to the huge heterogeneity.¹⁵ A recent systematic review compared the mean weighted cumulative survival rates of OSFE with or without grafting. It concluded that no significant difference was found in relation to the use of grafting materials.¹⁶ However, no meta-analysis could be performed, because most included studies were low evidence-level case series with single cohorts.

The aim of present review was to systematically analyze the scientific literature regarding the direct comparison of clinical and radiological outcomes after OSFE with and without grafting. The primary outcome is implant survival rates. Only comparative studies or randomized controlled trials were included.
Methods

Search strategy

A PubMed, Web of Science, and Cochrane Central Register of Controlled Trials search from January 1, 1994 to August 30, 2015 was conducted for articles published in the dental literature, and was limited to human trials, using search terms (“sinus floor elevation” or “sinus lift” or “sinus augmentation” or “sinus graft” or “osteotome sinus floor elevation” or “bone-added osteotome sinus floor elevation” or “internal sinus floor elevation” or “indirect sinus floor elevation” or “transcrestal sinus floor elevation”) and (“dental implants” or “dental implantation” or implant). Then, the terms: not (trauma or tumor or injuries or cancer or lateral) were added to exclude any off-topic studies.


Inclusion criteria

The inclusion criteria for the study selection were:

1. Studies reporting OSFE with and without grafting;
2. Studies reporting survival rates of grafted and nongrafted implants;
3. Studies with at least 1-year follow-up;
4. Studies with a minimum of 10 patients;
5. Publications in the dental literature, based on human trials.
Table 1: General characteristics of the included studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Study design</th>
<th>Follow-up (months)</th>
<th>Implant system</th>
<th>Residual bone height (mm)</th>
<th>Grafting material</th>
<th>No. of patients/implants</th>
<th>Drop-out (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dierens et al</td>
<td>2005</td>
<td>Prosp.</td>
<td>14.4</td>
<td>Straumann</td>
<td>5.78</td>
<td>None</td>
<td>33/17</td>
<td>0</td>
</tr>
<tr>
<td>Pjetursson et al</td>
<td>2009</td>
<td>Prosp.</td>
<td>38.4</td>
<td>Straumann</td>
<td>8.1</td>
<td>ABG+DBBM</td>
<td>181/164</td>
<td>NR</td>
</tr>
<tr>
<td>Lai et al</td>
<td>2010</td>
<td>Prosp.</td>
<td>12</td>
<td>Straumann</td>
<td>5.6</td>
<td>None</td>
<td>202/191</td>
<td>NR</td>
</tr>
<tr>
<td>Nedir et al</td>
<td>2015</td>
<td>RCT</td>
<td>36</td>
<td>Straumann</td>
<td>2.6</td>
<td>β-TCP+ABG</td>
<td>12/17</td>
<td>0</td>
</tr>
<tr>
<td>Si et al</td>
<td>2013</td>
<td>RCT</td>
<td>36</td>
<td>Straumann</td>
<td>2.2</td>
<td>DBBM</td>
<td>20/20</td>
<td>8.89</td>
</tr>
<tr>
<td>Nedir et al</td>
<td>2014</td>
<td>Prosp.</td>
<td>12</td>
<td>Straumann</td>
<td>7 (6-10)</td>
<td>ABG+DBBM</td>
<td>21/21</td>
<td>0</td>
</tr>
<tr>
<td>Markovic et al</td>
<td>2015</td>
<td>RCT</td>
<td>29.7</td>
<td>Straumann</td>
<td>3.6 (2-5)</td>
<td>Bioglass</td>
<td>9/20</td>
<td>0</td>
</tr>
</tbody>
</table>

Prosp.: prospective study, ABG: autogenous bone graft, DBBM: deproteinized bovine bone mineral, β-TCP: β-tricalcium phosphate

Figure 2: Risk of bias.

Exclusion criteria

1. Studies with multiple publications on the same patient cohort;
2. Studies concerning lateral sinus floor elevation;
3. Studies not reporting the detailed information on surgical procedures.

Study selection

Titles and abstracts of the searches were initially screened by two independent reviewers (SJY, CMH). Any disagreement was resolved by discussion. Finally, the full-text articles were assessed by a risk of bias table.

Bias risk assessment

Two independent investigators assessed the studies’ bias. A risk of bias table (Cochrane Handbook for Systematic Reviews of Interventions, version 5.1.0., http://www.cochrane.org/resources/handbook) was used to assess the included studies. It is worth mentioning that blinding methods of grafting protocol are impossible to be applied to the surgeons when OSFE procedures are performed.
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Figure 3

Risk of bias.

Data extraction

Two independent reviewers extracted data using a data extraction form. Any disagreement regarding data extraction was resolved by discussion. General information, implant systems, study characteristics, survival rates, complication rates, and radiographic outcomes were retrieved. The primary outcome was implant survival rates.

Statistical analysis

Clinical and radiological outcomes were present in descriptive statistics. Meta-analysis was performed for studies reporting survival rates of implants in OSFE with and without grafting. The risk ratio differences, together with 95% confidence intervals, were analyzed using random-effect model. A forest plot was generated, and heterogeneity was calculated by use of the statistical software package STATA (v11.0; StataCorp, College Station, TX).

Results

Included studies

In total, 928 titles and abstracts were retrieved from the electronic search for possible inclusion in the review. After manual searching, six studies were added to full-text evaluation. Thirty articles were selected for full text evaluation. The k values were 0.83 and 0.87 at the abstract and full-text article levels, respectively. Three studies were excluded because lateral approach was reported;17-19 18 were excluded because patients with or without grafting were reported separately.10-13,20-33 Two studies were excluded because the same patient cohort was used.34,35 Finally, 7 studies were included in this review (Fig 1).36-42 Table 1 shows the general characteristics of included studies. After bias assessment, three studies36,40,42 were considered as low risk, and other four studies37-39,41 as high risk (Figs 2 and 3).

Implant survival rates with and without grafting

All seven studies compared the implant survival rates after OSFE with and without grafting (Table 2). Nedir et al36,41 and Markovic et al42 used the success criteria of Buser et al (1997),43 and Si et al30 used the success criteria of Buser et al (1997)43 and Cochran et al (2002)44 to describe clinical implant survival. The random-effect model meta-analysis based on 463 implants in patients without grafting and 415 implants in patients with grafting showed that the risk ratio difference of survival rates was 1.010 (95%CI 0.910, 1.120), which did not reach statistical significance ($P = 0.99$) (Fig 4). Low heterogeneity was found among five studies ($I^2 = 0\%$). Begg’s test showed low publication bias ($Z = 0.90, p = 0.368$, after continuity corrected) (Fig 5).

Membrane perforation rates

Five of the seven studies reported sinus membrane perforation rates. The perforation of the sinus membrane was tested by the Valsalva maneuver (nose blowing test) in these studies. Pjetursson et al39 reported overall perforation rates of 10.80%. Si et al40 reported overall perforation rates of 6.67%. Lai et al38 reported similar perforation rates in grafting group (7.87% vs. 2.62%, respectively). Other studies reported that no perforation of sinus membrane happened during the surgical procedures.

Radiographic outcomes

Four of the seven studies reported the radiographic outcomes of included studies (Table 2). The mean residual bone height (RBH) ranged from 2.6 to 8.1 mm in nongraft groups and from 2.2 to 6.4 mm in graft groups. The mean endo-sinus bone gain (ESBG) ranged from 1.7 to 4.1 mm in nongraft groups and from 3.17 to 5.1 mm in graft groups at 3-year follow-up. Two studies36,39 reported significantly more in the graft group. Another40 reported similar ESBG between two groups. In addition, frequency analysis on ESBG was performed in two studies.36,39 Pjetursson et al39 reported that the probability of gaining 2 mm or more of new bone was 39.1% in the nongraft group and 77.9% in the graft group. Nedir et al46 reported that an ESBG >2 mm was observed in 93.8% of the nongraft group.
Table 2  Clinical and radiographic outcomes of included studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Survival rate (N/G) (%)</th>
<th>6 months (N/G)</th>
<th>12 months (N/G)</th>
<th>36 months (N/G)</th>
<th>12 months (N/G)</th>
<th>36 months (N/G)</th>
<th>Perforation rate (N/G) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dierens et al</td>
<td>2005</td>
<td>100.0/100.0</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>0</td>
</tr>
<tr>
<td>Pjetursson et al</td>
<td>2009</td>
<td>97.6/97.7</td>
<td>NR</td>
<td>NR</td>
<td>1.7/4.1</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
</tr>
<tr>
<td>Lai et al</td>
<td>2010</td>
<td>97.4/92.1</td>
<td>2.66</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>2.62/7.87</td>
<td>NR</td>
</tr>
<tr>
<td>Nedir et al</td>
<td>2015</td>
<td>94.1/90.0 *</td>
<td>NR</td>
<td>3.9/5.0</td>
<td>NR</td>
<td>0.6/0.4</td>
<td>NR</td>
<td>0</td>
</tr>
<tr>
<td>Si et al</td>
<td>2013</td>
<td>95.0/95.24</td>
<td>2.06/5.66</td>
<td>2.45/3.56</td>
<td>3.07/3.17</td>
<td>1.28/0.44</td>
<td>1.38/1.33</td>
<td>NR</td>
</tr>
<tr>
<td>Markovic et al</td>
<td>2014</td>
<td>100.0/100.0</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>0</td>
</tr>
</tbody>
</table>

NR, not reported; N/G, nongraft/graft;
*a success rate: criteria by Buser et al, 1997;

Figure 4  Forest plots of implant survival rate.

and 100% of the graft group. Three studies36,38,40 reported the acceptable crestal bone loss (CBL), and none reported significant difference between graft and nongraft groups.

Discussion

The present review is focused on implant survival rates after OSFE with and without grafting. Stringent inclusion criteria were used, and only studies that reported implant survival rates with two cohorts were included.

Based on seven included studies reporting 878 implants and 527 patients, the short-term survival rates after OSFE with and without grafting were both over 90%. The meta-analysis found no significant difference between graft and nongraft groups. This indicated that the OSFE technique with or without grafting were both predictable in the short term. This result was also in line with a previous systematic review.16 All the implant systems of included studies in present review were Straumann. Thus, caution should be taken for clinicians to extrapolate this result to other implant systems. In addition, the follow-up of included studies ranged from 1 to 3 years. So RCTs with
long-term follow-up are needed to provide evidence for long-term survival rates of OSFE with or without grafting.

In this review, all four studies reported that there was sufficient endo-sinus bone gain (range from 1.7 to 5.1 mm) to permit stress distribution. It was reported that grafting materials could play the role of scaffold to maintain the space below the sinus membrane and to promote the ESBG. Two studies reported more ESBG in graft group. However, different results of frequency analysis on ESBG were found. An ESBG > 2 mm was observed for 39.1% vs. 93.8% in nongraft groups and 77.9% vs. 100% in graft groups. Moreover, another study reported similar endo-sinus bone gain regardless of the procedure with or without grafting at the 3-year examination. The result was also in line with a recently published animal study.

The possible reason for the contradictory results might be the 2D measurement methods. Only one study used 3D CBCT to measure the endo-sinus bone volumetric changes. Another possible reason may be the different penetration implant lengths. Several studies have indicated that the ESBG was significantly correlated with penetration implant lengths. The space below the sinus membrane created by the penetrated implants could help to gain new bone.

The mean residual bone height (RBH) before surgery of the included studies ranged from 2.2 to 8.1 mm, and the mean RBH in four of the five studies was below 6 mm. One study even reported RBH of 2.6 mm in patients without grafting and 2.2 mm in patients with grafting. High survival rates were reported after 1-year follow-up (94.1% without grafting and 90% with grafting). According to the current evidence, the OSFE technique was recommended to be limited to RBH ≥ 6 mm. However, a meta regression analysis based on nine studies using the OSFE technique showed no relationship between mean RBH and implant survival rates. In that study, most included studies selected patients with RBH > 4 mm. Recently, favorable results of implant survival rates after OSFE have been reported in severely atrophic maxilla (RBH < 4 mm) in both short- and long-term studies. This seemed to imply that limited RBH may also provide enough osseointegrated bone-to-implant surfaces to support implant prostheses; however, more well-designed studies are needed to provide evidence for long-term predictability of OSFE in severely atrophic maxilla.

The present systematic review revealed several shortcomings. First, the result of the present review showed that only limited studies with short-term follow-up are available, and only three RCTs were included in the review. Thus, more high-level evidence is needed to evaluate the clinical outcomes following OSFE with and without grafting in the long term. In addition, the possible influence of the surface type (SLA vs. SLActive) could not be evaluated due to the limited number of included studies.

**Conclusion**

Based on evidence currently available, the OSFE techniques with and without grafting were both predictable in the short term. In addition, survival rates of dental implants in osteotome sinus floor elevation with or without grafting did not show any significant difference in the short term.

**Acknowledgment**

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**References**

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