The Prognostic Outcome of Transalveolar Sinus Floor Elevation With or Without Grafting Materials: A Meta-analysis

Qian-Hui Shi, MDS1,2/Yi Luo, MDS2/Yu-Ting Cheng, DDS1/Hua Huo, MDS1/Chao Wu, MDS1/Jian Liao, PhD, DDS, Prof1

Purpose: To assess the effect of nongrafted and grafted materials on transalveolar sinus floor elevation (TSFE) with implant placement. Relevant studies published between January 1, 1994, and July 31, 2021, were selected by searching Embase, PubMed/MEDLINE, Web of Science, and Cochrane Central Register of Controlled Trials. The study subjects were restricted to humans, and the language was limited to English. The study was confined to randomized controlled trials, controlled clinical trials, and observational studies (prospective and retrospective cohort) related to TSFE with and without bone-grafting materials. Two reviewers independently extracted study data and conducted quality assessments according to the Cochrane handbook and NOS scale. RevMan 5.3 and Stata 15.1 software were then used to analyze the research data that met the inclusion criteria. Results: A total of nine articles were included, including 421 implants in the graft group and 502 implants in the nongraft group. Meta-analysis showed that there was no significant difference in the implant failure rate (RR = 1.03, 95% CI: 1.00, 1.06, P = .08) or marginal bone loss (SMD = 0.06, 95% CI: −0.23, −0.35, P = .69) between implants with and without graft materials after TSFE. The amount of endosinus bone gain in the nongraft group was significantly lower than that in the graft group (SMD = −1.07, 95% CI: −1.73: −0.41, P = .0001). Conclusion: TSFE in implants with or without grafting can achieve similar results, but there may be more bone gain in TSFE with grafting. Int J Oral Maxillofac Implants 2022;37:869–878. doi: 10.11607/jomi.9758

Keywords: bone graft material, guided bone regeneration, maxillary sinus, maxillary sinus elevation, meta-analysis, oral implants, survival rate, transalveolar sinus floor elevation

In recent years, the continuous development of the economy has increased the living standards of the human population, and dental implants have become the first choice for numerous patients with missing teeth because of their good stability, realistic esthetics, comfort, and ability to avoid tooth preparations. However, not all tooth losses are suitable for implant rehabilitation, and implant success depends on many factors, with sufficient bone density and residual bone height (RBH) in the edentulous area being the most important.1

In the posterior maxilla, the loss of posterior teeth and subsequent maxillary sinus pneumatization result in severely atrophic alveolar crests, and implants cannot yield sufficient primary stability after implantation; insufficient bone density and RBH often cause huge difficulties in dental implant placement.2 Fortunately, with continuous improvement of dental implant technology, many clinical approaches, such as maxillary sinus floor elevation and/or the use of a short or angled implant, have been developed to increase the bone volume in the posterior maxilla,3 which makes implant rehabilitation more accessible.

Maxillary sinus floor augmentations include the lateral window approach and transalveolar surgical approach of maxillary sinus floor elevation.4,5 The lateral window approach of maxillary sinus floor elevation, which was first introduced by Boyne and James in the 1980s,6 can give expected results in large bone defect areas7,8 and has been widely applied in clinical practice due to its high survival rates and long-term predictability. However, it also has some shortcomings, such as excessive operation trauma and more time-consuming and postoperative complications.9 Transalveolar maxillary sinus floor elevation (TSFE) was first described by Tatum in 198610 and was later modified by Summers in 1994.11 The TSFE technique has the advantages of less trauma, lower cost, mild prospective reaction, and a shorter healing time compared to the lateral window approaches.12 Simultaneous bone grafting after TSFE was used to maintain the volume formed by the elevated sinus membrane, could provide space for new endosinus bone formation, and has achieved high survival rates.12,13–16 In recent years, various grafting materials, including autogenous bone,
allogeneic bone, xenogeneic bone, and artificial bone, have been used in the clinic.\(^\text{17}\) However, some deficiencies were also reported in the use of bone-grafting materials after TSFE. On the one hand, the use of bone-grafting materials increases the sinus membrane perforation rate,\(^\text{18}-\text{20}\) which may lead to sinus infection, disease transmission, and immune rejection. On the other hand, severe postoperative reactions and prolonged postoperative healing times may occur following the use of bone-grafting materials, and patients may refuse to accept complicated surgical procedures and bone-grafting costs.\(^\text{21}-\text{23}\) Moreover, high survival rates and new bone formation in the space after maxillary sinus mucosa elevation were also reported for TSFE without grafting material,\(^\text{24}-\text{26}\) which indicated that the use of grafting materials was not necessary for TSFE. The maxillary sinus membrane and the bone surface of the maxillary sinus floor have potential osteogenic ability, which may explain the endosinus bone formation.\(^\text{27}\) Many randomized clinical trials have assessed the outcome of TSFE with or without bone-grafting materials,\(^\text{28}-\text{30}\) yet controversy remains regarding the use of bone-grafting materials in TSFE.\(^\text{31}\)

The purpose of the present meta-analysis was to assess the effect of nongrafted and grafted materials on the survival rate, crestal/marginal bone loss (CBL/MBL), and endosinus bone gain (ESBG) of TSFE with immediate implant placement.

**MATERIALS AND METHODS**

This study was conducted in accordance with the Preferred Reporting Items for Systematic Review and Meta-analysis Protocols (PRISMA) statement and registered at the International Prospective Register of Systematic Reviews (number CRD: 42021224146).\(^\text{32}\)

**Eligibility Criteria**
The inclusion criteria were:

- Population (P): Maxillary posterior tooth loss patients who received transcrestal/osteotome/indirect sinus floor elevation.
- Intervention (I): Patients underwent TSFE with or without bone-grafting materials and implant placement.
- Comparison (C): TSFE with graft materials vs TSFE without graft materials.
- Outcome (O): The primary outcome was implant success/failure. The secondary outcomes were CBL/MBL, sinus membrane perforation, and ESBG.
- Study design (S): Studies included prospective cohort studies, retrospective cohort studies, randomized controlled trials (RCTs), and controlled clinical trials (CCTs) relevant to TSFE with and without bone-grafting material.

- Reports of a minimum of five patients, and the information about the patients and inserted implants should be clearly provided.
- Study subjects were restricted to humans, and the language was limited to English.
- The follow-up was limited to at least 6 months and no more than 10 years after TSFE with or without graft materials.

The exclusion criteria were:

- Surgical procedures were related to the lateral window technique.
- TSFE with delayed implant placement studies.
- Reports of fewer than five patients and lack of information about patients, implants, and surgical procedures.
- Presence of multiple reports on the same patient cohort.
- Literature review, case report, systematic review, animal studies, and meta-analysis.

**Search Strategy**

Relevant studies published from January 1, 1994, to July 31, 2021, were selected by searching Embase, PubMed/MEDLINE, Web of Science, and Cochrane Central Register of Controlled Trials. The study subjects were restricted to humans, and the language was limited to English. The PubMed search strategy was a combination of Medical Subject Headings (MeSH) terms and free words as follows:

- #1 Sinus Floor Augmentation [MeSH Terms]
  - OR sinus floor elevation OR sinus lift OR sinus augmentation OR Maxillary Sinus Floor Augmentation OR Sinus Augmentation Therapies [Title/Abstract]
- #2 transcrestal OR osteotome OR transcrestal sinus floor elevation OR indirect sinus floor elevation OR osteotome sinus floor elevation [Title/Abstract]
- #3 graft OR grafts OR grafting OR bone graft OR bone grafts OR bone grafting OR grafting materials OR bone transplantation [Title/Abstract]
- #4 #1 AND #2 AND #3

**Data Extraction**

Two researchers (S.Q.H. and W.C.) independently screened documents and extracted data strictly according to a data extraction form. If disagreement occurred during the data extraction process, negotiation was required; if agreement could not be reached after negotiation, a third researcher (Z.Q.) was used to resolve the disagreement. The following items were extracted from the included studies: first authors, publication years, study types, follow-up time, mean age/sex, surgical
technique, prosthetic loading, number of implants placed, number of failed implants, RBH, CBL/MBL, ESBG, radiographic assessment, and implant survival rate. The primary outcome was implant survival rate.

Assessments of the Risk of Bias and Quality
The risk of bias and quality of the included studies were assessed independently by two researchers (S.Q.H. and W.C.). For randomized clinical trials (RCTs), the risk of bias was evaluated using the Cochrane Collaboration risk of bias tool (www.training.Cochrane.org/handbook). Each study was analyzed based on seven criteria:

1. Random sequence generation (selection bias)
2. Allocation concealment (selection bias)
3. Blinding of participants and personnel (performance bias)
4. Blinding of outcome data (detection bias)
5. Incomplete outcome data (attrition bias)
6. Selective outcome reporting (reporting bias)
7. Other bias

Studies were classified as having a low, medium, or high risk of bias. When they met all the quality criteria described above, the quality of the study was considered as “low risk of bias”; if one item of the criteria was not met, it was considered as “moderate risk of bias”; and if two or more items of the criteria were not met, it was considered as “high risk of bias.” The quality of prospective and retrospective cohort studies was assessed using the Newcastle-Ottawa Scale (NOS; http://www.ohri.ca/programs/clinical_epidemiology/oxford.asp). The NOS total score was 9 points, and those with more than 7 points were considered as high-quality studies.

Statistical Analysis
The survival rate of implants was considered as a binary variable, and the MBL/CBL and ESBG of implants were regarded as continuous variables. For the binary variable outcome (ie, implant survival rate), risk ratio (RR) with corresponding 95% confidence interval (95% CI) was used to evaluate the intervention effect. For continuous variable outcome (ie, MBL), standardized mean difference (SMD) with corresponding 95% confidence interval (95% CI) was used to evaluate the intervention effect. A statistical test level of $P < .05$ was significant.

Heterogeneity tests were performed using the $I^2$ statistics and Cochran Q test.33 When $I^2 \leq 50\%$, the heterogeneity was considered as not significant, and a fixed-effect model was used; when $I^2 > 50\%$, the heterogeneity was considered as significant, and a random-effect model was used.34 Furthermore, publication bias was assessed by using Begg or Egger tests for the symmetry of the funnel plot, and significant publication bias was defined as $P < .1$.35

RESULTS

Literature Search
The process for searching and selecting literature is shown in Fig 1. A total of 539 related reports were initially detected by literature research, including 165 in PubMed, 167 in Embase, 27 in The Cochrane Library, and 180 in Web of Science. In addition, 9 reports were obtained by manual searching. A total of 386 duplicate studies were further excluded, with 162 records left. After reviewing the titles and abstracts, 143 articles were excluded. In the end, 12 articles were included for full-text analysis. Through careful reading, 1 study30 lacked complete data and 2 studies36,37 that used the lateral window technique as the surgical technique were further excluded. Finally, 9 studies were included in this meta-analysis, including 2 prospective cohort studies28,38 and 7 controlled studies.31,39–44

Characteristics of Included Studies
There were nine studies, including two prospective cohort studies28,38 with 279 implants and seven controlled studies with 644 implants.29,31,40–44 Among the 644 implants, 320 were placed with grafting material, and 324 were placed without grafting material. The types of materials included Bio-Oss, autogenous bone grafts (ABGs), deproteinized bovine bone minerals (DBBMs), and β-tricalcium phosphate (β-TCP). Different implant systems, including Straumann28,31,38,39,41–44 and Osstem,40 were adopted. The characteristics of the included studies are presented in Table 1.

Quality Assessment of Included Studies
The risk of bias and quality assessments of the seven controlled studies and two prospective cohort studies are shown in Fig 2 and Table 2. Among the seven controlled studies, six studies29,31,40,41,43,44 were considered as “low risk of bias.” The allocation concealment was unclear in the studies by Lai et al42 and both performance bias and detection bias were regarded as having a high risk of bias, so the studies by Lai et al42 were evaluated as having a “high risk of bias.” For the two prospective cohort studies28,38 both studies scored 8 or more and were deemed to be high quality with a low risk of bias.

Data Synthesis and Results of Meta-analysis
Implant survival rate. A total of nine studies reported the implant survival rates, including 502 implants in the nongraft group and 421 implants in the graft group. The fixed-effect model meta-analysis was used because no obvious heterogeneity was found among the studies ($I^2 = 0\%$, $P = .58$), and no statistically significant difference between the two groups was observed (RR = 1.03, 95% CI: 1.00 to 1.06, $P = .08 > .05$; Fig 3).
Table 1  Basic Characteristics of Included Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Study type</th>
<th>Follow-up (mo)</th>
<th>Mean age (sex)</th>
<th>Implant system</th>
<th>Surgical technique</th>
<th>Prosthetic loading (mo)</th>
<th>Graft materials</th>
<th>Implants placed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verdugo et al</td>
<td>2017</td>
<td>Prospective</td>
<td>64.6</td>
<td>64.5 ± 9.5</td>
<td>Straumann</td>
<td>TSFE</td>
<td>NR</td>
<td>No graft</td>
<td>14</td>
</tr>
<tr>
<td>Si et al</td>
<td>2013</td>
<td>RCT</td>
<td>12</td>
<td>57.6</td>
<td>Straumann</td>
<td>TSFE</td>
<td>6</td>
<td>No graft</td>
<td>20</td>
</tr>
<tr>
<td>Lai et al</td>
<td>2010</td>
<td>RCT</td>
<td>60</td>
<td>47 ± 3.6</td>
<td>Straumann</td>
<td>TSFE</td>
<td>6–8</td>
<td>No graft</td>
<td>89</td>
</tr>
<tr>
<td>Nedir et al</td>
<td>2017</td>
<td>RCT</td>
<td>60</td>
<td>57.6 ± 6</td>
<td>Straumann</td>
<td>TSFE</td>
<td>10</td>
<td>No graft</td>
<td>20</td>
</tr>
<tr>
<td>Pjetursson et al</td>
<td>2009</td>
<td>Prospective</td>
<td>38.4</td>
<td>NR</td>
<td>Straumann</td>
<td>TSFE</td>
<td>4–6</td>
<td>No graft</td>
<td>164</td>
</tr>
<tr>
<td>Qian et al</td>
<td>2020</td>
<td>RCT</td>
<td>120</td>
<td>48.5</td>
<td>Straumann</td>
<td>TSFE</td>
<td>NR</td>
<td>No graft+DBBM+Bio-Oss</td>
<td>19</td>
</tr>
<tr>
<td>Marković et al</td>
<td>2016</td>
<td>RCT</td>
<td>29.7</td>
<td>56.7 ± 16 M</td>
<td>Straumann</td>
<td>TSFE</td>
<td>NR</td>
<td>No graft+β-TCP</td>
<td>45</td>
</tr>
<tr>
<td>Trinh et al</td>
<td>2019</td>
<td>RCT</td>
<td>6</td>
<td>51 ± 7</td>
<td>Osstem</td>
<td>TSFE</td>
<td>NR</td>
<td>No graft+Acemannan sponge</td>
<td>15</td>
</tr>
</tbody>
</table>

M BL. Only five studies reported CBL/MBL with 87 implants in the nongraft group and 95 implants in the graft group. The fixed-effect model meta-analysis was used because no obvious heterogeneity was found among the studies ($I^2 = 0\%$, $P = .90$). There was no statistically significant difference between the two groups (SMD = 0.06, 95% CI: –0.23 to 0.35, $P = .69 > .05$; Fig 4).

ESBG. A total of seven studies reported ESBG, with 266 implants in the nongraft group and 197 implants in the graft group. The heterogeneity test showed statistically significant heterogeneity among the included studies ($I^2 = 87\%$, $P < .05$; Fig 5a). Sensitivity analysis was carried out to determine the causes of heterogeneity (Fig 6), which indicated that Pjetursson et al$^{38}$ and Trinh et al$^{40}$ had a

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Fig 1  Flow diagram of study identification and selection.
**Table 1** Basic Characteristics of Included Studies

<table>
<thead>
<tr>
<th>Study (year)</th>
<th>Study type</th>
<th>Mean age (sex)</th>
<th>Implant system</th>
<th>Implants placed</th>
<th>Surgical technique</th>
<th>Prosthetic loading</th>
<th>Graft materials</th>
<th>Radiographic assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009</td>
<td>Prospective</td>
<td>38.4 (9 F, 3 M)</td>
<td>Straumann TSFE 4–6</td>
<td>164</td>
<td>No graft</td>
<td></td>
<td></td>
<td>CBCT</td>
</tr>
<tr>
<td>2016</td>
<td>RCT</td>
<td>29.7 (20 F, 10 M)</td>
<td>Straumann TSFE 6</td>
<td>88</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>Prospective</td>
<td>64.6 (15 F, 26 M)</td>
<td>Straumann TSFE NR</td>
<td>89</td>
<td>No graft</td>
<td></td>
<td>ABG+β-TCP</td>
<td></td>
</tr>
<tr>
<td>2010</td>
<td>RCT</td>
<td>60 (9 F, 3 M)</td>
<td>Straumann TSFE 6–8</td>
<td>20</td>
<td>No graft</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>RCT</td>
<td>36 (14 F, 14 M)</td>
<td>Osstem TSFE NR</td>
<td>20</td>
<td>No graft</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>RCT</td>
<td>12 (8 F, 4 M)</td>
<td>Straumann TSFE NR</td>
<td>20</td>
<td>No graft</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>RCT</td>
<td>60 (10 F, 26 M)</td>
<td>Straumann TSFE NR</td>
<td>20</td>
<td>No graft</td>
<td></td>
<td>ABG+DBBM</td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>RCT</td>
<td>61 ± 7 (6 F, 5 M)</td>
<td>Straumann TSFE 10</td>
<td>45</td>
<td>No graft</td>
<td></td>
<td>ABG+DBBM+Bio-Oss</td>
<td></td>
</tr>
<tr>
<td>2019</td>
<td>RCT</td>
<td>61 ± 7 (6 F, 5 M)</td>
<td>Straumann TSFE NR</td>
<td>45</td>
<td>No graft</td>
<td></td>
<td>DBBM</td>
<td></td>
</tr>
</tbody>
</table>

**Fig 2** Assessment of the risk of bias and quality (Cochrane scale). Risk of bias summary for randomized studies += low risk of bias, ? = unclear risk of bias, + = high risk of bias.

<table>
<thead>
<tr>
<th>Random sequence generation (selection bias)</th>
<th>Allocation concealment (selection bias)</th>
<th>Blinding of participants and personnel (performance bias)</th>
<th>Blinding of outcome assessment (detection bias)</th>
<th>Incomplete outcome data (attrition bias)</th>
<th>Selective reporting (reporting bias)</th>
<th>Other bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>+</td>
<td>?</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

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**Table 2** Risk of Bias and Quality (Newcastle-Ottawa scale) of Included Studies

<table>
<thead>
<tr>
<th>Study (year)</th>
<th>Selection (4★)</th>
<th>Comparability (2★)</th>
<th>Outcome (3★)</th>
<th>Similarity of follow-up of cohorts</th>
<th>Adequacy of follow-up of cohorts</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Verdugo et al (2017)</td>
<td>★ ★ ★ ★</td>
<td>★ ★ ★</td>
<td>★</td>
<td>★ ★ ★</td>
<td>★ ★ ★</td>
<td>8/9</td>
</tr>
</tbody>
</table>

★ = score of 1; ★★ = score of 0.
<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Without graft</th>
<th>Graft</th>
<th>Weight (%)</th>
<th>Risk ratio M-H, fixed, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Events</td>
<td>Total</td>
<td>Events</td>
<td>Total</td>
</tr>
<tr>
<td>Lai et al(^4) (2010)</td>
<td>187</td>
<td>191</td>
<td>82</td>
<td>89</td>
</tr>
<tr>
<td>Marković et al(^4) (2016)</td>
<td>45</td>
<td>45</td>
<td>135</td>
<td>135</td>
</tr>
<tr>
<td>Nedir et al(^4) (2013)</td>
<td>17</td>
<td>17</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Nedir et al(^4) (2017)</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>20</td>
</tr>
<tr>
<td>Pjetursson et al(^4) (2009)</td>
<td>160</td>
<td>164</td>
<td>86</td>
<td>88</td>
</tr>
<tr>
<td>Qian et al(^3) (2020)</td>
<td>18</td>
<td>19</td>
<td>19</td>
<td>21</td>
</tr>
<tr>
<td>Si et al(^3) (2013)</td>
<td>19</td>
<td>20</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>Trinh et al(^3) (2019)</td>
<td>15</td>
<td>15</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Verdugo et al(^3) (2017)</td>
<td>14</td>
<td>14</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>502</strong></td>
<td><strong>421</strong></td>
<td><strong>100.0</strong></td>
<td><strong>1.03 (1.00, 1.06)</strong></td>
</tr>
</tbody>
</table>

Total events 491 405

Heterogeneity: chi\(^2\) = 6.58, df = 8 (\(P = .58\)); \(I^2 = 0\%\).
Test for overall effect: Z = 1.78 (\(P = .08\)).

**Fig 3** Forest plots of implant survival rate.

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Without graft</th>
<th>Graft</th>
<th>Weight (%)</th>
<th>Standard mean difference IV, fixed, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Total</td>
<td>Mean</td>
</tr>
<tr>
<td>Nedir et al(^4) (2013)</td>
<td>0.6</td>
<td>0.8</td>
<td>17</td>
<td>0.4</td>
</tr>
<tr>
<td>Nedir et al(^4) (2017)</td>
<td>0.6</td>
<td>0.9</td>
<td>17</td>
<td>0.7</td>
</tr>
<tr>
<td>Qian et al(^3) (2020)</td>
<td>1.52</td>
<td>1.08</td>
<td>19</td>
<td>1.67</td>
</tr>
<tr>
<td>Si et al(^3) (2013)</td>
<td>1.38</td>
<td>0.23</td>
<td>20</td>
<td>1.33</td>
</tr>
<tr>
<td>Trinh et al(^3) (2019)</td>
<td>0.9</td>
<td>0.6</td>
<td>14</td>
<td>0.8</td>
</tr>
<tr>
<td>Verdugo et al(^3) (2017)</td>
<td>0.0</td>
<td>0.0</td>
<td>14</td>
<td>0.0</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>87</strong></td>
<td><strong>95</strong></td>
<td><strong>100.0</strong></td>
<td><strong>0.06 (–0.23, 0.35)</strong></td>
</tr>
</tbody>
</table>

Heterogeneity: chi\(^2\) = 1.05, df = 4 (\(P = .90\)); \(I^2 = 0\%\).
Test for overall effect: Z = 0.39 (\(P = .69\)).

**Fig 4** Forest plots of marginal bone loss.

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Without graft</th>
<th>Graft</th>
<th>Weight (%)</th>
<th>Standard mean difference IV, fixed, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Total</td>
<td>Mean</td>
</tr>
<tr>
<td>Nedir et al(^4) (2013)</td>
<td>3.9</td>
<td>1</td>
<td>17</td>
<td>5</td>
</tr>
<tr>
<td>Nedir et al(^4) (2017)</td>
<td>3.8</td>
<td>1</td>
<td>17</td>
<td>4.8</td>
</tr>
<tr>
<td>Pjetursson et al(^4) (2009)</td>
<td>1.7</td>
<td>2</td>
<td>164</td>
<td>4.1</td>
</tr>
<tr>
<td>Qian et al(^3) (2020)</td>
<td>3.14</td>
<td>1.26</td>
<td>19</td>
<td>3.07</td>
</tr>
<tr>
<td>Si et al(^3) (2013)</td>
<td>3.07</td>
<td>1.68</td>
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<tr>
<td>Trinh et al(^3) (2019)</td>
<td>1.6</td>
<td>0.3</td>
<td>15</td>
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<tr>
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<td>6.8</td>
<td>0.5</td>
<td>14</td>
<td>8.5</td>
</tr>
<tr>
<td><strong>Total (95% CI)</strong></td>
<td><strong>266</strong></td>
<td><strong>197</strong></td>
<td><strong>100.0</strong></td>
<td><strong>−0.91 (–1.11, −0.70)</strong></td>
</tr>
</tbody>
</table>

Heterogeneity: \(\tau^2 = 0.64; \chi^2 = 46.43, df = 6 (P < .00001); I^2 = 87\%\).
Test for overall effect: Z = 8.78 (\(P < .00001\)).

**Fig 5** Forest plots of endosinus bone gain.
Fig 6 (Right) Sensitivity analysis of endosinus bone gain.

Fig 7 (Below) Forest plots of endosinus bone gain subgroup.

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>Without graft</th>
<th>Graft</th>
<th>Weight (%)</th>
<th>Standard mean difference IV, random, 95% CI</th>
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<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Total</td>
<td>Mean</td>
</tr>
<tr>
<td>3.2.1 RBH &lt; 4 mm</td>
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<td>1</td>
<td>17</td>
<td>5</td>
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<tr>
<td>Nedir et al43 (2017)</td>
<td>3.8</td>
<td>1</td>
<td>17</td>
<td>4.8</td>
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<tr>
<td>Subtotal (95% CI)</td>
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<td>40</td>
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<tr>
<td>3.2.2 4 mm &lt; RBH &lt; 6 mm</td>
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<tr>
<td>Qian et al39 (2020)</td>
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<td>1.26</td>
<td>19</td>
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<tr>
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<td>20</td>
<td>3.17</td>
</tr>
<tr>
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<td>14</td>
<td>8.5</td>
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<tr>
<td>Subtotal (95% CI)</td>
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<td>55</td>
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<td>3.2.3 RBH &gt; 6 mm</td>
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<tr>
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<tr>
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<tr>
<td>Subtotal (95% CI)</td>
<td>179</td>
<td></td>
<td>102</td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>266</td>
<td></td>
<td>197</td>
<td></td>
</tr>
</tbody>
</table>

great influence on heterogeneity. Therefore, the full texts of Pjetursson et al38 and Trinh et al40 were reread carefully to ensure the correctness of the included data, the research design, and the inclusion criteria. Furthermore, the seven included studies were analyzed according to the RBH, where two studies43,44 had a mean RBH ≤ 4 mm, three studies28,31,45 showed 4 mm < RBH < 6 mm, and two studies38,40 reported RBH ≥ 6 mm (Fig 7). No significant change was observed for heterogeneity. Since no publication bias was detected by Egger test (Fig 8), a random-effects model meta-analysis was performed. The results revealed that there was more ESBG in the graft group than in the group without grafts (SMD = –1.07, 95% CI: –1.73 to –0.41, P < .05; Fig 5b).

**DISCUSSION**

In the present analysis, the clinical results of TSFE with or without grafting materials followed by immediate implant placement do not show a significant difference, which suggests that TSFE with or without grafting cannot achieve a similar survival rate. This result is also in accordance with two previous meta-analyses,46,47 one of which included eight studies of five RCTs and three prospective studies,46 while the other included seven
REFERENCES


ACKNOWLEDGMENTS

The authors have declared that no competing interests exist.

CONCLUSIONS

There are no significant differences in the survival rate and MBL between TSFE with and without grafts, and both types of TSFE provide the expected results. In addition, more ESBG is achieved in the graft group than in the nongraft group. However, due to the presence of some limitations, more studies with higher-quality data, larger samples, and more strictly controlled trials (with multiple centers) are still needed to fully understand the effects of these procedures.

The authors have declared that no competing interests exist.


