Traditionally, a submerged healing period (12 to 25 weeks) was always a requisite to establish the osseointegration of endosseous implants.1 Due to the recent developments in oral implantology, dental implants with better osseointegration and different designs in terms of forms, dimensions, materials, and surface coatings are available.2–4 These developments resulted in enhanced primary implant stability and improved prognosis. Consequently, the restoration protocol for dental implants has been modified from conventional loading to an earlier and even immediate loading, particularly in patients with edentulous mandibles with good bone quality.5 The key benefits of immediate loading include a reduction of surgical interventions and total treatment time; hence, the time span between tooth extraction and insertion of implant-supported restorations may be remarkably decreased.6 Therefore, the immediate loading protocol has been extensively adopted and showed promise in selected cases,7 especially in the anterior maxilla, owing to its esthetic advantages.8–10

The immediate loading protocol can be commonly applied in both postextraction sockets and healed alveolar ridges.11,12 Moreover, the comparison of survival rate and marginal bone stability between healed and fresh extraction sites of immediately loaded implants...
showed comparable results. These findings suggest that the immediate loading protocol may provide predictable and beneficial outcomes in different implant sites.13–16

The concepts of nonocclusal17,18 and progressive loading19,20 of the prostheses have been suggested to decrease the failure risks of immediately loaded single implants. However, in a recent RCT, single implants restored with definitive crowns in direct functional occlusion (within 48 hours) provided promising results of short-term follow-up.21 Another prospective RCT22 compared the immediate nonloaded (nonocclusal) and immediately loaded single-tooth maxillary implants and reported no significant differences between groups in terms of radiographic bone loss and soft tissue esthetics.

For dental implants in the esthetic zone, one of the crucial parameters to assess clinical success is the stability of peri-implant soft and hard tissues. Most recently, additional parameters such as the patient’s perception have been regarded as nonnegligible parameters and are being increasingly considered by clinicians for comprehensive evaluation.23–26

A number of systematic reviews published recently have focused on the impact of different loading protocols on dental implants of various clinical conditions concerning different experiment designs.27–32 It is well-known that the highest level of evidence derives from data of RCTs,33 and unfortunately, relevant systematic reviews involving the esthetic zone are still limited. Therefore, the aim of this study was to identify whether or not immediate loading yields different clinical outcomes from conventional loading of single-tooth implants in the esthetic zone.

MATERIALS AND METHODS

The present study constructed a focused question: “Does immediate loading yield different clinical outcomes from conventional loading of single-tooth implants in the esthetic zone?”; this followed the guidelines described by Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA).34

Selection Criteria

The following criteria were implemented: (1) RCTs; (2) number of patients/implants: ≥ 10/group; (3) follow-up duration: ≥ 12 months; (4) implants definitively restored with fixed prostheses; (5) immediate loading in the test group should be within 24 hours following implant placement; (6) studies reporting the use of identical implant system for both groups; (7) studies reporting specified implant survival data; and (8) providing quantitative data for assessing changes of marginal bone and soft tissues (mean ± standard deviation [SD]).

Search Strategy

Two investigators (Q.C., Y.-Y.S.) conducted an electronic search using databases (MEDLINE/PubMed, Cochrane [CENTRAL] and Embase) for articles published in the English language from January 2000 to April 2018 (Table 1). A manual search of the references of relevant literature was conducted as well.
Study Selection and Data Extraction
Two investigators (Q.C., Y.-Y.S.) screened the searched articles’ titles and abstracts independently. Following the initial screening, full texts of all studies satisfying the inclusion criteria were retrieved for further independent assessment by the same two reviewers. Disagreement (if any) between the reviewers was solved through further discussion. The following information was extracted from included studies: (1) publication year; (2) author(s); (3) number of patients included/dropouts; (4) patient demographic data; (5) number of implants; (6) follow-up period; (7) implant sites (healed or fresh extraction sites); (8) type of incision (flap or flapless); (9) insertion torque; (10) bone grafting; (11) occlusal contact of immediate loading group; (12) time of definitive crown insertion; (13) antibiotic prophylaxis; (14) implant system; (15) implant survival rate; and (16) level changes in the marginal bone and soft tissues.

Quality Assessment
Two investigators (Q.C., X.W.) evaluated the quality of the RCTs following the bias risk assessment recommendations provided by the Cochrane Handbook for Systematic Reviews of Interventions. Disagreement (if any) between the reviewers was solved through further discussion.

Statistical Analysis
Meta-analysis was carried out if a minimum of two studies reported similar findings with adequate uniformity. For dichotomous outcomes (implant survival), the assessment of relative effect was expressed in risk ratio (RR) and 95% confidence interval (CI); for continuous outcomes (marginal bone loss and soft tissue level changes), the estimate of relative effect was expressed in mean difference (MD) and 95% CI. The statistical unit was the implant, and the chi-squared test for heterogeneity was performed. If noteworthy heterogeneity was found, the significance of intervention outcomes was assessed by a random-effect model. In cases of no evident heterogeneity, a fixed-effect model was applied for the analysis. The meta-analysis was conducted using the Review Manager statistical software (v5.3.5, The Nordic Cochrane Centre).

RESULTS
The electronic search found a total of 505 articles (Fig 1). After initial screening of the titles/abstracts, only 19 articles were considered for further evaluation. In addition, three articles extracted from the reference lists of relevant literature were retrieved for full-text screening. Out of 22 publications, seven articles were finally included in the present review.

Characteristics of the Included Studies
A total of 386 single-tooth implants (189 implants immediately loaded, and 197 conventionally loaded) were placed (Table 2). All RCTs were parallel designed, and only one multicenter study adopted both parallel and split-mouth designs. One trial included patients only with a missing single maxillary lateral incisor, and patients enrolled in the other studies required single-tooth rehabilitation from premolar to premolar. Sample-size calculation was performed in four studies, and the homogeneity of the study population was stated in two reports. Three RCTs assessed implants placed in fresh extraction sites, two without bone wall dehiscence or fenestration, and one with the vertical buccal bone defect (< 5 mm). The quality assessment showed that the majority of included RCTs had a low to moderate risk of bias (Table 3).

Main Outcomes of the Study

Implant Survival.
All articles reported implant survival. The overall survival rate at the 1-year follow-up remained 97.9% (184/188) for immediately loaded implants, and 99.0% (190/192) for conventionally loaded implants (Table 4). According to the meta-analysis, no significant differences were observed between groups with RR of 0.99 (95% CI: 0.95 to 1.02), and no evident heterogeneity was found (Fig 2). Two studies reported no implant failure throughout the follow-up duration.

Marginal Bone Loss. All RCTs reported the overall marginal bone loss and/or changes restricted to mesial/distal sites (Table 5). Data of four and two studies with the comparative baseline were pooled for meta-analysis at the 1-year and 2-year follow-ups, respectively. The weighted mean differences were 0.03 mm (95% CI: −0.09 to 0.15 mm) for the 1-year comparison and −0.01 mm (95% CI: −0.16 to 0.15 mm) for the
### Table 2  Characteristics of Included Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>No. of patients</th>
<th>No. of patient dropouts</th>
<th>Mean age (range) (y)</th>
<th>No. of implants</th>
<th>No. of implant dropouts</th>
<th>Follow-up (mo)</th>
<th>Implant sites (healed or fresh extraction sites)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hall et al(^36)</td>
<td>2007</td>
<td>14</td>
<td>1</td>
<td>2</td>
<td>43.25 (23–71)</td>
<td>14</td>
<td>14</td>
<td>HS</td>
</tr>
<tr>
<td>Crespi et al(^37)</td>
<td>2008</td>
<td>20</td>
<td>0</td>
<td>0</td>
<td>47.21 (24–68)</td>
<td>20</td>
<td>20</td>
<td>FES</td>
</tr>
<tr>
<td>Donati et al(^38)</td>
<td>2008</td>
<td>NR</td>
<td>NR</td>
<td>NR</td>
<td>Male: 46.7 ± 18.3 Female: 44.2 ± 12.9</td>
<td>50</td>
<td>57</td>
<td>12</td>
</tr>
<tr>
<td>Degidi et al(^40)</td>
<td>2009</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>31.5 ± 11.8 (18–55)</td>
<td>30</td>
<td>30</td>
<td>36</td>
</tr>
<tr>
<td>De Rouck et al(^39)</td>
<td>2009</td>
<td>24</td>
<td>0</td>
<td>0</td>
<td>IL: 55 ± 13     CL: 52 ± 12</td>
<td>24</td>
<td>25</td>
<td>12</td>
</tr>
<tr>
<td>den Hartog et al(^41)</td>
<td>2011</td>
<td>31</td>
<td>0</td>
<td>0</td>
<td>IL: 38.4 ± 14.0 (18–66) CL: 40.1 ± 14.4 (18–67)</td>
<td>31</td>
<td>31</td>
<td>18</td>
</tr>
<tr>
<td>Slagter et al(^42)</td>
<td>2015</td>
<td>20</td>
<td>0</td>
<td>1</td>
<td>IL: 39.4 ± 16.9 (19–70) CL: 42.3 ± 14.2 (23–66)</td>
<td>20</td>
<td>20</td>
<td>12</td>
</tr>
</tbody>
</table>

IL = immediate loading; CL = conventional loading; NR = not reported.

### Table 3  Bias and Quality Assessment of Included RCTs

<table>
<thead>
<tr>
<th>RCT</th>
<th>Random sequence generation</th>
<th>Allocation concealment</th>
<th>Blinding of outcome assessment</th>
<th>Incomplete outcome data addressed</th>
<th>Free of selective reporting</th>
<th>Free of other bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hall et al(^36)</td>
<td>Y</td>
<td>U</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Crespi et al(^37)</td>
<td>U</td>
<td>U</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>U</td>
</tr>
<tr>
<td>Donati et al(^38)</td>
<td>Y</td>
<td>U</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>U</td>
</tr>
<tr>
<td>De Rouck et al(^39)</td>
<td>Y</td>
<td>N</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>U</td>
</tr>
<tr>
<td>Degidi et al(^40)</td>
<td>Y</td>
<td>Y</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>U</td>
</tr>
<tr>
<td>den Hartog et al(^41)</td>
<td>Y</td>
<td>Y</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>U</td>
</tr>
<tr>
<td>Slagter et al(^42)</td>
<td>Y</td>
<td>U</td>
<td>U</td>
<td>Y</td>
<td>Y</td>
<td>U</td>
</tr>
</tbody>
</table>

Y = yes (bias risk is low); U = unclear (bias risk is unclear); N = no (bias risk is high).
<table>
<thead>
<tr>
<th>Study</th>
<th>No. of implants available for analysis</th>
<th>No. of implant failures</th>
<th>Implant survival rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IL CL</td>
<td>IL CL</td>
<td>IL CL</td>
</tr>
<tr>
<td>Hall et al&lt;sup&gt;36&lt;/sup&gt;</td>
<td>13 12</td>
<td>1 0</td>
<td>92 100</td>
</tr>
<tr>
<td>Crespi et al&lt;sup&gt;37&lt;/sup&gt;</td>
<td>20 20</td>
<td>0 0</td>
<td>100 100</td>
</tr>
<tr>
<td>Donati et al&lt;sup&gt;38&lt;/sup&gt;</td>
<td>50 55</td>
<td>1 0</td>
<td>98 100</td>
</tr>
<tr>
<td>Degidi et al&lt;sup&gt;40&lt;/sup&gt;</td>
<td>30 30</td>
<td>0 0</td>
<td>100 100</td>
</tr>
<tr>
<td>De Rouck et al&lt;sup&gt;39&lt;/sup&gt;</td>
<td>24 25</td>
<td>1 2</td>
<td>96 92</td>
</tr>
<tr>
<td>den Hartog et al&lt;sup&gt;41&lt;/sup&gt;</td>
<td>31 31</td>
<td>1 0</td>
<td>97 100</td>
</tr>
<tr>
<td>Slagter et al&lt;sup&gt;42&lt;/sup&gt;</td>
<td>20 19</td>
<td>0 0</td>
<td>100 100</td>
</tr>
</tbody>
</table>

IL = immediate loading; CL = conventional loading.
In addition, there were no significant differences between the two protocols for both of the comparisons (Fig 3).

**Soft Tissue Level Changes.** The results with divergent baselines of soft tissue level changes are presented in Table 6. One study reported the gain of midfacial mucosa for the immediate loading group and papilla height for both groups. Two studies evaluated papilla recession and midfacial recession from preoperative status to the 1-year follow-up. Due to the heterogeneity of these studies, the present study used a random-effects model. The meta-analysis regarding papilla recession revealed no significant differences between the two loading protocols in both mesial and distal sites (Fig 4). Similarly, in terms of midfacial recession, there was no significant difference between immediate and conventional loading protocols (Fig 5). Only two studies provided information about changes of the width of keratinized mucosa.

**Esthetic Outcomes.** Only two studies assessed esthetic outcomes, with one focusing on healed sites, and the other concerning fresh extraction sites. Both studies used the Implant Crown Aesthetic Index (ICAI) and the Pink Esthetic Score-White Esthetic Score (PES-WES), and reported no statistical differences between immediate and conventional loading groups (Table 7).

**Patient Satisfaction.** Three studies estimated the patients’ satisfaction. One trial utilized the 10-cm

<table>
<thead>
<tr>
<th>Study or subgroup</th>
<th>IL</th>
<th>CL</th>
<th>Weight (%)</th>
<th>Risk ratio M-H, Fixed, 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hall et al, 2007</td>
<td>12 13 12 12 6.8</td>
<td>0.93 [0.75, 1.15]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Crespi et al, 2008</td>
<td>20 20 20 20 10.7</td>
<td>1.00 [0.91, 1.10]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Donati et al, 2008</td>
<td>49 50 55 55 27.7</td>
<td>0.98 [0.93, 1.03]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Degidi et al, 2009</td>
<td>30 30 30 30 16.0</td>
<td>1.00 [0.94, 1.07]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>De Rouck et al, 2009</td>
<td>23 24 23 25 11.8</td>
<td>1.04 [0.90, 1.20]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>den Hartog et al, 2011</td>
<td>30 31 31 31 16.5</td>
<td>0.97 [0.89, 1.06]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Slagter et al, 2015</td>
<td>20 20 19 19 10.5</td>
<td>1.00 [0.91, 1.10]</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (95% CI)</td>
<td>188 192 100.0 100.0 0.99 [0.95, 1.02]</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Heterogeneity: Chi² = 1.42, df = 6 (P = .96); I² = 0%
Test for overall effect: Z = 0.61 (P = .54)

**Fig 2** Forest plot for implant survival comparing immediate loading (IL) and conventional loading (CL) at 1-year follow-up.

### Table 5 Marginal Bone Loss Reported by Included Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>1 y (mean ± SD) (mm)</th>
<th>2 y (mean ± SD) (mm)</th>
<th>3 y (mean ± SD) (mm)</th>
<th>Follow-up baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hall et al</td>
<td>0.63 ± 1.00</td>
<td>0.78 ± 1.01</td>
<td></td>
<td>Definitive crown placement</td>
</tr>
<tr>
<td>Crespi et al</td>
<td>Mean: 0.32 ± 0.87</td>
<td>Mean: 0.38 ± 0.89</td>
<td></td>
<td>Implant placement</td>
</tr>
<tr>
<td>Donati et al</td>
<td>Mean: 0.32 ± 0.87</td>
<td>Mean: 0.33 ± 0.89</td>
<td></td>
<td>Implant placement</td>
</tr>
<tr>
<td>Degidi et al</td>
<td>0.69 ± 0.38</td>
<td>0.58 ± 0.28</td>
<td>0.73 ± 0.40</td>
<td>0.70 ± 0.29</td>
</tr>
<tr>
<td>De Rouck et al</td>
<td>Mean: 0.86 ± 0.54</td>
<td>Mean: 0.97 ± 0.35</td>
<td></td>
<td>Provisional crown placement</td>
</tr>
<tr>
<td>den Hartog et al</td>
<td>Mean: 0.91 ± 0.61</td>
<td>Mean: 0.90 ± 0.57</td>
<td></td>
<td>Implant placement</td>
</tr>
<tr>
<td>Slagter et al</td>
<td>Mesial: 0.75 ± 0.69</td>
<td>Distal: 0.68 ± 0.65</td>
<td></td>
<td>Definitive crown placement</td>
</tr>
</tbody>
</table>

**IL = immediate loading; CL = conventional loading.**
Cheng et al

Study or subgroup | IL Mean | SD | Total | CL Mean | SD | Total | Weight (%) | Mean difference | IV, Fixed, 95% CI
--- | --- | --- | --- | --- | --- | --- | --- | --- | ---
1.1.1 1 year
Donati et al, 2008 | 0.32 | 0.87 | 49 | 0.38 | 0.89 | 55 | 12.5 | −0.06 [−0.40, 0.28]
Degidi et al, 2009 | 0.69 | 0.38 | 30 | 0.58 | 0.28 | 30 | 50.4 | 0.11 [−0.06, 0.28]
De Rouck et al, 2009 | 0.86 | 0.54 | 23 | 0.97 | 0.35 | 23 | 20.8 | −0.11 [−0.37, 0.15]
den Hartog et al, 2011 | 0.91 | 0.61 | 30 | 0.9 | 0.57 | 31 | 16.3 | 0.01 [−0.29, 0.31]
Subtotal (95% CI) | 132 | 139 | 100.0 | 0.03 [−0.09, 0.15]
Heterogeneity: Chi² = 2.24, df = 3 (P = .52); I² = 0%
Test for overall effect: Z = 0.44 (P = .66)

1.1.2 2 years
Crespi et al, 2008 | 1.02 | 0.53 | 20 | 1.16 | 0.51 | 20 | 23.1 | −0.14 [−0.46, 0.18]
Degidi et al, 2009 | 0.73 | 0.4 | 30 | 0.7 | 0.29 | 30 | 76.9 | 0.03 [−0.15, 0.21]
Subtotal (95% CI) | 50 | 50 | 100.0 | −0.01 [−0.16, 0.15]
Heterogeneity: Chi² = 0.82, df = 1 (P = .36); I² = 0%
Test for overall effect: Z = 0.12 (P = .91)
Test for subgroup differences: Chi² = 0.13, df = 1 (P = .72); I² = 0%

Fig 3 Forest plot for marginal bone loss comparing immediate loading (IL) and conventional loading (CL) at 1- and 2-year follow-up.

Study or subgroup | IL Mean | SD | Total | CL Mean | SD | Total | Weight (%) | Mean difference | IV, Random, 95% CI
--- | --- | --- | --- | --- | --- | --- | --- | --- | ---
1.1.1 mesial
De Rouck et al, 2009 | 0.44 | 0.77 | 23 | 0.43 | 0.42 | 23 | 47.9 | 0.01 [−0.35, 0.37]
Slagter et al, 2015 | 0.89 | 0.46 | 20 | 0.32 | 0.43 | 19 | 52.1 | 0.57 [0.29, 0.85]
Subtotal (95% CI) | 43 | 42 | 100.0 | 0.30 [−0.25, 0.85]
Heterogeneity: Tau² = 0.13; Chi² = 5.83, df = 1 (P = .02); I² = 83%
Test for overall effect: Z = 1.08 (P = .28)

1.1.2 distal
De Rouck et al, 2009 | 0.31 | 0.81 | 23 | 0.53 | 0.55 | 23 | 49.5 | −0.22 [−0.62, 0.18]
Slagter et al, 2015 | 1 | 0.58 | 20 | 0.79 | 0.66 | 19 | 50.5 | 0.21 [−0.18, 0.60]
Subtotal (95% CI) | 43 | 42 | 100.0 | −0.00 [−0.42, 0.42]
Heterogeneity: Tau² = 0.05; Chi² = 2.27, df = 1 (P = .13); I² = 56%
Test for overall effect: Z = 0.01 (P = .99)
Test for subgroup differences: Chi² = 0.74, df = 1 (P = .39); I² = 0%

Fig 4 Forest plot for papilla recession in mesial and distal sites comparing immediate loading (IL) and conventional loading (CL) at 1-year follow-ups.

Study or subgroup | IL Mean | SD | Total | CL Mean | SD | Total | Weight (%) | Mean difference | IV, Random, 95% CI
--- | --- | --- | --- | --- | --- | --- | --- | --- | ---
De Rouck et al, 2009 | 0.41 | 0.75 | 23 | 1.16 | 0.66 | 23 | 51.0 | −0.75 [−1.16, −0.34]
Slagter et al, 2015 | 0.95 | 0.62 | 20 | 0.85 | 0.86 | 19 | 49.0 | 0.10 [−0.37, 0.57]
Total (95% CI) | 43 | 42 | 100.0 | −0.33 [−1.17, 0.50]
Heterogeneity: Tau² = 0.31; Chi² = 7.12, df = 1 (P = .008); I² = 86%
Test for overall effect: Z = 0.79 (P = .43)

Fig 5 Forest plot for midfacial recession comparing immediate loading (IL) and conventional loading (CL) at 1-year follow-up.
Cheng et al

visual analog scale (VAS) to assess the patients’ esthetic satisfaction, and found insignificant differences between the immediate loading group (mean: 93%) and conventional loading group (mean: 91%). In another RCT,41 a self-administered questionnaire with a five-point rating scale and a 100-mm VAS were used. The study reported a high level of patient satisfaction in both groups without any obvious differences. The third trial42 used a 100-mm VAS and the Oral Health Impact Profile (OHIP)-14 questionnaire.45 The VAS scores were 8.2 ± 0.9 and 9.1 ± 0.8 for the immediate and conventional loading group, respectively (P < .002), whereas insignificant differences were detected between groups regarding the OHIP-14.

**DISCUSSION**

The present review exclusively analyzed RCTs comparing immediate and conventional loading of single-tooth implants in the esthetic zone for a minimum follow-up period of 1 year. When assessing the implants’ survival rate and changes in the levels of surrounding soft and hard tissues, the meta-analyses suggest that immediate and conventional loading protocols are equally beneficial for clinical success during short-term follow-up. Undoubtedly, long-term follow-up data can provide more compelling evidence, and a longer follow-up period is required to validate the present findings.

Considering the benefits of shortened treatment time and meeting patients’ expectations, the immediate loading protocol has been extensively performed in various clinical conditions. Although the immediate loading of single-tooth implants and full-arch restorations showed comparable survival rates, single-tooth implants were thought to have a higher risk of failure.32 For implant sites, loading protocols (immediate or conventional) were supposed to be irrelevant for clinical success concerning the implant survival or stability of marginal bone in fresh extraction or healed sites.46

Previously, it was deemed that implant placement into fresh extraction sites would intervene in bone remodeling and therefore likely maintain the original dimension of the alveolar ridge.47 Later, a review48 recommended that clinicians should be conservative while planning immediate implant insertion and provisionization to restore a single tooth in the maxillary anterior segment, since postoperative bone remodeling and marginal gingival change would proceed

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**Table 6**  
Soft Tissue Level Changes Reported by Included Studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Papilla recession (mm ± SD)</th>
<th>Midfacial recession (mm ± SD)</th>
<th>Width of keratinized mucosa (mm ± SD)</th>
<th>Follow-up status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hall et al36</td>
<td>Mesial: 0.67 ± 0.49</td>
<td>Mesial: 0.33 ± 0.78</td>
<td>Mesial: 0.67 ± 0.49</td>
<td>4 weeks</td>
</tr>
<tr>
<td></td>
<td>Distal: 0.67 ± 0.49</td>
<td>Distal: 0.33 ± 0.78</td>
<td>Distal: 0.67 ± 0.49</td>
<td>after</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>definitive</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>crown</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>placement</td>
</tr>
<tr>
<td>Donati et al39</td>
<td>Mesial: 0.44 ± 1.20</td>
<td>Mesial: 0.31 ± 0.81</td>
<td>Mesial: 0.44 ± 1.20</td>
<td>Provisional</td>
</tr>
<tr>
<td></td>
<td>Distal: 0.44 ± 1.20</td>
<td>Distal: 0.31 ± 0.81</td>
<td>Distal: 0.44 ± 1.20</td>
<td>crown placement</td>
</tr>
<tr>
<td>De Rouck et al40</td>
<td>Mesial: 0.41 ± 0.49</td>
<td>Mesial: 0.32 ± 0.43</td>
<td>Mesial: 0.41 ± 0.49</td>
<td>Preoperative</td>
</tr>
<tr>
<td></td>
<td>Distal: 0.41 ± 0.49</td>
<td>Distal: 0.32 ± 0.43</td>
<td>Distal: 0.41 ± 0.49</td>
<td>status</td>
</tr>
<tr>
<td>den Hartog et al41</td>
<td>Mean: –0.34 ± 0.49</td>
<td>Mean: –0.27 ± 0.42</td>
<td>Mean: –0.34 ± 0.49</td>
<td>Definitive</td>
</tr>
<tr>
<td></td>
<td>Mesial: –0.34 ± 0.49</td>
<td>Distal: –0.27 ± 0.42</td>
<td>Mesial: –0.34 ± 0.49</td>
<td>crown</td>
</tr>
<tr>
<td></td>
<td>Mesial: –0.41 ± 0.49</td>
<td>Distal: –0.35 ± 0.52</td>
<td>Mesial: –0.41 ± 0.49</td>
<td>placement</td>
</tr>
<tr>
<td></td>
<td>Distal: –0.41 ± 0.49</td>
<td>Distal: –0.35 ± 0.52</td>
<td>Distal: –0.41 ± 0.49</td>
<td></td>
</tr>
<tr>
<td>Slagter et al42</td>
<td>Mesial: 0.89 ± 0.46</td>
<td>Mesial: 0.32 ± 0.43</td>
<td>Mesial: 0.89 ± 0.46</td>
<td>Preoperative</td>
</tr>
<tr>
<td></td>
<td>Distal: 1.00 ± 0.58</td>
<td>Distal: 0.79 ± 0.66</td>
<td>Distal: 1.00 ± 0.58</td>
<td>status</td>
</tr>
</tbody>
</table>

IL = immediate loading; CL = conventional loading. Negative values mean gain of the mucosa level.

**Table 7**  
Evaluation of Esthetic Characteristics

<table>
<thead>
<tr>
<th>Study</th>
<th>PES (mean ± SD)</th>
<th>WES (mean ± SD)</th>
<th>ICAI (mean ± SD)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>den Hartog et al41</td>
<td>7.1 ± 1.5</td>
<td>7.8 ± 1.5</td>
<td>7.8 ± 1.5</td>
<td>&gt; .05</td>
</tr>
<tr>
<td></td>
<td>6.5 ± 1.63</td>
<td>7.6 ± 1.6</td>
<td>7.6 ± 1.6</td>
<td>&gt; .05</td>
</tr>
<tr>
<td></td>
<td>7.40 ± 1.46</td>
<td>7.90 ± 1.08</td>
<td>7.90 ± 1.08</td>
<td>&gt; .05</td>
</tr>
<tr>
<td></td>
<td>.79</td>
<td>.79</td>
<td>.79</td>
<td></td>
</tr>
<tr>
<td>Slagter et al42</td>
<td>7.50 ± 1.59</td>
<td>8.10 ± 0.90</td>
<td>4.2 ± 2.38</td>
<td>&gt; .05</td>
</tr>
<tr>
<td></td>
<td>7.40 ± 1.46</td>
<td>7.90 ± 1.08</td>
<td>5.2 ± 4.10</td>
<td>&gt; .05</td>
</tr>
<tr>
<td></td>
<td>.79</td>
<td>.79</td>
<td>.79</td>
<td></td>
</tr>
</tbody>
</table>

IL = immediate loading; CL = conventional loading; NR = not reported.

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regardless of implant placement timing. In contrast, another review\(^9\) reported that immediate loading or restoration of single-tooth implants in the anterior region did not interfere with the stability of peri-implant soft and hard tissues compared with the conventional approach, and these findings are in agreement with the present study.

It is commonly believed that implant stability is a prerequisite for successful osseointegration and a promising clinical outcome of immediately loaded implants.\(^7\) In addition, considering implant survival rate and the stability of marginal bone, the conventionally and immediately loaded single implants were similarly successful when inserted with an adequate torque (\(\geq 20\) to \(45\) Ncm) and implant stability quotient (\(\geq 60\) to \(65\)).\(^6\) In the present review, the insertion torque mentioned in the included studies was between the aforementioned range, although two studies\(^56,42\) did not report the specific values. In a previous study,\(^50\) nonocclusal provisional crowns were delivered immediately after implant insertion in the range of \(25\) to \(35\) Ncm or higher than \(80\) Ncm. The assessment of marginal bone loss and associated complications showed no significant differences between immediate and conventional loading groups. However, in order to attain a high survival rate of immediately loaded single implants, the authors believed that the medium insertion torque (\(25\) to \(35\) Ncm) was not enough.\(^50\)

Traditionally, implant surgery involves the exposure of the alveolar ridge using a full-thickness mucoperiosteal flap to prepare the site for implant positioning.\(^1,51\) The flapless approach was considered advantageous in the esthetic zone, since it avoids compromise of the vascular supply of peri-implant tissues.\(^32\) In the present review, two RCTs\(^37,42\) adopted the flapless approach, while the other studies used the traditional approach. A recent systematic review\(^53\) suggested that the flap design should be chosen for patients’ comfort, need for access and bone augmentation, and experience level of the surgeon. Encouragingly, with the help of a computer-guided implant technique, implants probably can be placed more accurately with reduced risk of associated complications.\(^54\)

There is a continuous debate concerning whether dental implants’ immediate loading should be occlusal or nonocclusal. A recent meta-analysis suggested that neither the occlusal nor nonocclusal implant loading is associated with clinical outcomes regarding marginal bone loss and survival rate.\(^55\) In the present review, only two RCTs\(^37,38\) reported using provisional crowns of immediately loaded implants in centric occlusion. For all other RCTs, provisional crowns were adjusted (nonocclusal) to avoid any centric or lateral excursion occlusal interferences. The aim of obliterating all the occlusal contacts was to ensure undisturbed healing; however, the pressure coming from surrounding soft tissues (tongue and perioral musculature) cannot be neglected.\(^55\) The absence of excessive interfacial micromotion was thought to be vital for osseointegration.\(^56\) Szmukler-Moncler et al indicated that the tolerable micromotion threshold ranged between \(50\) and \(150\) microns.\(^57\) Moreover, Brunski et al believed that the micromovement of more than \(100\) \(\mu\)m was sufficient to jeopardize the osseointegration with the formation of fibrous encapsulation.\(^58\)

Immediate loading of dental implants plays a vital role in maintaining the structural integrity of peri-implant soft tissues with the provisional prosthetic restoration during the healing process.\(^59\) The included RCTs\(^60,36,38,39,41,42\) reported gingival recession and soft tissue changes within the range of clinically acceptable level. Surprisingly, one RCT\(^41\) reported the gain of the mucosa. The promising outcome was supposedly attributed to the bone augmentation procedure before implant placement and comparatively less bone loss near the adjacent teeth. The interproximal bone level of adjacent teeth is directly related to the status of the implant’s interproximal papillae.\(^60–62\) Therefore, the bone level of adjacent teeth should also be considered as a critical factor to predict the esthetic outcomes.\(^41\) The RCTs included in this review failed to offer unified reference time points; hence, limited data were pooled for conducting the meta-analysis of soft tissue changes.

Although a number of outcome measures have been used in dental implant research, there is a lack of standardized assessment methods for dentate subjects.\(^63–65\) Vihljálmsson et al found that the modified Implant Crown Aesthetic Index (mod-ICAI) delivered an effective combination of objective and subjective evaluation to assess the esthetic components of implant-retained crowns.\(^66\) On the other hand, Tettamanti et al concluded that the PES-WES and Peri-Implant-Crown Index were preferable to assess the single implant crowns compared with the ICAI, due to reproducibility considerations.\(^67\) In a recent systematic review,\(^68\) the PES and the Papilla Index were related to the patients’ responses about peri-implant soft tissues, whereas the ICAI and mod-ICAI showed an association to soft tissue and crown satisfaction. In the authors’ opinion, there was a need to develop a comprehensive and practical index to estimate esthetic components of single-tooth implant restorations in the anterior maxilla.\(^68\)

The results of the present review should be interpreted carefully, as both the amount of currently available RCTs and the quantitative data extracted from the original articles are relatively limited. Rigorous experimental design and blind method can help to reduce risk of bias and ensure the credibility of the study.
CONCLUSIONS

A short-term follow-up of single-tooth implants in the aesthetic zone showed that the loading protocols (conventional or immediate loading) are not likely to influence clinical outcomes, regarding implant survival rate and the stability of peri-implant soft and hard tissues. More RCTs comprising larger sample sizes and with a longer follow-up period are required to validate these findings.

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