Loading Protocols for Single-Implant Crowns: A Systematic Review and Meta-Analysis

Goran I. Benic, Dr Med Dent[1]/Javier Mir-Mari, DDS[2]/Christoph H.F. Hämmerle, Prof Dr Med Dent[3]

Purpose: *To test whether or not immediate loading of single-implant crowns renders different results from early and conventional loading with respect to implant survival, marginal bone loss, stability of peri-implant soft tissue, esthetics, and patient satisfaction.* ***Materials and Methods:*** *An electronic search of Medline and Embase databases including studies published prior to August 1, 2012, was performed and complemented by a manual search. Randomized controlled trials (RCTs) comparing different loading protocols of single-implant crowns with a follow-up after restoration of at least 1 year were included. A meta-analysis yielded odds ratios (OR) and standardized mean differences (SMD) together with the corresponding 95% confidence intervals (95% CI).* ***Results:*** *The search provided 10 RCTs comparing immediate and conventional loading and 1 RCT comparing immediate and early loading. When assessing the implant survival at 1 year of loading, the meta-analysis of 10 studies found no significant differences between immediate and conventional loading (OR = 0.75; 95% CI: 0.32 to 1.76). The total difference of marginal bone loss during the first year of function between immediate and conventional loading protocols in 7 RCTs did not reach statistical significance (SMD = –0.05 mm; 95% CI: –0.41 to 0.31 mm). There were no significant differences between immediate and conventional loading regarding implant survival and marginal bone loss at 2, 3, and 5 years of loading. Three RCTs comparing the change of papilla level between immediate and conventional loading identified no significant differences. One study investigated the recession of the buccal mucosa after implant placement and found significantly inferior soft tissue loss for immediate loading as compared to conventional loading. Two RCTs investigated the recession of the buccal mucosa after insertion of the definitive crown and found no differences between immediate and conventional loading. The esthetics and the patient satisfaction were assessed in one and two RCTs, respectively. There were no significant differences between immediate and conventional loading.* ***Conclusions:*** *Immediately and conventionally loaded single-implant crowns are equally successful regarding implant survival and marginal bone loss. This conclusion is primarily derived from studies evaluating implants inserted with a torque ≥ 20 to 45 Ncm or an implant stability quotient (ISQ) ≥ 60 to 65 and with no need for simultaneous bone augmentation. Immediately and conventionally loaded implants do not appear to differently affect the papilla height during the first year of loading. Due to the heterogeneity of the time point of baseline measurements and contradictory findings in the studies, it is difficult to draw clear conclusions regarding the recession of the buccal mucosa. With respect to the assessment of esthetic outcomes and patient satisfaction, the data available remain inconclusive.* Int J Oral Maxillofac Implants 2014;29(Suppl):222–238. doi: 10.11607/jomi.2014suppl.g4.1

Key words: *bone, crowns, dental implants, early, esthetics, function, immediate, loading, meta-analysis, papilla, restoration, satisfaction, soft tissue, survival, systematic review*

Dental implants supporting single crowns represent a well-documented therapy for the restoration of single tooth gaps showing high long-term survival rates.[1] Despite varying rates of technical, biologic, and

[1]Assistant Professor, Clinic of Fixed and Removable Prosthodontics and Dental Material Science, Center of Dental Medicine, University of Zurich, Switzerland
[2]International Team of Implantology Scholar, Clinic of Fixed and Removable Prosthodontics and Dental Material Science, Center of Dental Medicine, University of Zurich, Switzerland
[3]Professor and Chairman, Clinic of Fixed and Removable Prosthodontics and Dental Material Science, Center of Dental Medicine, University of Zurich, Switzerland

Correspondence to: Dr Goran I. Benic, Clinic of Fixed and Removable Prosthodontics and Dental Material Science, Center of Dental Medicine, University of Zurich, Plattenstrasse 11, CH-8032 Zurich, Switzerland.
Fax: +41 44 634 43 05.
Email: goran.benic@zzm.uzh.ch

esthetic complications, this treatment modality can be considered a safe and predictable therapeutic option.[1]

Traditional clinical guidelines recommended the placement of implants in healed sites, followed by 3 to 6 months of submucosal healing prior to functional loading.[2] Subsequently, new clinical protocols have been applied, aiming at shortening the overall treatment duration and reducing the number of surgical interventions. These protocols were characterized by decreased time spans between tooth removal, implant placement, and delivery of the implant-supported prosthesis.

Several clinical studies showed similar short-term survival rates of single implants either loaded conventionally, early, or immediately after implant placement.[3–9] These favorable results have been reported for single implants placed in anterior and posterior regions of the jaw.

In addition to implant and crown survival rates, stability of the peri-implant bone and soft tissues are important factors for determining the clinical success of dental implant treatment. Several controlled clinical studies investigating marginal bone loss at single implants did not reveal significant differences among implants that were loaded at different time points following the implant placement.[3,4,10,11]

With respect to the facial soft tissue levels, heterogeneous results were found between studies comparing different loading protocols. One study found immediate loading of implants inserted into fresh extraction sockets, leading to more favorable levels of facial soft tissue compared with delayed loading.[10] On the other hand, studies investigating single tooth implants inserted into healed sites described similar soft tissue levels for conventionally and immediately loaded implants.[3,12]

Besides functional and health-related aspects, the visual appearance of the reconstruction becomes an important factor for clinical success in esthetic sites. It has recently been stated that the scientific literature regarding esthetic outcomes in implant dentistry remains inconclusive.[13,14] This statement was formulated because of the lack of studies using objective and well-defined parameters for the assessment of esthetics.

Furthermore, it is currently widely accepted that clinical measures provide limited understanding regarding patients' perceptions. Therefore, a standardized use of validated patient-reported outcome measures (eg, patient satisfaction) was recommended for clinical research to understand the benefit of a treatment with implants from the patients' perspectives.[15,16]

The highest level of evidence for answering clinical questions derives from systematic reviews analyzing the results of randomized controlled clinical trials (RCTs).[17] The aim of the present systematic review was, therefore, to test whether or not the immediate loading of single-implant crowns render different clinical results from early and conventional loading with respect to implant survival rate, marginal bone loss, stability of peri-implant soft tissue, esthetics, and patient satisfaction.

MATERIALS AND METHODS

This systematic review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) guidelines.[18]

Focus Question

The following focus question was developed according to the PICO (population, intervention, comparison, outcome) format for this review: Does immediate loading of single-implant crowns render different results from early and conventional loading with respect to implant survival rate, marginal bone loss, stability of peri-implant soft tissue, esthetics, and patient satisfaction?

Search Strategy

An electronic search of Medline (PubMed) and Embase databases was performed including studies published prior to August 1 2012. The search was limited to publications with abstract (text options), published in English, French, and German (language). The search strategy is summarized in Table 1.

The electronic search was complemented by a manual search of reference lists of the reviews published from January 1, 2009, to July 31, 2012. Additionally, the bibliographies of the reviews on loading protocols from the 4th ITI Consensus Conference (2008) were screened.

Selection of Studies

The criteria for inclusion and exclusion of studies are specified in Table 1.

Two investigators independently performed the literature search including selection of titles, abstracts, and full-text publications. Any disagreement regarding inclusion was resolved by a discussion between the two investigators. All titles obtained by the search were screened for meeting the selection criteria. If the title did not contain sufficient information for exclusion, it was selected for the abstract evaluation. Subsequently, the abstracts of all potentially relevant titles were reviewed based on the selection criteria. Cohen's kappa coefficient (κ) was used as measure of inter-reviewer agreement for the title and the abstract selection.[19] The selected abstracts were obtained as full texts and screened for the final inclusion by reading the Materials and Methods and Results sections. The reason for rejecting studies based on the full-text evaluation was recorded.

Table 1 Search Strategy and Selection Criteria

Focus question	**Does immediate loading of single implant crowns render different results from early and conventional loading with respect to implant survival rate, marginal bone loss, stability of peri-implant soft tissue, esthetics, and patient satisfaction?**
Search strategy	
Population	#1 - (dental implantation, endosseous[MeSH] OR dental implants[MeSH] OR implantation*[all fields] OR implant[all fields] OR implants[all fields])
Intervention or exposure	#2 - (crowns[MeSH] OR crown[MeSH] OR dental crowns[MeSH] OR crowns, dental[MeSH] OR crowns[all fields] OR crown[all fields] OR denture, partial, fixed[MeSH] OR dental prosthesis, implant-supported[MeSH] OR fixed partial denture*[all fields] OR FPD[all fields] OR FPDs[all fields] OR fixed dental prosthesis[all fields] OR fixed dental prostheses[all fields] OR FDP[all fields] OR FDPs[all fields])
Comparison	#3 - (Immediate Dental Implant Loading[MeSH] OR function[all fields] OR time[all fields] OR immediate [all fields] OR early[all fields] OR load*[all fields])
Outcome	#4 - (Survival[MeSH] OR survival rate[MeSH] OR survival analysis[MeSH] OR intraoperative complications[MeSH] OR postoperative complications[MeSH] OR dental restoration failure[MeSH] OR prosthesis failure[MeSH] OR treatment failure[MeSH] OR complication*[all fields] OR success*[all fields] OR failure*[all fields] OR esthetics, dental[MeSH] OR dental esthetics[MeSH] OR esthetics[MeSH] OR esthetic*[all fields] OR aesthetic*[all fields])
Filters	#5 - (English[lang] OR German[lang] OR French[lang]) AND hasabstract[text]
Search combination	#1 AND #2 AND #3 AND #4 AND #5
Database search	
Electronic	Pubmed and Embase
Journals	All peer reviewed journals available in PubMed and Embase. No filters were applied for the journals.
Selection criteria	
Inclusion criteria	· Single implants supporting single crowns · Rough surface solid screw type implants · Prospective and retrospective clinical study · ≥ 10 patients; if number of patients not reported: ≥ 20 implants · ≥ 1 year of loading · Must specify: number of implants placed, time of loading, follow-up duration, number of failures
Exclusion criteria	· In vitro and animal studies; studies based on charts or questionnaires · Machined and hydroxyapatite surface implants; ceramic implants · Monotype implants; non–solid-screw-type implants; scalloped-platform implants · Implants with a diameter < 3 mm; orthodontic or temporary implants · Sinus floor elevation · Zygomatic or pterygoid implants; bicortically stabilized (transmandibular) implants · Implants placed in irradiated bone or bone reconstructed after tumor resection; implants placed in grafted alveolar cleft sites · Splinted fixed or removable implant-supported reconstructions · In case of multiple publications on the same patient cohort the article with less inclusive data

Data Extraction

The data were extracted independently by two reviewers using data extraction tables. Disagreement regarding data extraction was resolved by a discussion between the two reviewers.

The implant loading protocols were classified as follows[20]:

- *Immediate loading:* prosthesis connected to the dental implant within 1 week subsequent to implant placement
- *Early loading:* prosthesis connected to the dental implant between 1 week and 2 months subsequent to implant placement
- *Conventional loading:* prosthesis connected to the dental implant > 2 months subsequent to implant placement.

The following data were extracted from the full-text publications: author(s), year of publication, loading protocol, time of implant placement following tooth extraction, number of patients included, number of patient drop-outs, number of implants placed, number of implant drop-outs, follow-up period of loading, jaw, intraoral region, implant system, implant length and diameter, implant insertion torque, implant stability quotient (ISQ), simultaneous bone augmentation procedure, and number of implant failures. Mean

and standard deviation values of marginal bone loss were recorded between the implant placement and the annual follow-up examinations. The patient cohorts presenting a gain of marginal bone following implant placement were excluded from the analysis of the marginal bone level. Mean and standard deviation values of recessions of midbuccal mucosa and of interproximal papillae were recorded between the implant placement, the insertion of the final crown, and the 1-year follow-up examination. In addition, results regarding the esthetics of peri-implant mucosa and crowns and the patient's satisfaction were recorded.

Quality Assessment

Two reviewers independently assessed the methodological quality of the included studies, by using the Cochrane risk of bias tool[21] for RCTs. For this purpose, the Materials and Methods, Results, and Discussion sections of the publications were evaluated. Any disagreement between the reviewers was resolved by a discussion aiming for consensus.

Statistical Analysis

A meta-analysis of binary and continuous outcome variables was computed for RCTs (STATA software version 10.1) if there were at least two studies comparing the same loading protocols and reporting the same outcome measures.

For binary outcomes (eg, implant survival) the estimate of the effect of an intervention was expressed as odds ratio (OR) and 95% confidence interval (CI). For continuous outcomes (eg, marginal bone loss, soft tissue recession) mean differences and standard deviations (SD) were used to calculate standardized mean differences (SMD) and 95% CI.

The outcomes were pooled by using both the fixed effect model (Mantel-Haenzel-Peto test) and the random effect model (Dersimonian-Laird test). The *Q*-test for heterogeneity was performed and the corresponding forest plots were drawn. If a significant heterogeneity was found, the results of the random effect model have been considered valid. In cases with no evidence of heterogeneity the results of the fixed effect model were considered valid. The level of statistical significance was set at $P \leq .05$.

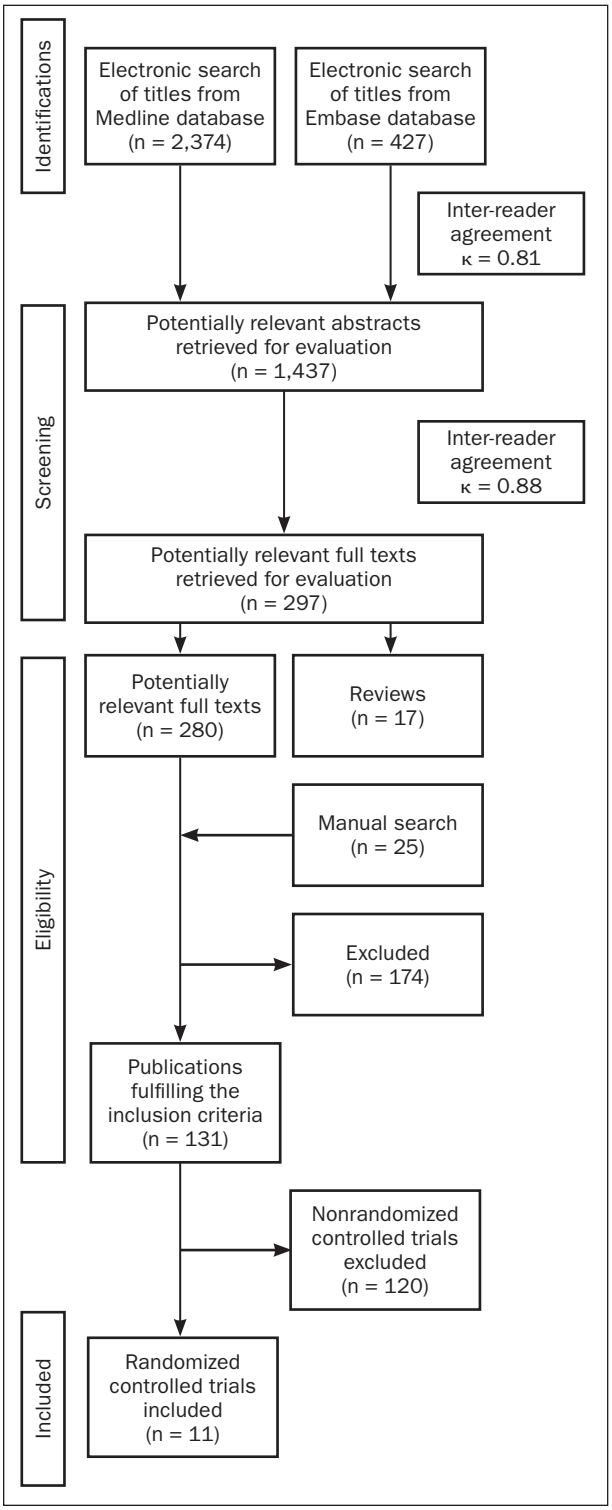

Fig 1 Search flow diagram.

RESULTS

Literature Search

The search of the electronic databases yielded a total of 2,726 titles (Fig 1). A total of 1,437 potentially relevant titles were selected by the two reviewers for abstract evaluation (inter-rater agreement $\kappa = 0.81$). The screening of the abstracts resulted in the selection of 297 publications (inter-rater agreement $\kappa = 0.88$). A manual search of the 17 reviews rendered an additional 25 relevant publications (see Appendix 1 in online edition). After the full-text evaluation, 174 publications were excluded (see Appendix 2 in online edition).

Table 2 Characteristics of the Included Studies

Study	Year of publication	Loading protocol	Occlusal contact	Implant placement (type 1–4)	No. of patients	No. of drop-outs	No. of implants	No. of implant drop-outs	Follow-up period (y)
Crespi et al[5]	2008	Immediate Conventional	Yes	1 1	20 20	0 0	20 20	0 0	2 2
De Rouck et al[10]	2009	Immediate Conventional	No	1 1	24 25	0 0	24 25	0 0	1 1
Degidi et al[4]	2009	Immediate Conventional	No	2,3,4 2,3,4	30 30	0 0	30 30	0 0	3 3
den Hartog et al[3]	2011	Immediate Conventional	No	3,4 3,4	31 31	0 0	31 31	0 0	1.5 1.5
Donati et al[22]	2008	Immediate Conventional	Yes	3,4 3,4	NR NR	NR NR	50 57	0 2	1 1
Güncü et al[23]	2008	Immediate Conventional	Yes	4 4	12 12	0 0	12 12	0 0	1 1
Hall et al[12]	2007	Immediate Conventional	No	2,3,4 2,3,4	14 14	1 2	14 14	1 2	1 1
Prosper et al[24]	2010	Immediate Conventional	Yes	1 1	NR NR	0 0	60 60	0 0	5 5
Schincaglia et al[25]	2008	Immediate Conventional	Yes	3,4 3,4	15 15	0 0	15 15	0 0	1 1
Shibly et al[6]	2010	Immediate Conventional	NR	1 1	30 30	1 1	30 30	1 1	2 2
Testori et al[26]	2007	Immediate Early	No No	NR NR	7 10	0 0	7 10	0 0	1 1

I, incisive; C, canine; PM, premolar; M, molar; NR, not reported.

The reasons for excluding studies based on the full-text evaluation are specified in Table A1 (see online edition). A total of 131 publications fulfilled the inclusion criteria, of which 11 were RCTs comparing different loading protocols. Due to the significant number of RCTs available for analysis, 120 non-RCTs were excluded from the analysis (see Appendix 3 in online edition).

Study Characteristics

In 11 RCTs, a total number of 597 single implants were placed. The characteristics of the included studies are presented in Table 2.

There were 10 RCTs comparing immediate and conventional loading protocols.[3–6,10,12,22–25] In one study, one out of three groups under investigation (osteotome technique in combination with immediate loading) was excluded from the meta-analysis.[22] In the included studies, 286 implants were immediately loaded and 294 implants were conventionally loaded. The grouping of studies according to the duration of the follow-up period of loading yielded the following results: six studies analyzed a loading period of up to 1 year, two up to 2 years, one up to 3 years, and one up to 5 years. In six studies the need for simultaneous bone augmentation at implant placement was considered as an exclusion criterion. Seven studies included implants inserted with a minimal insertion torque ranging from 20 to 45 Ncm. In four studies, a minimal ISQ ranging from 60 to 65 was considered as an inclusion criterion. There were no studies evaluating implants placed in the maxillary molar region.

One RCT compared immediately and early loaded implants.[26] The follow-up period of these 17 implants amounted to 1 year. This study included implants inserted with a minimum torque of 30 Ncm and presenting no peri-implant bone defects at implant placement.

Parameters and Methods of Measurement

Eleven RCTs assessed implant survival. In eight trials, the level of interproximal bone level was measured by means of periapical radiographs immediately following the implant placement and at the annual follow-up examinations. The level of papillae and the level of buccal mucosa were evaluated and expressed in millimeters in three studies each.[3,10,12,22] In one study, the measurements were clinically performed prior to tooth extraction and after 1 year by means of acrylic stents with direction grooves.[10] In another RCT, the assessment was performed 6 months after the implant placement and at the 1-year follow-up. For this purpose, calibrated digital photographs were analyzed and the incisal edge of the implant-supported crown was used as reference for the measurement.[3] One publication reported the results of the examinations at 3 months

Jaw	Region	Implant brand	Implant length (mm)	Implant diameter (mm)	Implant insertion torque (Ncm)	ISQ	Simultaneous bone augmentation
Maxilla	I,C,PM	Sweden & Maritina	13	3.75–5	≥ 25	≥ 60	No
Maxilla	I,C,PM	Sweden & Maritina	13	3.75–5	≥ 25	≥ 60	No
Maxilla	I,C,PM	Nobel	NR	NR	≥ 35	NR	Yes
Maxilla	I,C,PM	Nobel	NR	NR	≥ 35	NR	Yes
Maxilla	I	Xive	13–15	3	≥ 25	≥ 60	No
Maxilla	I	Xive	13–15	3	≥ 25	≥ 60	No
Maxilla	I,C,PM	Nobel	13–16	3.5–4.3	≥ 45	NR	Yes
Maxilla	I,C,PM	Nobel	13–16	3.5–4.3	≥ 45	NR	Yes
Mixed	I,C,PM	Astra Tech	8–13	4–4.5	≥ 20	NR	No
Mixed	I,C,PM	Astra Tech	8–13	4–4.5	≥ 20	NR	No
Mandible	M	Nobel	11.5	4	NR	≥ 65	No
Mandible	M	Nobel	11.5	4	NR	≥ 65	No
Maxilla	I,C,PM	Southern Implants	10–15	4	NR	≥ 60	Yes
Maxilla	I,C,PM	Southern Implants	10–15	4	NR	≥ 60	Yes
Mandible	M	Winsix	9–13	6.5–7.5	NR	NR	No
Mandible	M	Winsix	9–13	6.5–7.5	NR	NR	No
Mandible	M	Nobel	8.5–11.5	5	≥ 20	NR	No
Mandible	M	Nobel	8.5–11.5	5	≥ 20	NR	No
NR	NR	Nobel	NR	NR	≥ 35	NR	Yes
NR	NR	Nobel	NR	NR	≥ 35	NR	Yes
NR	NR	3i	8.5–15	4–6	≥ 30	NR	No
NR	NR	3i	8.5–15	4–6	≥ 30	NR	No

after implant placement and at the 1-year follow-up.[22] In this study, the level of the papillae was clinically assessed. The line between the mucosal margin of the implant-supported crown and the gingival margin of the adjacent tooth was used as a reference structure. In one study, the level of facial mucosa was clinically assessed 4 weeks after the insertion of the definitive crown and at the 1-year examination.[12] In the immediate loading group the definitive crowns were inserted 12 weeks after the implant placement, whereas in the conventional loading group this occurred 32 weeks after the implant placement. A circumferential reference line on the surface of the definitive crown was used for the clinical measurements.

Quality Assessment

The results of the quality assessment of the included RCTs are presented in Table 3. No study fulfilled all the criteria for the control of bias as described in the Cochrane Collaboration's tool for assessing risk of bias (Table 3).

Study Outcomes

Implant Survival. The results regarding implant survival are summarized in Table 4.

In RCTs comparing immediate and conventional loading, 275 of the original 284 immediately loaded implants (96.8%) survived up to 1 year of function, whereas 283 of the 289 implants assigned to conventional loading (97.9%) survived up to 1 year. The meta-analysis of the 10 trials found no significant differences with OR fixed-effects of 0.75 (95% CI: 0.32 to 1.76) and no evidence of heterogeneity (Fig 2). In the four RCTs evaluating implants at 2 years of loading, 136 of the 139 immediately loaded implants (97.8%) and 135 of the 139 implants assigned to conventional loading (97.1%) were in situ at the follow-up examination.[4–6,24] The meta-analysis did not reveal significant differences between the treatment groups with OR fixed-effects of 1.26 (95% CI: 0.33 to 4.80) and no evidence of heterogeneity (Fig 3). Immediately and conventionally loaded implants were examined at 3 years of loading in two trials.[4,24] Based on the meta-analysis of these studies, there were no differences between the two loading protocols (Fig 4). In one RCT, immediately and conventionally loaded implants were assessed at 5 years of loading.[24] In both treatment groups in this study there were two implant failures rendering an implant survival rate of 96.7% in each group.

In one study comparing immediate and early loading, 17 implants were evaluated at 1 year of function.[26] One out of seven immediately loaded implants failed 2 months after the implant placement. There were no implant failures in the early loading group.

Table 3 Quality Assessment of RCTs Based on The Cochrane Collaboration's Tool for Assessing Risk of Bias

Study	Year of publication	Adequate sequence generation	Allocation concealment	Blinding	Incomplete outcome data addressed	Free of selective reporting	Free of other sources of bias
Crespi et al[5]	2008	Unclear	Unclear	Unclear	Yes	Yes	Yes
Degidi et al[4]	2009	Yes	Yes	Unclear	Yes	Yes	Yes
De Rouck et al[10]	2009	Yes	No	Yes	Unclear	Yes	Yes
den Hartog et al[3]	2011	Yes	Yes	Yes	Yes	No	Yes
Donati et al[22]	2008	Yes	Unclear	Unclear	Yes	Yes	Yes
Güncü et al[23]	2008	Yes	Yes	Unclear	Yes	Yes	Yes
Hall et al[12]	2007	Yes	Unclear	Unclear	Yes	Yes	Yes
Prosper et al[24]	2010	Unclear	Unclear	Partial	Yes	Yes	Yes
Schincaglia et al[25]	2008	Yes	Unclear	Yes	Yes	Yes	Yes
Shibly et al[6]	2010	Yes	Unclear	Yes	Yes	Yes	Yes
Testori et al[26]	2007	Yes	Yes	Partial	Yes	Yes	Yes

Table 4 Implant Survival Results

Study	Year of publication	Loading protocol	No. of implants	No. of implant drop-outs	Mean follow-up (y)	At 1 y	
						No. of failures	Survival rate
Crespi et al[5]	2008	Immediate	20	0	2	0	100%
		Conventional	20	0	2	0	100%
De Rouck et al[10]	2009	Immediate	24	0	1	1	96%
		Conventional	25	0	1	2	92%
Degidi et al[4]	2009	Immediate	30	0	3	0	100%
		Conventional	30	0	3	0	100%
den Hartog et al[3]	2011	Immediate	31	0	1.5	1	97%
		Conventional	31	0	1.5	0	100%
Donati et al[22]	2008	Immediate	50	0	1	1	98%
		Conventional	57	2	1	0	100%
Güncü et al[23]	2008	Immediate	12	0	1	1	92%
		Conventional	12	0	1	0	100%
Hall et al[12]	2007	Immediate	14	1	1	1	92%
		Conventional	14	2	1	0	100%
Prosper et al[24]	2010	Immediate	60	0	5	2	97%
		Conventional	60	0	5	2	97%
Schincaglia et al[25]	2008	Immediate	15	0	1	1	93%
		Conventional	15	0	1	0	100%
Shibly et al[6]	2010	Immediate	30	1	2	1	97%
		Conventional	30	1	2	2	93%
Testori et al[26]	2007	Immediate	7	0	1	1	86%
		Early	10	0	1	0	100%

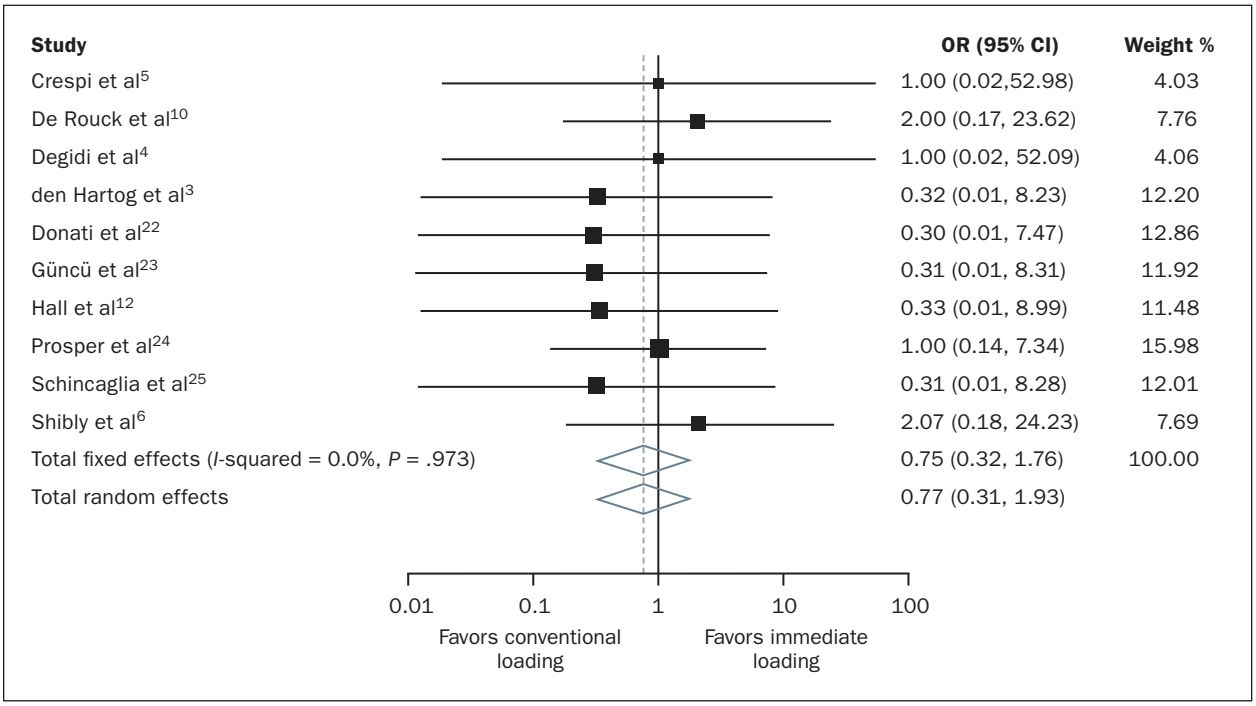

Fig 2 Results of meta-analysis for the comparison of implant survival at 1 year between immediate and conventional loading.

At 2 y		At 3 y		At 5 y	
No. of failures	Survival rate	No. of failures	Survival rate	No. of failures	Survival rate
0	100%	0			
0	100%	0			
0	100%	0	100%		
0	100%	0	100%		
2	97%	2	97%	2	97%
2	97%	2	97%	2	97%
1	97%				
2	93%				

Marginal Bone Loss. Table 5 depicts the data for marginal bone loss between the implant placement and the annual follow-up examinations.

Seven RCTs comparing 215 immediately and 224 conventionally loaded implants reported marginal bone level changes at 1 year of loading. The heterogeneity reached statistical significance ($P = .003$). The meta-analysis found no significant differences with SMD random-effect –0.05 mm (95% CI: –0.41 to 0.31 mm) (Fig 5). In two trials immediate and conventional loadings were compared with regards to bone level change at 2 years of function.[4,5] The SMD fixed-effect amounted to –0.06 mm (95% CI: –0.45 to 0.34 mm) with no significant difference between the two treatment groups (Fig 6). One RCT compared 30 immediately and 30 conventionally loaded implants and found no differences in marginal bone loss at the 3-year follow-up examination.[4] In one study the outcomes of immediate and conventional loading were assessed 5 years after prosthesis delivery.[24] The mean marginal bone loss for immediately and conventionally loaded implants amounted to 1.31 mm and 1.01 mm, respectively. There was no significant difference between the two groups.

Papilla Level. The results of the change in papilla level are presented in Table 6.

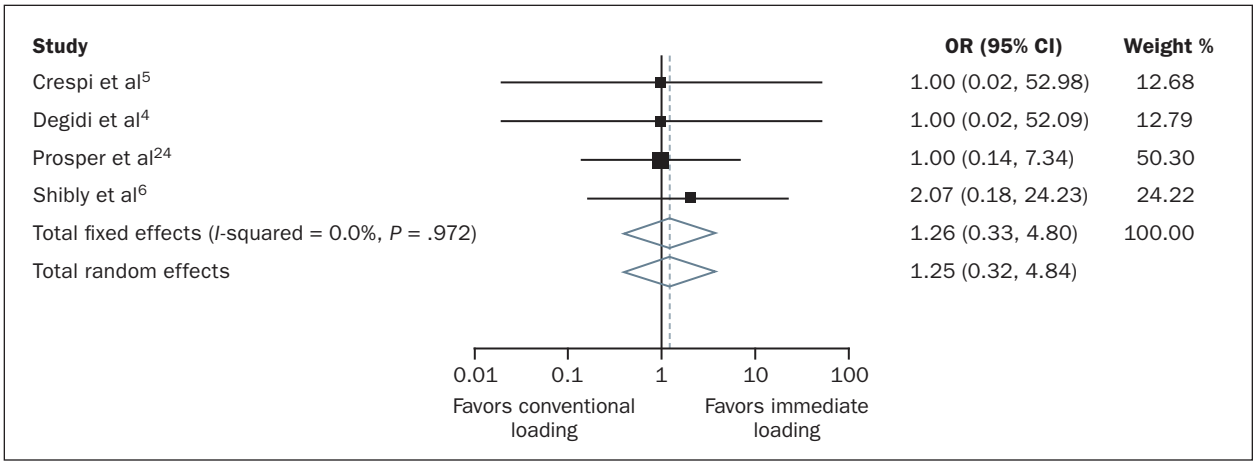

Fig 3 Results of meta-analysis for the comparison of implant survival at 2 years between immediate and conventional loading.

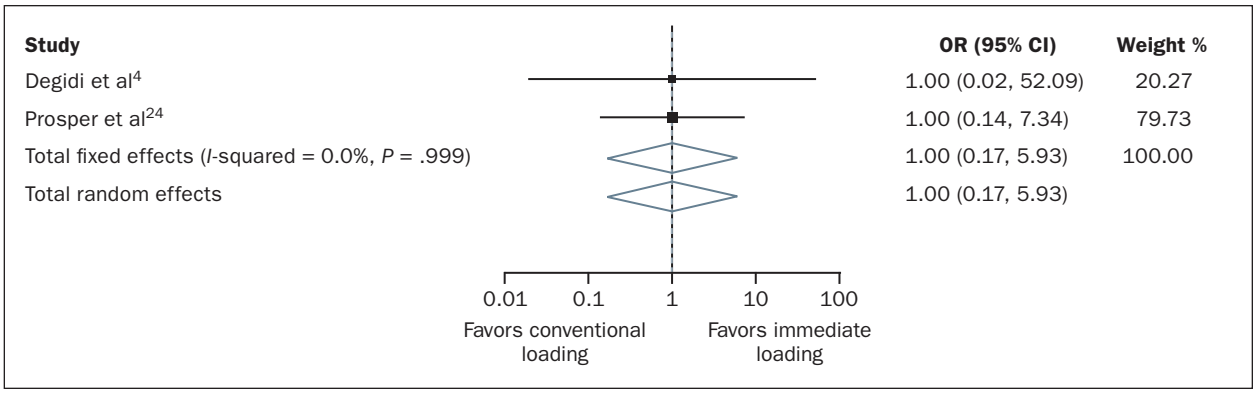

Fig 4 Results of meta-analysis for the comparison of implant survival at 3 years between immediate and conventional loading.

Table 5 Marginal Bone Loss Results

Study	Year of publication	Loading protocol	Marginal bone loss (mm)			
			At 1 y (mean ± SD)	At 2 y (mean ± SD)	At 3 y (mean ± SD)	At 5 y (mean ± SD)
Crespi et al[5]	2008	Immediate Conventional		1.02 ± 0.53 1.16 ± 0.51		
De Rouck et al[10]	2009	Immediate Conventional	0.86 ± 0.54 0.97 ± 0.35			
Degidi et al[4]	2009	Immediate Conventional	0.69 ± 0.38 0.58 ± 0.28	0.73 ± 0.40 0.70 ± 0.29	0.85 ± 0.71 0.75 ± 0.63	
den Hartog et al[3]	2011	Immediate Conventional	0.91 ± 0.61 0.90 ± 0.57			
Donati et al[22]	2008	Immediate Conventional	0.32 ± 0.87 0.38 ± 0.89			
Güncü et al[23]	2008	Immediate Conventional	0.45 ± 0.39 0.68 ± 0.30			
Prosper et al[24]	2010	Immediate Conventional	0.24 ± 0.12 0.17 ± 0.11			1.31 ± 0.44 1.01 ± 0.59
Schincaglia et al[25]	2008	Immediate Conventional	0.77 ± 0.38 1.20 ± 0.55			

Positive values represent bone loss.

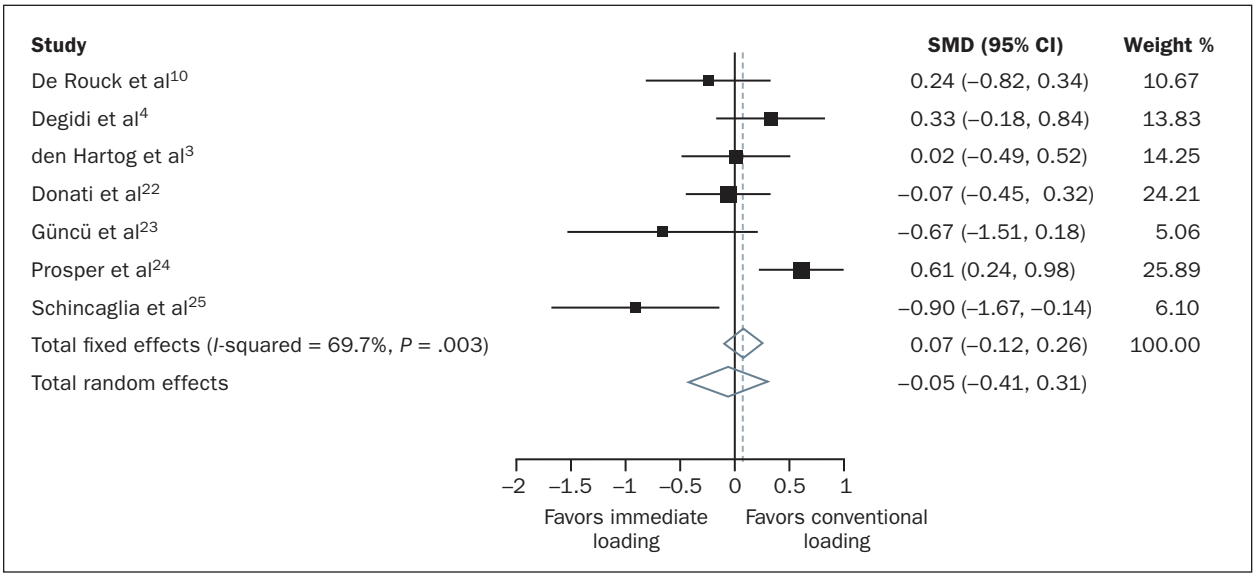

Fig 5 Results of meta-analysis for the comparison of bone loss at 1 year between immediate and conventional loading.

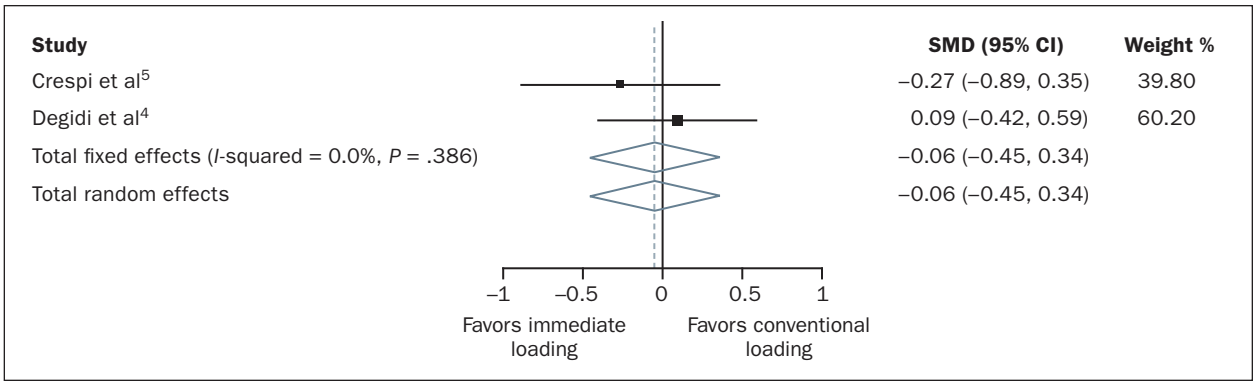

Fig 6 Results of meta-analysis for the comparison of bone loss at 2 years between immediate and conventional loading.

Table 6 Results Regarding Change of Papilla Level

			At 1 y after implant placement (mm)		At 1 y after placement of definitive prosthesis (mm)	
Study	Year of publication	Loading protocol	Mesial (mean ± SD)	Distal (mean ± SD)	Mesial (mean ± SD)	Distal (mean ± SD)
De Rouck et al[10]	2009	Immediate	0.44 ± 0.77	0.31 ± 0.81		
		Conventional	0.43 ± 0.42	0.53 ± 0.55		
den Hartog et al[3]	2011	Immediate			–0.41 ± 0.49	–0.27 ± 0.49
		Conventional			–0.19 ± 0.29	–0.35 ± 0.52
Donati et al[22]	2008	Immediate			0.43 ± 1.20	0.21 ± 1.27
		Conventional			0.55 ± 1.14	0.50 ± 0.95

Positive values represent papilla recession.

One RCT evaluated the change of papilla height between the implant placement and the 1-year follow-up at conventionally and immediately loaded implants placed into fresh extraction sockets.[10] At 1-year of follow-up, the mean recession of mesial and distal papillae ranged from 0.31 to 0.53 mm with no significant differences between immediate and conventional loading.

Two RCTs evaluated the level of the papillae at immediately and conventionally loaded implants between insertion of the definitive crown and the 1-year follow-up.[3,22] In one study, average papilla recession was found in both groups, ranging from 0.21 to 0.55 mm.[22] In the other study, an average gain of papilla height was reported for both groups.[3] The meta-analysis of the

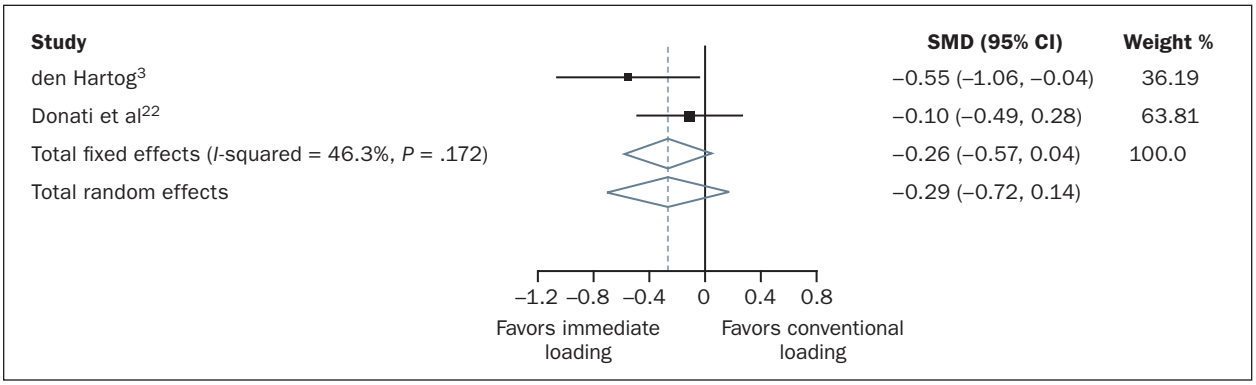

Fig 7 Results of meta-analysis for the comparison regarding change of mesial papilla level at 1 year between immediate and conventional loading.

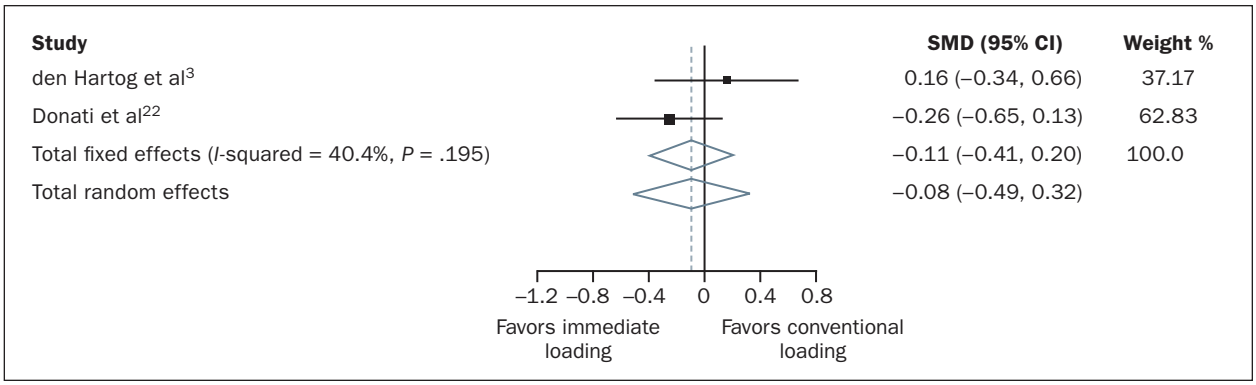

Fig 8 Results of meta-analysis for the comparison regarding change of distal papilla level at 1 year between immediate and conventional loading.

Table 7 Results Regarding Change of Buccal Mucosal Level

Study	Year of publication	Loading protocol	At 1 y after implant placement (mean ± SD) (mm)	At 1 y after placement of definitive prosthesis (mean ± SD) (mm)
De Rouck et al[10]	2009	Immediate Conventional	0.41 ± 0.75 1.16 ± 0.66	
den Hartog et al[3]	2011	Immediate Conventional		–0.06 ± 0.42 0.09 ± 0.34
Hall et al[12]	2007	Immediate Conventional		0.67 ± 0.49 0.33 ± 0.78

Positive values represent mucosal recession.

two RCTs did not reveal significant differences between immediate and conventional loading (Figs 7 and 8).

Midbuccal Mucosa Level. The results of the midbuccal mucosal recession are summarized in Table 7.

In one RCT comparing immediately and conventionally loaded implants placed into fresh extraction sockets, the level of the midbuccal mucosa was recorded at implant placement and at the 1-year follow-up.[10] The immediate loading group presented a mean mucosal recession of 0.41 mm, whereas in the conventional loading group the midbuccal mucosa receded by 1.16 mm on average. The difference between the study groups was statistically significant.

Two studies including 42 immediately and 43 conventionally loaded implants recorded the level of the facial soft tissue at definitive crown insertion and at the 1-year follow-up.[3,12] There was no evidence of heterogeneity and the meta-analysis did not reveal significant differences with SMD fixed-effects –0.14 mm (95% CI: –0.57 to 0.29 mm) (Fig 9).

Esthetic Outcomes. Only one RCT included in the present review assessed the overall esthetic out-

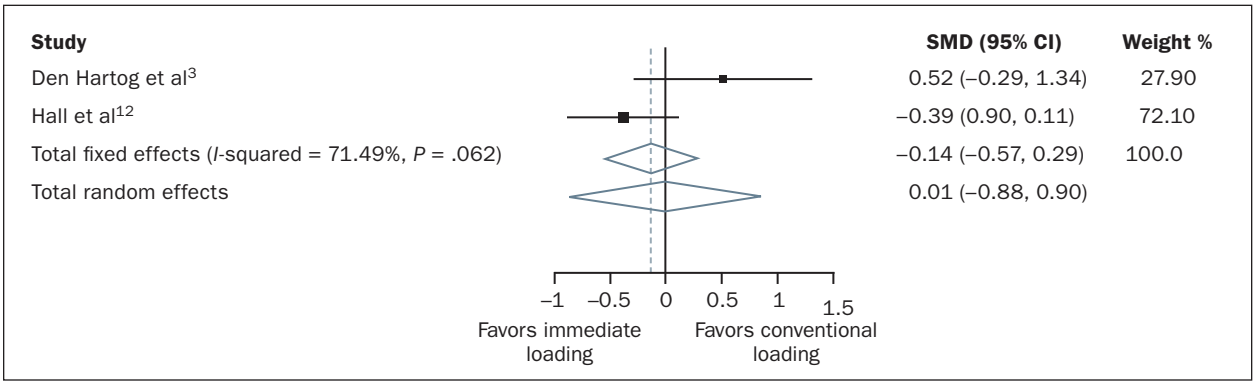

Fig 9 Results of meta-analysis for the comparison regarding change of buccal mucosal level at 1 year between immediate and conventional loading.

comes.[3] In this study, the esthetics of peri-implant mucosa and crowns at immediately and conventionally loaded implant sites were determined using the Pink Esthetic Score-White Esthetic Score (PES-WES)[27] and Implant Crown Esthetic Index (ICEI).[28] The mucosal esthetics were rated with a mean PES of 7.1 ± 1.5 (range: 3 to 10) and 6.5 ± 1.6 (range: 4 to 10) for the immediate and the conventional group, respectively. According to ICEI, the mucosal esthetics were satisfactory in 24 cases (80%) in the immediate loading group and in 19 cases (62%) in the conventional loading group. One case in both groups showed excellent soft tissue esthetics. The esthetics of the crown, expressed as WES, amounted to 7.8 ± 1.5 (range: 4 to 10) in the immediate loading group and to 7.6 ± 1.6 (range: 4 to 10) in the conventional loading group. None of the scores described in these studies showed significant differences between the two groups under investigation.

Patient Satisfaction. One RCT analyzed the patient satisfaction after immediate and conventional loading of implants.[3] Satisfaction regarding function, esthetics and treatment procedures was assessed using a form comprised of questions to be answered on a five-point rating scale. In addition, the overall satisfaction was measured using a 100-mm visual analog scale (VAS). Patient satisfaction was generally high and no differences were observed between the groups. However, approximately one-third of the patients in the conventional loading group judged the healing time after implant placement as long.

Another trial comparing immediate and conventional loading of implants placed into fresh extraction sockets evaluated patient satisfaction regarding esthetics by means of a 100 mm VAS.[10] This study reported an average patient satisfaction of 93% (range: 80% to 96%) for the immediate loading. The satisfaction for the conventional loading amounted to 91% (range: 80% to 96%) with no significant difference between the groups.

DISCUSSION

Implant Survival and Marginal Bone Level

Ten RCTs comparing immediately and conventionally loaded implants and one RCT comparing immediately and early loaded implants met the inclusion criteria. The meta-analysis of data from the included trials did not reveal differences between immediately and conventionally loaded implants with regards to implant survival and marginal bone loss. The majority of the included studies evaluated implants inserted with a minimal torque in the range of 20 to 45 Ncm or a minimal ISQ in the range of 60 to 65. In addition, approximately half of the included studies considered the presence of peri-implant bone defects at implant insertion as an exclusion criterion.

Two recent systematic reviews did not find a significant effect of the loading protocol on implant survival and marginal bone loss.[29,30] Differently from the present study, however, these reviews included trials evaluating both single and splinted implants. In a previous systematic review comparing immediate, early, and conventional loading of single-implant restorations in the esthetic zone, no significant differences were found regarding the implant survival and marginal bone loss.[31]

It has been stated that a high degree of primary implant stability is one of the prerequisites for successful outcomes of immediate or early loading.[29] From the clinical standpoint, it is important to know what amount of primary stability is required to immediately or early load a single implant. Moreover, there are different methods for the assessment of primary implant stability.

In a previous study, a significant correlation was found between implant insertion torque and early failures of immediately restored single implants.[32] Nine out of 10 immediately loaded implants placed with 20 Ncm failed versus only 1 out of 10 inserted with a torque of 32 Ncm. In this study, step-cylinder type

implants were used. The implant survival rate was independent of implant length, site, bone quality and quantity. It was, therefore, concluded that an insertion torque of 32 Ncm is necessary to achieve osseointegration of immediately loaded implants. In another study, 50 patients received two single nonadjacent implants, randomly inserted with a torque either ranging from 25 to 35 Ncm or being above 80 Ncm.[33] Nonoccluding provisional crowns were inserted immediately after implant placement. At 6 months of loading, seven implants inserted with a torque ranging from 25 to 35 Ncm failed whereas none of the implants failed inserted with high insertion torque. The difference of the implant survival rate between groups was statistically significant. There were no significant differences with regards to marginal bone loss and complication rates. The investigators concluded that an insertion torque of 35 Ncm was not sufficient to achieve high survival rates for immediately loaded single implants.

In contrast, several clinical studies reported high survival rates for immediately loaded implants inserted with low insertion torques.[34–36] A retrospective clinical study evaluated immediately restored, single-tooth implants placed into fresh extraction sockets with a torque of ≤ 25 Ncm.[35] Lack of axial stability was an exclusion criterion in this study. At 1.25 to 9.5 years of loading, an implant survival rate of 95.5% and optimal maintenance of marginal bone levels were found.

Another parameter for the assessment of primary implant stability is ISQ as measured by resonance frequency analysis (RFA).[37] Interestingly, several preclinical and clinical studies found a lack of correlation between insertion torque and ISQ.[38–42] These results may be explained by the fact that the ISQ is a measure of axial stiffness between implant and bone. In contrast, the insertion torque corresponds to the degree of rotational friction between an implant and the surrounding bone tissue.

Currently, results remain inconclusive regarding the minimum insertion torque and the minimum ISQ needed to achieve successful osseointegration of immediately or early loaded implants. Hence, more research is needed to make clear clinical recommendations.

Level of Interproximal Papillae

The results of the present review indicated that the timing of the restorative procedure does not influence the level of the papillae at single-implant crowns at 1 year of function.

Only one RCT included in this review evaluated the change of papilla height between implant placement and the 1-year follow-up.[10] This study compared conventionally and immediately loaded implants placed into fresh maxillary extraction sockets. The mean papilla shrinkage at 3 months was about twice as high in the conventional group as in the immediate loading group (0.9 mm vs 0.5 mm). In the following 9 months, papillae at conventionally loaded implants showed a tendency to fill the proximal spaces. At the 1-year follow-up, the mean recession of mesial and distal papillae ranged from 0.3 to 0.5 mm with no significant differences between immediate and conventional loading. Two RCTs included in this systematic review measured the change of the papilla height from the insertion of the definitive crown to the 1-year follow-up at immediately and conventionally loaded implants.[3,22] In both studies, implants were placed into sites with healed soft tissues. In one trial, a mean gain of the papilla height of approximately 0.3 mm was observed in both treatment groups.[3] In contrast, the other RCT recorded a minimal mean recession of the papillae between 3- and 12-month examinations.[22] The meta-analysis of data from the two trials did not reveal significant differences between immediate and conventional loading.

Other clinical studies, not meeting the inclusion criteria of the present systematic review, investigated immediately loaded implants placed into fresh extraction sockets in the anterior maxilla.[43–47] These studies measured the changes of the soft tissue level 12 months following the implant placement in relation to the preoperative status. The average papilla recession ranged from 0.3 to 0.5 mm. The papilla recession at conventionally loaded implants was evaluated in a study, in which 3 months of healing was allowed before restoration.[48] The measurements were taken prior to the implant placement and repeated at the insertion of the provisional, at 3 and 15 months. When compared to the presurgical soft tissue level, approximately 1 mm of papilla recession was recorded at the time of insertion of the provisional restoration, after which little changes took place. Other clinical studies assessed the change of the papilla level from the insertion of the definitive crown to the 1-year examination.[49–53] In the majority of the trials a slight gain of the papilla height was found during this time frame for both immediately and conventionally loaded implants.[49–52] In a recent publication, immediately loaded implants placed into fresh extraction sockets were followed up to 2 to 8 years.[54] When compared to the pre-surgical status, mesial and distal papillae had lost 0.53 mm and 0.39 mm of height at the 1-year follow-up. The corresponding values at the last examination amounted to 0.22 mm and 0.21 mm. These results indicate that a recession of the papilla level occurs after implant placement and that the papillae have the capacity of growing following incorporation of the restoration. The papilla growth following the crown insertion, however, does not completely compensate the postoperative papilla recession.

Level of Buccal Mucosa

Only one RCT included in the present systematic review assessed the change of the buccal mucosa level from implant placement to the 1-year follow-up.[10] This study compared immediately and conventionally loaded implants placed into fresh extraction sockets. In the conventional loading group, the buccal mucosa receded by 1.2 mm in average, whereas immediate loading of implants led to 0.4 mm of mucosal recession. The difference between the groups was statistically significant. It was, therefore, concluded that immediate restoration of implants placed into fresh extraction sockets help limit the amount of buccal mucosal recession. Two RCTs analyzed in this review recorded the level of the facial soft tissue at the insertion of the definitive crown and at the 1-year follow-up.[3,12] In both studies implants were placed into sites with healed soft tissues. One study found stable mucosal levels at the 1-year follow-up for both immediate and conventional loading.[3] In the other trial mucosal recession amounting to 0.67 mm and 0.33 mm, respectively, was reported for immediate and conventional loading.[12] This difference did not reach statistical significance. The meta-analysis of the data from the two investigations did not reveal significant differences between immediate and conventional loading.

Other clinical studies, not meeting the inclusion criteria of the present systematic review, investigated immediately loaded maxillary implants. These trials measured the change of the buccal mucosa level 1 year following the implant placement in relation to the preoperative status. The average soft tissue recession ranged from 0.12 mm to 0.67 mm.[45–47,55] A recent systematic review included three trials investigating immediately loaded implants placed into fresh extraction sockets in the anterior maxilla.[56] The calculated average recession of the buccal mucosa from implant placement to the 1-year follow-up was 0.5 mm. Recession of the midbuccal mucosa at conventionally loaded implants was evaluated in a study described above.[48] The measurements were taken prior to the implant placement and repeated at the insertion of the provisional and at 3 and 15 months. When compared to the pre-surgical soft tissue level, 0.8 mm of mucosal recession was recorded at the time of insertion of the provisional prosthesis, after which little changes took place. Other studies evaluated the level of the facial mucosa at the insertion of the definitive crown and at the 1-year examination. A trial investigating immediately loaded implants found 0.3 mm of gain of the midbuccal mucosal level.[49] Several clinical studies analyzing conventionally loaded implants reported stable mean buccal mucosal level at 1 year of function.[51–53] In contrast, one trial with 11 conventionally loaded implants found a mean mucosal recession amounting to 0.6 mm.[57]

In a recent publication, immediately loaded implants placed into fresh extraction sockets were followed up to 2 to 8 years.[54] Significantly more recession of the facial mucosa was reported at the last examination (1.13 mm) as compared to the 1-year follow-up (0.55 mm). These results indicate that recession of the buccal mucosa occurs after implant placement and can become more pronounced in the long term.

Esthetic Outcomes

Only one study included in the present systematic review reported the outcomes regarding esthetics following immediate and conventional implant loading.[3] In this study, the esthetics of peri-implant mucosa and implant crown were determined using the PES-WES[27] and ICEI.[28] There were no differences between the two groups under investigation.

Other clinical studies evaluating the esthetics of single-implant crowns by means of PES-WES and ICEI reported similar results.[27,58–60] In these studies, the mean total PES-WES for conventionally loaded single-implant crowns ranged from 13.5 to 16.8.[27,58,59] In a study including 93 patients with conventionally loaded single-implant crowns in the anterior maxilla, the mean ICEI amounted to 4.8. The overall result was rated as acceptable in 66% of the cases.[60]

Patient Satisfaction

Two RCTs analyzed in the present review reported patient satisfaction following immediate and conventional implant loading.[3,10] Patient satisfaction was high and no differences were observed between the groups. Other clinical studies evaluating the patient satisfaction after immediate and conventional loading of single-implant crowns by means of a VAS reported similar findings.[44,58,60–62]

It is well documented that patient satisfaction with esthetics can considerably differ from that of professionals, with patients usually showing a higher degree of satisfaction.[60,63–65] This indicates that concerning the esthetics of implant-supported reconstructions and their surrounding tissues, patients may have different views regarding the factors contributing to a satisfying result.

Time Points of Baseline Measurements

It is obvious that to assess the influence of a given therapeutic intervention on a certain parameter, baseline measurements are ideally performed prior to the intervention under investigation. In other words, to compare the effect of immediate and conventional loading protocols on peri-implant tissues, baseline assessments should be performed at implant placement in both groups.

Regarding marginal bone loss, a reasonable number of RCTs were found reporting bone level changes from

a baseline at the time of implant placement. Hence, a large amount of data were available for analysis.

In contrast, as far as soft tissue changes are concerned, only one RCT was found evaluating changes of the soft tissues with implant placement as the baseline for measurement. Therefore, inclusion was extended to studies reporting changes in soft tissue with insertion of the final crown as the baseline. As a consequence, the comparability of the results from different studies regarding mucosal levels was hampered by the fact that different time points for baseline measurements (implant placement and final crown insertion) were selected.

Study Strength and Limitation

The present systematic review included only the highest level of evidence (data from RCTs) for examining whether or not immediate loading of single-implant crowns rendered different results from early and conventional loading. One previous systematic review investigating the effects of different loading protocols on single-implant crowns included RCTs, controlled clinical trials, cohort studies, and case series.[31] Two other systematic reviews on loading protocols included studies investigating both single and splinted implants.[29,30]

The main limitation of this review is the fact that the majority of the included studies did not provide observations beyond 1 year of implant function. In addition, only a limited number of trials were found evaluating the levels of peri-implant soft tissue, esthetics, and patient satisfaction.

CONCLUSIONS

Based on the findings of the present systematic review it can be concluded that for single-implant crowns:

- Immediately and conventionally loaded implants are equally successful clinical procedures regarding implant survival and marginal bone loss. This conclusion is primarily derived from studies evaluating implants inserted with a minimal torque in the range of 20 to 45 Ncm or a minimal ISQ in the range of 60 to 65 and with no need for simultaneous bone augmentation. In addition, most studies did not include observation periods beyond 1 year of implant function.
- Immediately and conventionally loaded implants do not appear to differently affect the papilla height during the first year of loading.
- Due to the heterogeneity of the time point of baseline measurements and the contradictory findings in the studies it is difficult to draw clear conclusions regarding the recession of the buccal mucosa between immediately and conventionally loaded implants.
- With respect to the assessment of esthetic outcomes, the data available remain inconclusive.
- Patient satisfaction was measured in only very few trials rendering insufficient data to draw conclusions.

There is a need for well-designed prospective randomized controlled trials investigating the effectiveness of different loading protocols.

Future investigations should ideally focus on clinically relevant parameters able to assess whether or not the treatment goal of a given therapy has been achieved. A standardized use of patient-reported outcome measures is, therefore, recommended to understand the benefit of a treatment from the patients' perspectives. Moreover, clinical trials should include analyses of the cost-effectiveness of the examined therapy.

To assess the esthetic outcome of an intervention, the use of reproducible methods and validated indices is recommended. More studies are needed comparing different loading protocols regarding their effect on the mucosal level over time. For repeated metric assessments, adequate reference structures should be selected for baseline and follow-up measurements.

Baseline assessments should be performed prior to the intervention under investigation. Therefore, in cases of immediate loading, baseline measurement is ideally performed at implant placement. However, to truly understand the influence of treatment timing on the therapeutic outcomes, future studies should be designed to investigate both the effects of the time point of implant placement and the time point of loading. For studies investigating the timing of implant placement, baseline measurements should be assessed prior to tooth extraction. Finally, there is a need for more long-term observation.

ACKNOWLEDGMENTS

The investigators gratefully acknowledge Malgorzata Roos, PhD (Department of Biostatistics, University of Zurich, Zurich, Switzerland) for assistance in analyzing the data and Gisela Müller (Clinic of Fixed and Removable Prosthodontics and Dental Material Science, Center of Dental Medicine, University of Zurich, Zurich, Switzerland) for assistance in preparing the manuscript.

The present systematic review was funded by the Clinic of Fixed and Removable Prosthodontics and Dental Material Science, University of Zurich, Switzerland.

The authors declare no conflict of interest regarding any part of the systematic review.

REFERENCES

1. Jung RE, Zembic A, Pjetursson BE, Zwahlen M, Thoma DS. Systematic review of the survival rate and the incidence of biological, technical, and aesthetic complications of single crowns on implants reported in longitudinal studies with a mean follow-up of 5 years. Clin Oral Implants Res 2012;23(suppl 6):2–21.
2. Brånemark P, Zarb GA, Albrektsson T. Tissue-Integrated Prostheses: Osseointegration in Clinical Dentistry. Berlin: Quintessence, 1985.
3. den Hartog L, Raghoebar GM, Stellingsma K, Vissink A, Meijer HJ. Immediate non-occlusal loading of single implants in the aesthetic zone: A randomized clinical trial. J Clin Periodontol 2011;38:186–194.
4. Degidi M, Nardi D, Piattelli A. Immediate versus one-stage restoration of small-diameter implants for a single missing maxillary lateral incisor: A 3-year randomized clinical trial. J Periodontol 2009;80: 1393–1398.
5. Crespi R, Cappare P, Gherlone E, Romanos GE. Immediate versus delayed loading of dental implants placed in fresh extraction sockets in the maxillary esthetic zone: A clinical comparative study. Int J Oral Maxillofac Implants 2008;23:753–758.
6. Shibly O, Patel N, Albandar JM, Kutkut A. Bone regeneration around implants in periodontally compromised patients: A randomized clinical trial of the effect of immediate implant with immediate loading. J Periodontol 2010;81:1743–1751.
7. Buser D, Bornstein MM, Weber HP, Grutter L, Schmid B, Belser UC. Early implant placement with simultaneous guided bone regeneration following single-tooth extraction in the esthetic zone: A cross-sectional, retrospective study in 45 subjects with a 2- to 4-year follow-up. J Periodontol 2008;79:1773–1781.
8. Cooper LF, Ellner S, Moriarty J, et al. Three-year evaluation of single-tooth implants restored 3 weeks after 1-stage surgery. Int J Oral Maxillofac Implants 2007;22:791–800.
9. Salvi GE, Gallini G, Lang NP. Early loading (2 or 6 weeks) of sandblasted and acid-etched (SLA) ITI implants in the posterior mandible. A 1-year randomized controlled clinical trial. Clin Oral Implants Res 2004;15:142–149.
10. De Rouck T, Collys K, Wyn I, Cosyn J. Instant provisionalization of immediate single-tooth implants is essential to optimize esthetic treatment outcome. Clin Oral Implants Res 2009;20:566–570.
11. Hall JA, Payne AG, Purton DG, Torr B. A randomized controlled clinical trial of conventional and immediately loaded tapered implants with screw-retained crowns. Int J Prosthodont 2006;19:17–19.
12. Hall JA, Payne AG, Purton DG, Torr B, Duncan WJ, De Silva RK. Immediately restored, single-tapered implants in the anterior maxilla: Prosthodontic and aesthetic outcomes after 1 year. Clin Implant Dent Relat Res 2007;9:34–45.
13. Belser UC, Schmid B, Higginbottom F, Buser D. Outcome analysis of implant restorations located in the anterior maxilla: A review of the recent literature. Int J Oral Maxillofac Implants 2004;19(suppl):30–42.
14. Benic GI, Wolleb K, Sancho-Puchades M, Hammerle CH. Systematic review of parameters and methods for the professional assessment of aesthetics in dental implant research. J Clin Periodontol 2012; 39(suppl 12):160–192.
15. McGrath C, Lam O, Lang N. An evidence-based review of patient-reported outcome measures in dental implant research among dentate subjects. J Clin Periodontol 2012;39(suppl 12):193–201.
16. Lang NP, Zitzmann NU. Clinical research in implant dentistry: Evaluation of implant-supported restorations, aesthetic, and patient-reported outcomes. J Clin Periodontol 2012;39(suppl 12):133–138.
17. Egger M, Smith GD, Sterne JA. Uses and abuses of meta-analysis. Clin Med 2001;1:478–484.
18. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. BMJ 2009;339:b2535.
19. Landis JR, Koch GG. The measurement of observer agreement for categorical data. Biometrics 1977;33:159–174.
20. Esposito M, Grusovin MG, Willings M, Coulthard P, Worthington HV. Interventions for replacing missing teeth: Different times for loading dental implants. Cochrane Database Syst Rev 2007:CD003878.
21. Higgins JP, Altman DG, Gotzsche PC, et al. The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ 2011; 343:d5928.
22. Donati M, La Scala V, Billi M, Di Dino B, Torrisi P, Berglundh T. Immediate functional loading of implants in single tooth replacement: A prospective clinical multicenter study. Clin Oral Implants Res 2008; 19:740–748.
23. Güncu MB, Aslan Y, Tumer C, Güncu GN, Uysal S. In-patient comparison of immediate and conventional loaded implants in mandibular molar sites within 12 months. Clin Oral Implants Res 2008;19:335–341.
24. Prosper L, Crespi R, Valenti E, Cappare P, Gherlone E. Five-year follow-up of wide-diameter implants placed in fresh molar extraction sockets in the mandible: Immediate versus delayed loading. Int J Oral Maxillofac Implants 2010;25:607–612.
25. Schincaglia GP, Marzola R, Giovanni GF, Chiara CS, Scotti R. Replacement of mandibular molars with single-unit restorations supported by wide-body implants: Immediate versus delayed loading. A randomized controlled study. Int J Oral Maxillofac Implants 2008; 23:474–480.
26. Testori T, Galli F, Capelli M, Zuffetti F, Esposito M. Immediate nonoccusal versus early loading of dental implants in partially edentulous patients: 1-year results from a multicenter, randomized controlled clinical trial. Int J Oral Maxillofac Implants 2007;22:815–822.
27. Belser UC, Grutter L, Vailati F, Bornstein MM, Weber HP, Buser D. Outcome evaluation of early placed maxillary anterior single-tooth implants using objective esthetic criteria: A cross-sectional, retrospective study in 45 patients with a 2- to 4-year follow-up using pink and white esthetic scores. J Periodontol 2009;80:140–151.
28. Meijer HJ, Stellingsma K, Meijndert L, Raghoebar GM. A new index for rating aesthetics of implant-supported single crowns and adjacent soft tissues—The implant crown aesthetic index. Clin Oral Implants Res 2005;16:645–649.
29. Esposito M, Grusovin MG, Achille H, Coulthard P, Worthington HV. Interventions for replacing missing teeth: Different times for loading dental implants. Cochrane Database Sys Rev 2009:CD003878.
30. Suarez F, Chan HL, Monje A, Galindo-Moreno P, Wang HL. Effect of the timing of restoration on implant marginal bone loss: A systematic review. J Periodontol 2013;84:159–169.
31. den Hartog L, Slater JJ, Vissink A, Meijer HJ, Raghoebar GM. Treatment outcome of immediate, early and conventional single-tooth implants in the aesthetic zone: A systematic review to survival, bone level, soft-tissue, aesthetics, and patient satisfaction. J Clin Periodontol 2008;35:1073–1086.
32. Ottoni JM, Oliveira ZF, Mansini R, Cabral AM. Correlation between placement torque and survival of single-tooth implants. Int J Oral Maxillofac Implants 2005;20:769–776.
33. Cannizzaro G, Leone M, Ferri V, Viola P, Federico G, Esposito M. Immediate loading of single implants inserted flapless with medium or high insertion torque: A 6-month follow-up of a split-mouth randomised controlled trial. Eur J Oral Implantol 2012;5:333–342.
34. Toljanic JA, Baer RA, Ekstrand K, Thor A. Implant rehabilitation of the atrophic edentulous maxilla including immediate fixed provisional restoration without the use of bone grafting: A review of 1-year outcome data from a long-term prospective clinical trial. Int J Oral Maxillofac Implants 2009;24:518–526.
35. Norton MR. The influence of insertion torque on the survival of immediately placed and restored single-tooth implants. Int J Oral Maxillofac Implants 2011;26:1333–1343.
36. Degidi M, Daprile G, Piattelli A. Implants inserted with low insertion torque values for intraoral welded full-arch prosthesis: 1-year follow-up. Clin Implant Dent Relat Res 2012;14(suppl 1):e39–e45.
37. Meredith N, Alleyne D, Cawley P. Quantitative determination of the stability of the implant-tissue interface using resonance frequency analysis. Clin Oral Implants Res 1996;7:261–267.
38. Al-Nawas B, Wagner W, Grotz KA. Insertion torque and resonance frequency analysis of dental implant systems in an animal model with loaded implants. Int J Oral Maxillofac Implants 2006;21:726–732.
39. Gonzalez-Garcia R, Monje F, Moreno-Garcia C. Predictability of the resonance frequency analysis in the survival of dental implants placed in the anterior non-atrophied edentulous mandible. Med Oral Patol Oral Cir Bucal 2011;16:e664–e669.

40. Degidi M, Daprile G, Piattelli A. Primary stability determination by means of insertion torque and rfa in a sample of 4,135 implants. Clin Implant Dent Relat Res 2012;14:501–507.
41. Barewal RM, Stanford C, Weesner TC. A randomized controlled clinical trial comparing the effects of three loading protocols on dental implant stability. Int J Oral Maxillofac Implants 2012;27:945–956.
42. Hof M, Pommer B, Strbac GD, Vasak C, Agis H, Zechner W. Impact of insertion torque and implant neck design on peri-implant bone level: A randomized split-mouth trial. Clin Implant Dent Relat Res 2013 Feb 7 [epub ahead of print].
43. Kan JY, Rungcharassaeng K, Lozada J. Immediate placement and provisionalization of maxillary anterior single implants: 1-year prospective study. Int J Oral Maxillofac Implants 2003;18:31–39.
44. De Rouck T, Collys K, Cosyn J. Immediate single-tooth implants in the anterior maxilla: A 1-year case cohort study on hard and soft tissue response. J Clin Periodontol 2008;35:649–657.
45. Cosyn J, Eghbali A, De Bruyn H, Collys K, Cleymaet R, De Rouck T. Immediate single-tooth implants in the anterior maxilla: 3-year results of a case series on hard and soft tissue response and aesthetics. J Clin Periodontol 2011;38:746–753.
46. Cosyn J, De Bruyn H, Cleymaet R. Soft tissue preservation and pink aesthetics around single immediate implant restorations: A 1-year prospective study. Clin Implant Dent Relat Res 2012 Feb 29 [epub ahead of print].
47. Pieri F, Aldini NN, Marchetti C, Corinaldesi G. Influence of implant-abutment interface design on bone and soft tissue levels around immediately placed and restored single-tooth implants: A randomized controlled clinical trial. Int J Oral Maxillofac Implants 2011;26:169–178.
48. Cordaro L, Torsello F, Roccuzzo M. Clinical outcome of submerged vs nonsubmerged implants placed in fresh extraction sockets. Clin Oral Implants Res 2009;20:1307–1313.
49. De Bruyn H, Raes F, Cooper LF, et al. Three-years clinical outcome of immediate provisionalization of single Osseospeed implants in extraction sockets and healed ridges. Clin Oral Implants Res 2013;24: 217–223.
50. Tortamano P, Camargo LO, Bello-Silva MS, Kanashiro LH. Immediate implant placement and restoration in the esthetic zone: A prospective study with 18 months of follow-up. Int J Oral Maxillofac Implants 2010;25:345–350.
51. Meijndert L, Raghoebar GM, Meijer HJ, Vissink A. Clinical and radiographic characteristics of single-tooth replacements preceded by local ridge augmentation: A prospective randomized clinical trial. Clin Oral Implants Res 2008;19:1295–1303.
52. Santing HJ, Raghoebar GM, Vissink A, den Hartog L, Meijer HJ. Performance of the Straumann Bone Level Implant system for anterior single-tooth replacements in augmented and nonaugmented sites: A prospective cohort study with 60 consecutive patients. Clin Oral Implants Res 2013;24:941–948.
53. Tymstra N, Raghoebar GM, Vissink A, Den Hartog L, Stellingsma K, Meijer HJ. Treatment outcome of two adjacent implant crowns with different implant platform designs in the aesthetic zone: A 1-year randomized clinical trial. J Clin Periodontol 2011;38:74–85.
54. Kan JY, Rungcharassaeng K, Lozada JL, Zimmerman G. Facial gingival tissue stability following immediate placement and provisionalization of maxillary anterior single implants: A 2- to 8-year follow-up. Int J Oral Maxillofac Implants 2011;26:179–187.
55. Raes F, Cosyn J, Crommelinck E, Coessens P, De Bruyn H. Immediate and conventional single implant treatment in the anterior maxilla: 1-year results of a case series on hard and soft tissue response and aesthetics. J Clin Periodontol 2011;38:385–394.
56. Lang NP, Pun L, Lau KY, Li KY, Wong MC. A systematic review on survival and success rates of implants placed immediately into fresh extraction sockets after at least 1 year. Clin Oral Implants Res 2012; 23(suppl 5):39–66.
57. Cardaropoli G, Lekholm U, Wennstrom JL. Tissue alterations at implant-supported single-tooth replacements: A 1-year prospective clinical study. Clin Oral Implants Res 2006;17:165–171.
58. Gallucci GO, Grutter L, Nedir R, Bischof M, Belser UC. Esthetic outcomes with porcelain-fused-to-ceramic and all-ceramic single-implant crowns: A randomized clinical trial. Clin Oral Implants Res 2011;22:62–69.
59. Buser D, Wittneben J, Bornstein MM, Grutter L, Chappuis V, Belser UC. Stability of contour augmentation and esthetic outcomes of implant-supported single crowns in the esthetic zone: 3-year results of a prospective study with early implant placement postextraction. J Periodontol 2011;82:342–349.
60. Meijndert L, Meijer HJ, Stellingsma K, Stegenga B, Raghoebar GM. Evaluation of aesthetics of implant-supported single-tooth replacements using different bone augmentation procedures: A prospective randomized clinical study. Clin Oral Implants Res 2007;18:715–719.
61. Gotfredsen K. A 5-year prospective study of single-tooth replacements supported by the Astra Tech implant: A pilot study. Clin Implant Dent Relat Res 2004;6:1–8.
62. Schropp L, Isidor F, Kostopoulos L, Wenzel A. Patient experience of, and satisfaction with, delayed-immediate vs delayed single-tooth implant placement. Clin Oral Implants Res 2004;15:498–503.
63. Chang M, Wennstrom JL, Odman P, Andersson B. Implant supported single-tooth replacements compared to contralateral natural teeth. Crown and soft tissue dimensions. Clin Oral Implants Res 1999;10: 185–194.
64. Chang M, Odman PA, Wennstrom JL, Andersson B. Esthetic outcome of implant-supported single-tooth replacements assessed by the patient and by prosthodontists. Int J Prosthodont 1999;12:335–341.
65. Kourkouta S, Dedi KD, Paquette DW, Mol A. Interproximal tissue dimensions in relation to adjacent implants in the anterior maxilla: Clinical observations and patient aesthetic evaluation. Clin Oral Implants Res 2009;20:1375–1385.