CLINICAL ORAL IMPLANTS RESEARCH

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A systematic review on survival and success rates of implants placed immediately into fresh extraction sockets after at least 1 year

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Conflicts of interest
The authors declare no conflict of interest.

Key words: extraction sockets, immediate implants, implant dentistry, success, survival, systematic review

Abstract

Background: Type I immediate implant placement has gained popularity because it may reduce treatment time, number of surgeries and post-extraction bone loss. However, this is potentially challenged by inadequate keratinized mucosa for flap adaptation and difficulties in achieving primary stability. Moreover, it has been proven that post-extraction bone loss is an inevitable biological process, which affects treatment outcomes.

Objectives: To estimate survival and success rates of implants and the implant-supported prostheses, the prevalence of biological, technical and aesthetic complications, and the magnitude of soft and hard tissue changes following implant placement immediately into fresh extraction sockets.

Material and methods: An electronic search in MEDLINE (PubMed) and the Cochrane Library from 1991 to July 2010 was performed to include prospective studies on immediate implants with a mean follow-up time of at least 1 year. The survival rates were computed using the STATA statistical software. Weighted means of soft and hard tissue changes were obtained by the inverse variance method.

Results: A total of 46 prospective studies, with a mean follow-up time of 2.08 years, were included. The annual failure rate of immediate implants was 0.82% (95% CI: 0.48–1.39%), translating into the 2-year survival rate of 98.4% (97.3–99%). Among the five factors analysed (reasons for extraction, antibiotic use, position of implant [anterior vs. posterior, maxilla vs. mandible), type of loading], only the regimen of antibiotic use affected the survival rate significantly. Lower failure rates were found in groups that were provided with a course of post-operative antibiotics. The success of implant therapy was difficult to assess due to scarce reporting on biological, technical and aesthetic complications. Soft tissue changes occurred mostly in the first 3 months after the provision of restoration, and then stabilized towards end of the first year. Marginal bone loss predominantly took place in the first year after implant placement, with a magnitude generally less than 1 mm. Controversy on hard tissue preservation with platform-switching technique remained unsolved.

Conclusions: Despite the high survival rate observed, more long-term studies are necessary to determine the success of implant treatment provided immediately after tooth extraction. Special attention has to be given to aesthetic outcomes.

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Forty years ago, the first dental implant to replace a missing tooth in human oral cavity was reported (Brånemark et al. 1969). It was a sensational breakthrough in dentistry as it marked a new era to restore chewing function and aesthetics. Ever since, implant dentistry developed emphasizing aspects like dental materials, surface chemistry (Jansen et al. 1991; Klokkevold et al. 1997; Lazzara et al. 1999; Salvi et al. 2004, surface characteristics (Carlsson et al. 1988); Buser et al. 1991; Abrahamsson et al. 2004), as well as soft and hard tissue biology. The technique of placing titanium oral implants in healed edentulous sites and subsequently restoring the implant with a prosthesis has been recognized to be a highly predictive treatment for fully and partially edentulous patients. In general, the 5-year survival rate of implants is approximately 95%, and the

10-year survival rate is greater than 89% (Pjetursson et al. 2004). Nevertheless, over the years, researchers tried to minimize the treatment time needed and hence, timing of implant placement has recently drawn a large share of attention.

As the debate in timing of implant placement increased, the following new classification based on morphologic, dimensional and histologic changes that follow tooth extraction was proposed at the Third ITI Consensus Conference (Hämmerle et al. 2004):

- Type 1: Immediate placement: an implant is placed immediately in an extraction socket as part of the same procedure with no healing of bone or soft tissues.
- Type 2: Early placement (typically 4–8 weeks of healing) with some soft tissue healing: the post-extraction site has healed soft tissue coverage of the alveolus but without significant bone healing.
- Type 3: Early placement with partial bone healing (typically 12–16 weeks of healing): The post-extraction site has both healed soft tissues and a significant degree of bone healing.
- Type 4: Late placement (more than 6 months after extraction): implant placement in a fully healed edentulous site.

Previously, practitioners allowed a socket healing time of 12 months or longer before placing dental implants to restore an edentulous space (Adell et al. 1981). Such a lag time brought the patient compromised comfort, function, and aesthetics. In 1978, the first report of a situation, in which the extraction followed by the placement of an implant into the fresh socket at the same appointment, was described as the "Türbingen immediate implant" (Schulte et al. 1978). This method reduced the number of dental appointments, the time of treatment and the number of surgeries required.

While immediate implant placement may yield attractive advantages, it has inherent disadvantages. The potential lack of keratinized mucosa for flap adaptation makes primary closure more difficult to be achieved in Type 1 than other types of implant placement. Moreover, the incongruity of size and shape between implants and extraction sockets presents challenges to primary implant stability. While initial implant stability is obtained by intimate contact with the pristine bone in healed sites, residual bony defects always exist around implants in Type 1 immediate implantation. Consequently, primary stability is only achieved by anchoring the implant in the apical bony region (3–4 mm), where cancellous bone predominates. Moreover, although both animal (Araujo et al. 2005) and human studies (Covani et al. 2004a) show that spontaneous bone fill occurs in the peri-implant marginal defects after 3–4 months when the defect size is 2 mm or less, immediate implant placement cannot prevent intra- and extra-alveolar modelling and remodelling leading to the inevitable vertical and horizontal reduction in both buccal and lingual alveolar bony walls, conspicuously in the buccal aspect. Such biological changes imply higher risk of marginal mucosal recession after immediate implant placement, and hence, non-aesthetic restorations in areas of aesthetic priority may result, especially when the facial socket wall and tissue biotype are thin (De Rouck et al. 2008b).

In the posterior region, immediate implants may also be exposed to the dilemma between the difficulty in achieving primary stability if placed in the centre of the socket or a substantial defect if positioned leaning towards either wall of the socket. Consequently, more questions are invited such as the minimum dimension of defects in need of grafting (Botticelli et al. 2003), subsequently the choice of grafting material as well as the risk in graft exposure and management. All these aspects related to immediate implants could possibly lower the survival rate of the implant.

In a series of systematic reviews (Pjetursson et al. 2004, 2007; Jung et al. 2008), survival and complication rates of fixed dental prosthesis, *formerly "fixed partial dentures"* (FPDs) and single crowns supported by oral implants were estimated. The 5-year survival rate of implants was >95% and that of FPDs and SCs were approximately 95%. Technical and biological complications were reasonably prevalent. In the review concerning peri-implant diseases (Zitzmann & Berglundh 2008), it was found that after 5–10 years in function, peri-implant mucositis occurred in approximately 80% of the subjects and in 50% of the implants. Peri-implantitis was found in 28–56% of the subjects and 12–43% of the implants.

In a recent Cochrane systematic review, success, complications, aesthetics and patient satisfaction among different timing of implant placement (immediate, immediate–delayed and delayed) after tooth extraction were evaluated (Esposito et al. 2010). Two studies of parallel group design, comparing immediate and delayed implant placement were included in this review. The meta-analysis of the two trials did not show any statistically significant difference between the two groups regarding prosthesis and implant failures. Concerning immediate vs. immediate–delayed implant placement only one trial was included in the review. There were eight patients in each group. Two years after implant placement, no implant failure and complications occurred, and no statistically significant difference was found with respect to the level of peri-implant marginal mucosa and marginal bone level changes. Based on the few under-powered trials, it was concluded that there was insufficient evidence to determine possible advantages or disadvantages of immediate, immediate–delayed or delayed implants (Esposito et al. 2010).

Therefore, the main objectives of this systematic review are to quantitatively estimate the survival and success rates of immediate implants and the implant-supported prosthesis, the prevalence of biological, technical and aesthetic complications, and the magnitude of soft and hard tissue changes following implant placement in fresh extraction sockets (Type 1).

Material and methods

Search strategy

An electronic search in MEDLINE (PubMed) and the Cochrane library from January 1991 to July 2010 was performed using the following search terms:

{Intervention}

[immediate implant*] **OR** [immediate implant placement*] **OR** [(immediate implant*] **AND** (extraction socket*)] **OR** [immediate implant installation*] **OR** [early implant placement*] **OR** [early implant installation]

and in combination with the outcome terms: **AND**

{Outcome}

[survival] **OR** [complication*] **OR** [failure*]

Moreover, manual searches of the biliographies of all full text articles and the following journals from January 2000 to December 2010 were also conducted:

- *Clinical Oral Implants Research*
- *International Journal of Oral & Maxillofacial Implants*
- *Journal of Clinical Periodontology*
- *Journal of Periodontology*
- *Journal of Prosthetic Dentistry*
- *Clinical Implant Dentistry & Related Research*
- *International Journal of Periodontics & Restorative Dentistry*
- *International Journal of Prosthodontics.*

Inclusion criteria

The studies to be selected had to yield the following inclusion criteria:

- English publications in the dental literature
- Human adults (≥18 years old) in good general health
- RCTs, prospective cohort studies and case series with a minimum of 10 subjects in the immediate implant placement group
- Studies with a mean follow-up time ≥12 month following implant placement
- Studies reporting survival rates of the immediate implants
- Studies without multiple interventions (e.g. sinus augmentation via the transalveolar approach)
- Studies which clearly state timing of restorations or loading protocol.

Selection of studies

After the electronic search, two independent reviewers (K. Y. L. and L. P.) screened all titles and determined the number of abstracts to be evaluated. Following this, the two independent reviewers screened all selected abstracts for possible inclusion in the review and determined the selection of full-text articles. The full texts of all studies of possible relevance were then obtained for independent assessment by the reviewers. Any disagreement was resolved by discussion. The κ-values were 0.85 and 0.76 at the title and abstract levels, respectively.

Fig. 1 describes the process of identifying the 46 studies selected from an initial yield of 5887 titles. In the included studies, two had publications repeated on the same patient cohorts. In this situation, only the one with a longer observation period was chosen. Reasons for exclusion of articles not considered were noted as well.

Excluded studies

Of the 164 full-text articles examined, 118 were excluded from the final analysis (reasons, see reference list).

The main reasons for exclusion were: (Fig. 1):

- Not reporting on immediate implants,
- Unknown survival rate of immediate implants in the study (no report/no separate report of the survival rate of immediate implants from other types of implant insertion),
- Unknown number of immediate implants,
- Mean follow-up time less than 1 year or unknown mean follow-up time,
- The sample size (number of subjects) less than 10 in the immediate implant group,
- Unknown number of patients treated with immediate implants,
- Multiple interventions (e.g. Sinus lift augmentation via the transalveolar approach) were carried out simultaneously with immediate implants and
- Unknown timing for restorations or unknown loading protocol.

Quality assessment

Two reviewers (K. Y. L. and L. P.) independently assessed the quality of randomized controlled trials and prospective cohort studies.

Randomized controlled trials

The risk of bias of RCTs was assessed according to the recommended approach suggested by the Cochrane Collaboration. In this two-part tool, six specific domains were addressed, namely sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting and other issues. A judgement of "Yes" indicated low risk of bias, "No" indicated high risk of bias, and "Unclear" indicated unclear or unknown risk of bias.

An RCT was assigned "Low risk of bias" if all key domains were of low risk of bias, "Unclear risk of bias" if there was unclear risk of bias of ≥1 key domains, and "High risk of bias" if ≥1 domains belonged to high risk of bias.

Prospective cohort studies

The quality of prospective cohort studies will be assessed using the Newcastle–Ottawa Scale (Wells et al. 2009). A maximum of nine

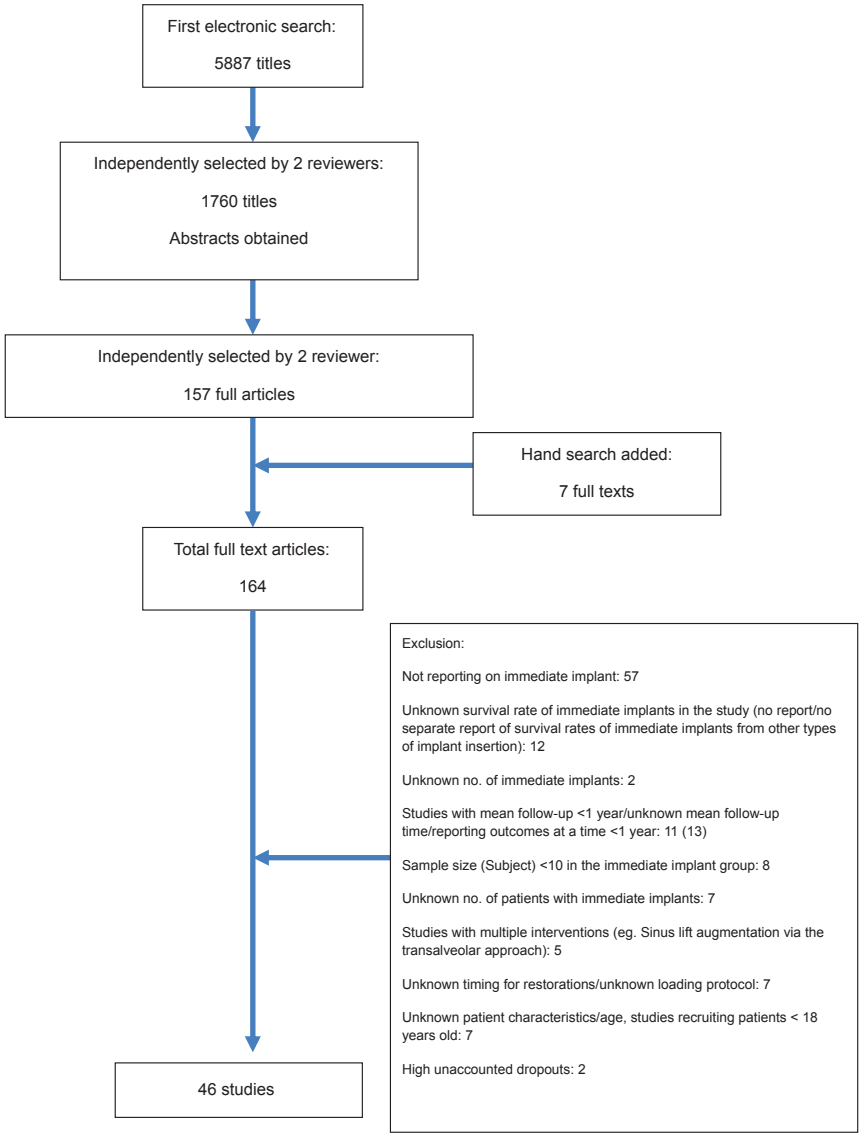

Fig. 1. Search strategy.

stars could be given to each study. Any study that scored less than five stars was excluded.

Data extraction

Data were extracted independently by the two reviewers (K. Y. L. & L. P.) using a data extraction form. Disagreement regarding data extraction was resolved by consensus after discussion.

Of the 46 studies included, information on the survival of the implants was retrieved. Survival was defined as implants remaining *in situ* at the follow-up examinations, irrespective of their conditions. Failure was defined as implants that were lost after implant placement immediately into the extraction socket.

For studies with a mean follow-up time of longer than 3 years, information regarding biological, technical and aesthetic complications was also extracted.

Biological complications included peri-implant mucositis and peri-implantitis. Peri-implant mucositis was defined as the presence of inflammation in the mucosa at the implant with no signs of supporting bone loss. Peri-implantitis was defined as the presence of inflammation in the mucosa and loss of supporting bone at the implant (Zitzmann & Berglundh 2008).

Technical complications denoted mechanical damage to implants, to implant components and/or the suprastructures. They included fractures of the implants, loss of retention, screw/abutment loosening, loss of access hole restorations, fracture of abutments/screws and fracture of veneering materials/framework of prosthesis.

Aesthetic outcomes were assessed by the Pink Esthetic Score (PES) introduced by Furhauser et al. (2005), and/or the papilla index described by Jemt (1997).

The PES was based on seven parameters: mesial papilla, distal papilla, soft tissue level, soft tissue contour, alveolar process deficiency, soft tissue colour, and texture. Each parameter was assessed with a 2-1-0 score, with 2 being the best and 0 being the worst result. A maximum score of 14 can be achieved. The aesthetic outcome was optimal if the PES was ≥ 10.

The papilla index (Jemt 1997) described the fullness of papillary fill:

- Index 0 = no papilla present
- Index 1 = less than one half the papilla height is present and a convex nature of the adjacent tissue nature is noted.
- Index 2 = greater than half the height of the papilla is present but not to the full extent of the contact point. Papilla is not in complete harmony.
- Index 3 = the papilla fills the entire proximal space and is in good harmony.
- Index 4 = the papilla is hyperplastic.

Data regarding marginal soft tissue changes in the vertical dimension and radiographic bony changes after immediate implant placement were also extracted.

Statistical analysis

Failure rates were calculated by dividing the number of events (failure or complication) in the numerator by the total exposure time (implant-time) in the denominator.

The numerator was usually extracted directly from the publications. The total exposure time was calculated by taking the sum of

1. The exposure time of implants that could be followed for the whole observation time.
2. The exposure time up to a failure of the implant that was lost during the observation time.
3. The exposure time up to the end of observation time for implants that did not complete the observation period due to reasons such as death, change of address, refusal to participate in the follow-up, chronic illness, missed appointments and work commitments.

For each study, event rates for implants were calculated by dividing the total number of events by the total implant exposure time in years. For further analysis, the total number of events was considered to be *Poisson* distributed for a given sum of implant exposure years and *Poisson* regression with a logarithmic link-function and total exposure time per study as an offset variable were used (Kirkwood & Sterne 2003a).

Robust standard errors were calculated to obtain 95% confidence intervals (CIs) of the summary estimates of the event rates. The Spearman goodness-of-fit statistics and associated *P*-values were calculated to assess heterogeneity of the study specific event rates. If the goodness-of-fit *P*-value was below 0.05, indicating heterogeneity, random-effects *Poisson* regression (with Gamma-distributed random-effects) was used to obtain a summary estimate of the event rates. One-year survival proportions were calculated via the relationship between event rates and survival function S, S(T) = exp(−T × event rate), by assuming constant event rates (Kirkwood & Sterne 2003b). The 95% CI for the survival proportions were calculated by using the 95% confidence limits of the event rates.

Multivariable *Poisson* regression was used to investigate whether reasons for extractions, use of antibiotics, locations of implants (anterior vs. posterior, maxillary vs. mandibular), and timing of restorations would affect the survival rate of immediate implants.

All analysis were performed using STATA/SE®, version 11 (Stata Corp., College Station, TX, USA).

To calculate vertical marginal soft tissue changes and radiographic bony changes, data obtained from studies at a specific time interval after restorations on immediate implants were pooled to derive the weighted mean and variance by the inverse variance method. The weighted mean was:

$$\bar{x} = \frac{\sum_{i=1}^{n}(x_i/\sigma_i^2)}{\sum_{i=1}^{n}(1/\sigma_i^2)},$$

and the variance of the weighted mean was:

$$\sigma_{\bar{x}}^2 = \frac{1}{\sum_{i=1}^{n}(1/\sigma_i^2)},$$

where x_i, σ_i^2 were the known mean and variance obtained from each study.

Moreover, to test for the homogeneity of the results of the studies, which contributed to a particular weighted mean, the chi-squared (χ^2, or Chi^2) test among these studies was carried out:

$$Q = \sum w_i(x_i - \bar{x})$$

where Q was the chi-squared statistic; w_i was the reciprocal of the variance of the effect of the ith study, i.e. $1/\sigma_i^2$; $\bar{x}$was the weighted mean; and x_i was the mean of the ith study. To quantify the inconsistency across the studies, the following statistic was used:

$$I^2 = \left(\frac{Q - df}{Q}\right) \times 100\%,$$

where df was its degrees of freedom (i.e. df = i−1, where i was the number of studies).

A rough guide to interpretation was as follows:

- I^2 = 0% to 40%: might not be important;
- I^2 = 30% to 60%: may represent moderate heterogeneity;
- I^2 = 50% to 90%: may represent substantial heterogeneity;
- I^2 = 75% to 100%: considerable heterogeneity.

Results

A total of 46 prospective studies on implants inserted immediately into extraction sockets were included in this systematic review.

With the exception of three studies (Becker et al. 1994; Lang et al. 1994; Becker et al. 1998), all the other 43 studies were published after the year 2000. Most studies had the mean follow-up time less than 3 years. Only nine studies reported implant survival rates with the mean observation period of 3 years or more.

The studies were mainly conducted in an institutional environment. Five studies were multicenter studies. There were 16 comparative studies. The test and control groups were recruited to compare (i) implants placed in extraction sockets vs. implants inserted at healed sites (Kan et al. 2007a; Ribeiro et al. 2008; Siciliano et al. 2009; Gokcen-Rohlig et al. 2010); (ii) immediate implants at sites with chronic periapical lesion vs. implants at healed sites (Lindeboom et al. 2006a); (iii) immediate implant placement at sites with chronic periapical lesion vs. at sites without periapical lesion (Crespi et al. 2010); (iv) implants in acutely infected sockets vs. implants in sockets without pathology (Siegenthaler et al. 2007); (v) immediate implant insertion and simultaneous connective tissue graft vs. coronally advanced flap (Cornelini et al. 2008); (vi) treatment of immediate implant and connective tissue graft vs. immediate implant only (Bianchi & Sanfilippo 2004); (vii) immediate implantation with GBR vs. without GBR (Bragger et al. 1996); (viii) submerged vs. non-submerged healing following implant placement in extraction sockets (Cordaro et al. 2009); (ix) immediate vs. delayed provisional restoration after immediate implant placement (Crespi et al. 2008; De Rouck et al. 2009; Prosper et al. 2010); (x) immediate implants restored with a platform-switching vs. a platform matching protocol (Crespi et al. 2009a; Canullo et al. 2009a,b).

Ten studies were randomized clinical trials (Bianchi & Sanfilippo 2004; Lindeboom et al. 2006a; Crespi et al. 2008; Cornelini et al. 2008; Cordaro et al. 2009; De Rouck et al. 2009; Canullo et al. 2009a,b; ; Crespi et al. 2009a; Siciliano et al. 2009; Prosper et al. 2010). Each study was assessed according to the recommended approach suggested by the Cochrane Collaboration. Four studies were judged to be at high and the remaining six studies at unclear risk of bias. (Fig. 2 and Table 1)

Five studies were prospective cohort studies, and were assessed using the Newcastle–Ottawa Scale (Wells et al. 2009). All of them scored eight of nine stars.

A total of 2130 patients, aged between 18 and 94 were included in the 46 studies. Totally, 3082 implants were placed in which 2934 were in fresh extraction sockets and 148 were in healed sites. Twenty-five implants in two studies were not restored (Fugazzotto 2002a); Vidal et al. 2010), and one implant in one study was lost to follow-up (Calvo-Guirado et al. 2009), leaving 2908 implants for further analysis. (Table 2)

Reasons for extraction

In 12 studies, implants were used to replace teeth extracted due to non-periodontal reasons, e.g. root fractures, caries, endodontic failure and root resorption (Table 2). Removal of teeth because of both periodontal and non-periodontal reasons was reported in 21 studies. In 13 studies, reasons for extraction were unclear.

Antibiotic prophylaxis

Antibiotics were prescribed in 33 studies (Table 2). Four studies involved pre-operative single dose of antibiotic prophylaxis, while post-operative antibiotic use of 5–7 days was reported in 15 studies. Fourteen studies provided both pre-operative single dose and post-surgical (5–7 days) antibiotic prescription. Data regarding antibiotic prescription were not forthcoming in the remaining studies.

Position of implants – anterior vs. posterior

In five studies, implants were inserted in the anterior region only, namely, central incisors, lateral incisors and canines (Table 2). Implants in another five studies were solely placed in posterior areas, i.e. premolars and molars. Thirty-five studies involved implantation in both anterior and posterior regions. One study did not state the implant locations.

Position of implants – maxilla vs. mandible

Eighteen studies reported on implants installed in the maxilla only, while only three studies had all implants placed in the mandible (Table 2). In 23 studies, both maxillary and mandibular arches were involved, and two studies did not explicitly specify the arch that implants were inserted.

Types of implants

Various implant systems were employed in the 46 studies (Table 2). The majority of the implants were rough surface implants. Only three studies used implants of machined surfaces (Goldstein et al. 2002; Becker et al. 1994, 1998).

Grafting materials

No grafting materials were utilized at all in six studies (Table 2). Eleven studies involved autogenous bone grafts. Bone substitutes were used in 16 studies, of which demineralised bovine bone matrix (DBBM) was most frequently applied. Other reported bone substitutes were demineralised freeze-dried bone allograft (DFDBA), enamel matrix derivatives (EMD), Biogran® bone graft, and HRT synthetic bone allograft. The main purposes of using grafting materials were to fill the marginal gaps between implants and socket walls and to cover bony dehiscences and/or fenestrations.

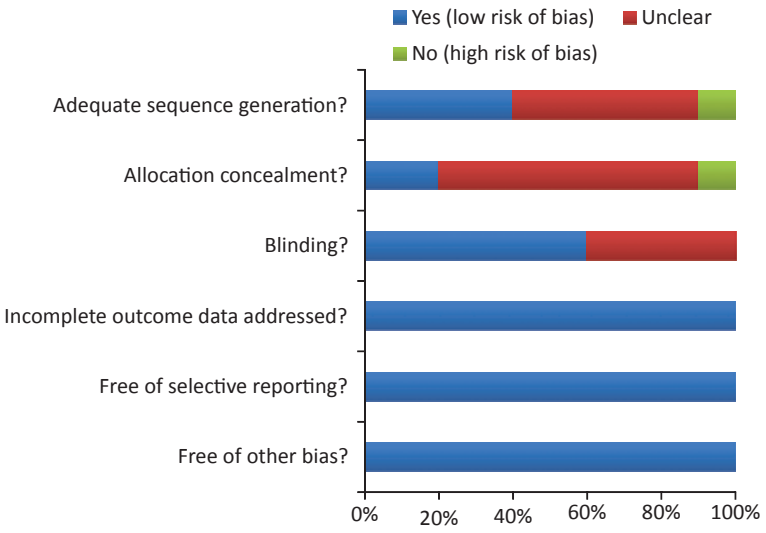

Fig. 2. "Risk of bias graph" of included RCTs.

Table 1. Summary of risk of bias of included RCTs

	Adequate sequence generation?	Allocation concealment?	Blinding?	Incomplete outcome data addressed?	Free of selective reporting?	Free of other bias?
Prosper et al. 2010	Unclear	Unclear	High	Low	Low	Low
Cordaro et al. 2009	Low	Low	High	Low	Low	low
De Rouck et al. 2009	Low	Unclear	Low	Low	Low	Low
Crespi et al. 2009a	Unclear	Unclear	High	Low	Low	Low
Canullo et al. 2009a,b	Low	Low	High	Low	Low	Low
Siciliano et al. 2009	High	High	High	Low	Low	Low
Crespi et al. 2008	Unclear	Unclear	Low	Low	Low	Low
Cornelini et al. 2008	Unclear	Unclear	Unclear	Low	Low	Low
Lindeboom et al. 2006a	Low	Unclear	Unclear	Low	Low	Low
Bianchi & Sanfilippo 2004	Unclear	Unclear	Low	Low	Low	Low

In 12 studies, the grafting materials were covered by barrier membranes. Resorbable membranes were more commonly used than non-resorbable membranes. In five studies, bony defects around implants were solely covered by barrier membranes.

Besides bone substitutes and barrier membranes, connective tissue grafting was also performed to cover immediate implants in six studies. Three studies reported a combined use of subepithelial connective tissue grafts (SCTG) with other grafting materials, while the other three employed SCTG as the only grafting material. The most common donor site was the palatal vault. This technique was mainly applied on subjects who were of the thin gingival biotype.

Loading

According to the Fourth ITI Consensus Report (Weber et al. 2009), immediate loading of dental implants was defined as loading being earlier than 1 week subsequent to implant placement; early loading was defined as loading being between 1 week and 2 months subsequent to implant placement; and conventional loading was loading being greater than 2 months subsequent to implant placement (Table 2).

Using definitions by this consensus report (Weber et al. 2009), implants in 19 studies were immediately loaded after implant insertion. Most of them used acrylic resin as the material for provisional restorations. Among the 19 studies, the provisionals were screw-retained in six studies and cement-retained in nine studies. One study used both methods for retention. Implants in 23 studies were conventionally restored. The time of loading varied from 8 weeks to 1 year, but most of them were loaded within 3–6 months. The remaining four studies had both immediate and conventionally loading groups.

Definitive restorations

In most studies, implants placed immediately into extraction sockets were used to replace single missing teeth and hence, the most prevalent prostheses constructed were single crowns (Table 2). In seven studies, some implants also served as abutments for implant–implant or implant–tooth supported fixed dental prostheses. In more than half of the studies, permanent restorations were retained by cement, while screw-retained restorations were used in only four studies.

Implant-supported overdentures were also reported in three studies (Huys 2001; Gokcen-Rohlig et al. 2010; Vidal et al. 2010). All the implants were conventionally loaded. Gokcen-Rohlig et al. (2010) used *locator* abutments, while Huys (2001) delivered ball-retained overdentures. In the third study, the type of abutments was not specified (Vidal et al. 2010).

Survival of implants

Survival was defined as implants remaining *in situ* at the follow-up examinations, irrespective of their conditions. Failure was defined as implants that were lost after immediate implant placement.

The 46 included studies provided data on 2908 implants with the mean follow-up time of 2.08 years following implant placement into the extraction sockets. Fifty-eight implants were lost during the observation period. The estimated annual failure rate of the implants was 0.82% (95% CI: 0.48–1.39%), yielding the 2-year survival rate of 98.4% (97.3–99%) (Table 3).

When the nine studies with the mean follow-up time $\geq$3 years were analysed separately, the estimated annual failure rate was 0.62% (95% CI: 0.31–1.23%), translating into a 4-year implant survival rate of 97.5% (95.2–98.8%) (Table 4).

Five factors were investigated for their impact on the survival of immediate implant: use of antibiotics, reasons for extractions, locations of implants (anterior vs. posterior, maxillary vs. mandibular), and timing of restorations:

Antibiotics

Four studies, with a total of 244 implants, involved a pre-operative single dose of antibiotic prophylaxis (Tables 5 and 6). Post-operative antibiotic use of 5–7 days was reported in 15 studies, involving 935 implants. Fourteen studies prescribed both pre-operative single dose and 5–7 days of post-operative antibiotics, and a total of 665 implants were examined. The relative failure rates of the three different groups were analysed with multivariable fixed-effect *Poisson* regression using pre-surgical antibiotic prophylaxis as the reference. The estimated annual failure rate for the pre-operative antibiotic use group was 1.87%. Both the post-operative antibiotic use group and pre- and post-operative antibiotic use group showed lower annual failure rates than did the pre-operative antibiotic use group, with the annual failure rates of 0.51% and 0.75%, respectively. The differences reached statistical significance (P = 0.002; 0.02).

Reasons for extraction

In 12 studies, 424 implants were used to replace teeth extracted due to non-periodontal reasons (Table 7). Removal of teeth because of both periodontal and non-periodontal reasons was reported in 21 studies, involving 1094 implants. The estimated annual failure rate of the former group was 0.81%, and that of the latter group was 0.92%. The difference in the failure rates was tested by using a random-effect *Poisson* regression analysis, and this difference did not reach statistical significance (P = 0.84).

Position of implants – anterior vs. posterior

In the 46 studies included, a total of 486 implants were placed in the anterior region and 967 implants were inserted in the posterior region (Table 8). The locations of the remainder of the 1455 implants were unclear. The estimated annual failure rate of implants placed in the posterior area was slightly higher than that of those placed in the ante-

Table 2. Summary table of included studies

Study	Year of publication	Study design	Setting	No of patients	Age range	Mean age	No of implants	Antibiotic use	Reasons for extraction	Position - Ant vs. Post	Position - Mx vs. Md	Implant	Grafting materials	Restorations on II-Timing	Restorations-definitives
Vidal et al.	2010	Prosp.	Institution	51	23–94	59	62 (8 unrestored)	Unknown	Unknown	Mixed	Mixed	Unknwon (sand-blasted, large grit, acid-etched surface)	Mineralized freeze-dried bone allograft + resorbable collagen membrane (Oragraft)	All conventional	40 single crowns (unknown type of retention), 14 support overdentures
Tortamano et al.	2010	Prosp.	Institution	12	22–54	Unknown	12	Unknown	Non-perio	All Ant: 12	All Mx: 12	Straumann TE implants	No grafting materials	All immediate	CMCs (screw-retained)
Gocen-Rohlig et al.	2010	Prosp.	Institution	10	49–68	54	40 (20 immediate implant)	Unknown	Perio + non-perio	Ant: 10, Post: 10	All Md: 20	AstraTech Osseospeed	Autogenous bone	All conventional	Overdentures on locator abutments.
Crespi et al.	2010	Prosp.	Institution	30	34–71	51.2	30	Pre + post	Non-perio	Ant: 15, Post: 15	Unknown: 30	Seven, Sweden-Martina	Unknown	All conventional	CMCs (cemented)
Prosper et al.	2010	Prosp.	Institution	71	26–72	58.3	120	Pre + post	Perio + non-perio	All Post: 120	All Md: 120	Bioactive Covering	Collagen sponge	immediate: 60, conventional: 60	Single CMCs (unknown type of retention)
Cordaro et al.	2009	RCT	Private, multicenter	30	18–70	Unknown	30	Unknown	Unknown	Mixed	Mixed	Straumann TE	No grafting materials	All conventional	Single crowns (unknown type of retention)
Calvo-Guirado et.al	2009	Prosp.	Institution	50	29–51	39.64	61 (1 lost to follow up)	Post	Non-perio	Ant: 46; Post: 14	All Mx: 60	3i, Osseotite	Unknown	All immediate	Porcelain crowns (cemented).
De Rouck et al.	2009	RCT	Institution	49	≥18	IRG: 55, DRG: 52	49	Unknown	Perio + non-perio	Mixed	All Mx: 49	Nobelreplace	Bio-Oss/Bio-Oss + Bio-Gide	Immediate: 24, conventional: 25	Single crowns (cemented)
Siciliano et al.	2009	Prosp.	Institution	30 (15 immediate implant)	≥18	48.1	30 (15 immediate implant)	Post	Non-perio	All Post: 15	Mixed	Straumann TE	Bio-Oss+ BioGide	All conventional	Single crowns (cemented)
Crespi et al.	2009	Prosp., comparative	Institution	45	25–67	48.73	64	Pre + post	Perio + non-perio	Mixed	Mx: 40, Md: 24	Seven Sweden & Martina, Ankylos Plus	No grafting materials	All immediate	CMCs (cemented)
Kan et al.	2009	Prosp.	Institution	20	28–71	52.3	20	Post	perio + non-perio	All Ant: 20	All Mx: 20	NobelReplace Tapered Groovy, NobelPerfect Groovy (Nobel biocare)	Bio-Oss + SCTG	All immediate	All-ceramic restorations (cemented)
Del Fabbro et al.	2009	Prosp.	Institution	30	31–75	55.8	61	Pre	Perio + non-perio	Ant: 21, post: 40	Mx: 30, Md: 31	unknown (acid-etched surface)	PRGFs	All conventional	14 partial prostheses, 26 single crowns (cemented)
Canullo et al.	2009	RCT	Private, 2 centres	22	32–76	50	22	Pre + post	Unknown	Ant: 6, Post: 16	All Mx: 22	unknown (sand-blasted, acid-etched, 0.3 mm machined neck)	Bio-Oss collagen + blood	All immediate	CMCs (cemented)
Kahnberg	2009	Prosp.	Institution	26	19–76	60	40	Unknown	Perio + non-perio	Mixed	Mixed	AstraTech TiOblast, TiOblast ST	Autologous bone	All conventional	Gold-ceramic crowns or gold-acrylic resin crowns (unknown type of retention)
Mijiritsky et al.	2009	Prosp.	Unknown	16	23–62	42	24	Pre	Perio + non-perio	Ant: 20, Post: 4	All Mx: 24	XIVE, Frialit-2, Seven MIS	Autogenous bone	All immediate	Single crowns (unknown type of retention)
Lops et al.	2008	Prosp.	Institution	46	18–71	47.2	46	Unknown	Non-perio	Mixed	Mx: 32, Md: 14	AstraTech Osseospeed	Unknown	All conventional	CMC/full porcelain (zirconia+porcelain) single crowns (cemented)
De Rouck et al.	2008	Prosp.	Institution	30	24–76	54	30	Pre + post	Perio + non-perio	Ant: 21, Post: 9	All Mx: 30	Nobelreplace, TiUnite	Bio-Oss	All immediate	CMCs (cemented)
Cafiero et al.	2008	Prosp.	Institution, multicenter	82	21–85	40.2	82	Post	Non-perio	All Post	Mx: 21, Md: 61	Straumann TE	Bio-Oss + Bio-Gide	All conventional	CMCs (cemented)
Cornelini et al.	2008	Prosp.	Unknown	34	21–62	43	34	Post	Perio + non-perio	Ant: 13, Post 21	Mx: 27, Md: 7	Straumann	Connective tissue graft/no connective tissue graft/ BioGide	All immediate	Single crowns (unknown type of retention)

Table 2. ***(continued)***

Study	Year of publication	Study design	Setting	No of patients	Age range	Mean age	No of implants	Antibiotic use	Reasons for extraction	Position - Ant vs. Post	Position - Mx vs. Md	Implant	Grafting materials	Restorations on II-Timing	Restorations-definitives
Fugazzotto	2008	Prosp.	Private	320	26–81	Unknown	341	Post	Unknown	All Post	All Md: 341	Straumann	DBBM/ demineralized allograft + cortical chips + Ti-reinforced ePTFE membrane or bioabsorbable membranes	All conventional	Single crowns (cemented)
Crespi et al.	2008	Prosp., randomized	Institution	40	24–68	47.21	40	Pre + post	Perio + non-perio	Ant: 24, Post: 16	All Mx: 40	Outlink	Unknown	Immediate: 20, conventional: 20	CMC (cemented)
Ribeiro et al.	2008	Prosp.	Institution & private	64	23–71	45.4	82 (46 immediate implant)	Post	Non-perio	Mixed	All Mx: 46	Conect, Conic	Unknown	All immediate	Single crowns (unknown type of retention)
Botticelli	2008	Prosp.	Private	18	21–81	49.1	21	Unknown	Non-perio	Ant: 5, post: 16	Mx: 16, Md: 5	Straumann	No grafting materials	All conventional	10 as abutments of FPDs (cemented), 11 single crowns
Kan et al.	2007	Prosp.	Institution	29 (19 immediate implants)	18-70	45.1	38 (23 immediate implants)	Post	Unknown	Mixed	All Mx: 23	TiUnite Nobel Biocare; Nobel Perfect Nobel Biocare	Autogenous bone graft + Bio-Oss	All immediate	Single crowns (cemented/ screw-retained)
Siegenthaler et al.	2007	Prosp.	Institution	29	23–82	Test: 45; Control: 55	29	Pre + post	Non-perio	Ant: 14, Post: 15	Mx: 23, Md: 6	Straumann	Bio-Oss + Bio-Gide	Immediate: 7, conventional: 22	Single crowns (unknown type of retention)
Covani et al.	2007	Prosp.	Institution	10	42–55	Unknown	10	Post	Perio + non-perio	Ant: 5, Post: 5	Mx: 7, Md: 3	Padova	Connective tissue graft	All conventional	Single crowns (unknown type of retention)
Kan et al.	2007	Prosp.	Institution	23	25–63	39.5	23	Post	Perio + non-perio	All Ant	All Mx: 23	Nobel Biocare: Replace select/ NobelPerfect	Autogenous bone/ xenograft + BioGide, + Subepithelial connective tissue graft	All immediate	CMCs (cemented)
Juodzbalys et al.	2007	Prosp.	Institution	12	18–49	28	14	Pre + post	Non-perio	All Ant	All Mx: 14	Nobel Biocare; Replace select	Bio-Oss + Bio-Gide + connective tissue graft	All conventional	Single crowns (cemented)
Crespi et al.	2007	Prosp.	Institution	27	42–72	57	160 (150 immediate implant)	Pre + post	Unknown	Mixed	Mixed	Outlink	Autogenous bone chips	All immediate	9 single crowns, 15 partial, 11 complete (cemented)
Barone et al.	2006	Prosp.	Institution	18	22–60	Unknown	18	Pre + post	Unknown	Mixed	Mixed	Premium	No grafting materials	All immediate	CMCs (cemented)
Lindeboom et al.	2006	Prosp.	Institution	50 (25 immediate implants)	19–69	39.7	50 (25 immediate implants)	Pre	Unknown	Mixed	Mixed	Frialit 2 synchro	Autogeneous corticocancellous bone + Bio-Gide	All conventional	Single crowns (cemented)
Ferrara et al.	2006	Prosp.	Institution	33	24–58	Unknown	33	Pre + post	Non-perio	Ant: 26, Post: 7	All Mx: 33	Frialit II	Autogenous bone grafts	All immediate	Single CMCs 6 months after implant placement
Cangini and Cornelini	2005	Prosp.	Private	32	21–60	45	32	Post	Perio + non-perio	Ant: 15, Post: 17	Mx: 15, Md: 17	Straumann	EMD/bioabsorble collagen membrane	All conventional	Single crowns (unknown type of retention)
Cornelini et al.	2005	Prosp.	Unknown	22	≥18	39	22	Post	Perio + non-perio	Ant: 9, Post: 13	Mx: 19, Md: 3	Straumann TE	BioGide	All immediate	Single crowns (unknown type of retention)
Vanden Bogaerde et al.	2005	Prosp.	Private	19	35–66	55	50	Pre + post	Unknown	Ant 19, Post: 31	Mx: 39, Md: 11	Mk IV TiUnite (Branemark)	Autogenous bone graft + resorbable membrane (Gore Resolut Adapt)	All immediate	Splinted FPDs (unknown type of retention)
Tsirlis	2005	Prosp.	Institution	38	20–60	Unknown	43 (28 immediate implants)	Unknown	Unknown	Mixed	All Mx: 28	NT Ossseotite 3I, Frialit-2	Biogran bone graft 3i + Bio-Gide	All immediate	Single crowns (unknown type of retention)
Norton	2004	Prosp.	Private	25 (16 immediate implant)	27–72	48.2	28 (16 immediate implants)	Pre + post	Perio + non-perio	Ant: 15, Post 1	All Mx: 16	Astra Tech ST	Unknown	All immediate	CMCs/all ceramic crowns (cemented)

Table 2. *(continued)*

Study	Year of publication	Study design	Setting	No of patients	Age range	Mean age	No of implants	Antibiotic use	Reasons for extraction	Position - Ant vs. Post	Position - Mx vs. Md	Implant	Grafting materials	Restorations on II-Timing	Restorations-definitives
Covani et al.	2004	Prosp.	Institution	95	20–68	Unknown	163	Post	Perio + non-perio	Ant: 82, Post: 81	Mx: 95, Md: 68	Premium (Sweden & Martina)	Autogenous bone graft + bioabsorbable membranes	All conventional	CMCs (screw-retained)
Bianchi et al.	2004	Prosp.	Institution	116	19–73	45.4	115	Unknown	Perio + non-perio	Mixed	Mixed	Straumann	SCTG	All conventional	CMCs (cemented)
Kan et al.	2003	Prosp.	Institution	35	18–65	36.5	35	Post	Non-perio	All Ant: 35	All Mx: 35	Replace, Nobel Biocare	Unknown	All immediate	CMCs (cemented)
Fugazzotto et al.	2002	Prosp.	Private	57	31–66	Unknown	63 (17 unrestored)	Unknown	Unknown	All Post: 46	All Mx: 46	Straumann/ Astra Tech	Autogenous bone chips + grafting materials	All conventional	CMCs, FPDs (cemented)
Goldstein et al.	2002	Prosp.	Institution	38	19–72	45.79	47	Unknown	Unknown	Ant: 16, Post: 31	All Mx: 47	Branemark, 3I.	DFDBA used to fill the defect/ barrier membranes	All conventional	Single crowns (unknown type of retention)
Huys	2001	Prosp.	Unknown	147	19–71	Unknown	556	Unknown	Unknown	Unknown	Unknown	Straumann: hollow screws, solid screws.	HRT synthetic bone allograft	All conventional	426: ball retained overdentures, 82: FPDs (cemented), 44 implant-tooth FPDs (cemented), 4 single crowns (cemented).
Becker et al.	1998	Prosp.	Institution	81	29–81	Unknown	134	Pre	Perio + non-perio	Mixed	Mixed	Branemark	No grafting materials	All conventional	Unknown (unknown type of retention)
Lang et al.	1994	Prosp.	Institution	21	20–81	Unknown	28	Post	Perio + non-perio	Mixed	Mixed	ITI Bonefit Dental implant System	E-PTFE barrier membrane	all conventional	13 CMCs (11: cemented, 2: screw-retained), 4: abutments of 3-unit FPDs, 4: implant-tooth supported FPDs.
Becker et al.	1994	Prosp.	Institution, multicenter	49	23–83	Unknown	49	Pre + post	Perio + non-perio	Mixed	Mixed	Nobelpharma AB, Gothenburg, Sweden	Oval 4 or Oval 6 e-PTFE tissue augmentation material + pedicle flap	All conventional	11 single crowns, 10 abutments for FPDs (cemented)

rior area (0.54% vs. 0.45%). However, the difference was not statistically significant ($P = 0.82$).

Position of implants – maxilla vs. mandible

In total, 933 implants were inserted in the maxilla, and 731 implants in the mandible (Table 9). The remainders were not specified about the implant position. The implants placed in the maxilla had a higher estimated annual failure rate (0.73%) than implants placed in the mandible (0.50%). However, in the *Poisson* regression analysis, this difference was not statistically significant ($P = 0.58$).

Loading

In the included studies, much more implants were conventionally ($n = 2086$) than immediately loaded ($n = 822$) (Table 10). The estimated annual failure rate of the conventional loading group was lower than that of the immediate loading group (0.75% vs. 0.89%). However, the difference, again, did not reach statistical significance in the *Poisson* regression analysis ($P = 0.73$).

Success

With regard to the success of an implant-related treatment, survival of the implants and their reconstructions should not be the ultimate goal of analysis. Rather, a successful treatment should be free of any biological and technical complications, and aesthetic outcomes should be satisfactory.

In this systematic review, the nine studies with the mean follow-up time of 3 years or more were evaluated for treatment success.

Biological complications

According to Lang & Berglundh (2011), the key parameter for the diagnosis of peri-implant mucositis was bleeding on gentle probing; and peri-implantitis was characterized by changes in the level of the crestal bone in conjunction with bleeding on probing with or without concomitant deepening of peri-implant pockets. Pus was a common finding in peri-implantitis sites.

To investigate the biological complications, the following parameters were considered:

1. Bleeding and suppuration on probing
2. Changes in marginal bone levels on radiographs

Among the nine studies, seven assessed radiographic bony changes; however, only three of them clinically assessed the peri-implant soft tissue response to periodontal

Table 3. Annual failure rates and survival of implants inserted in extraction sockets

	Year of publication	Total no. of implants	Mean follow-up time	No. of failure	Before loading	After loading	Loss to follow-up	Total implant exposure time (years)	Estimated failure rate (per 100 implant years)	Estimated survival (%) after 2 years
Vidal et al.	2010	54	1	0	0	0	0	54	0	100
Tortamano et al.	2010	12	1.5	0	na	0	0	18	0	100
Gocen-Rohlig et al.	2010	20	2.33	0	0	0	0	46.67	0	100
Crespi et al.	2010	30	2	0	0	0	0	60	0	100
Prosper et al.	2010	120	5	4	1	3	0	580.46	0.69	98.62
Mijiritsky et al.	2009	24	3.27	1	na	1	0	78.5	1.27	97.45
Crespi et al.	2009	64	2	0	na	0	0	128	0	100
Kan et al.	2009	20	2.15	0	na	0	0	43	0	100
Del Fabbro et al.	2009	61	1.79	1	1	0	0	107.67	0.93	98.14
Canullo et al.	2009	22	2.08	0	na	0	0	45.83	0	100
Kahnberg	2009	40	2	0	0	0	0	80	0	100
Cordaro et al.	2009	30	1.5	1	1	0	0	43.73	2.29	95.43
Calvo-Guirado et al.	2009	61	1	1	na	1	1	59.33	1.69	96.63
De Rouck et al.	2009	49	1.07	3	2	1	0	52.33	5.73	88.54
Siciliano et al.	2009	15	1	0	0	0	0	15	0	100
Botticelli et al.	2008	21	5	0	0	0	0	105	0	100
Lops et al.	2008	46	1.15	0	0	0	0	53.08	0	100
De Rouck et al.	2008	30	1	1	na	1	0	29.08	3.44	93.12
Cornelini et al.	2008	34	1	0	na	0	0	34	0	100
Fugazzotto	2008	341	2.72	2	1	1	0	929.06	0.22	99.57
Crespi et al.	2008	40	2	0	0	0	0	80	0	100
Ribeiro et al.	2008	46	2.17	3	na	3	0	99.91	3	93.99
Cafiero et al.	2008	82	1	0	0	0	0	82	0	100
Crespi et al.	2007	150	1.5	0	0	0	0	225	0	100
Kan et al.	2007	23	1	0	na	0	0	23	0	100
Siegenthaler et al.	2007	29	1	0	0	0	0	29	0	100
Covani et al.	2007	10	1	0	0	0	0	10	0	100
Kan et al.	2007	23	1	0	na	0	0	23	0	100
Juodzbalys et al.	2007	14	2	0	0	0	0	28	0	100
Barone et al.	2006	18	1	1	na	1	0	17.08	5.86	88.29
Lindeboom et al.	2006	25	1	2	2	0	0	24	8.33	83.33
Ferrara et al.	2006	33	2.34	2	na	2	0	77.25	2.59	94.82
Cangini and Cornelini	2005	32	1	0	0	0	0	32	0	100
Cornelini et al.	2005	22	1	0	na	0	0	22	0	100
Vanden Bogaerde et al.	2005	50	1.5	0	0	0	0	75	0	100
Tsirlis	2005	28	2	0	0	0	0	56	0	100
Norton	2004	16	1.61	0	na	0	0	25.75	0	100
Covani et al.	2004	163	4	5	2	3	0	636.5	0.79	98.43
Bianchi et al.	2004	115	5.38	0	0	0	0	618.5	0	100
Kan et al.	2003	35	1.39	0	na	0	0	48.71	0	100
Goldstein et al.	2002	47	3.37	0	0	0	0	158.5	0	100
Fugazzotto et al.	2002	46	1.40	0	0	0	0	64.33	0	100
Huys	2001	556	7	19	19	0	0	3763.75	0.50	98.99
Becker et al.	1998	134	3.61	9	2	7	0	483.17	1.86	96.27
Lang et al.	1994	28	3.28	0	0	0	0	91.93	0	100
Becker et al.	1994	49	1.51	3	3	0	0	74.06	4.05	91.90
Summary estimate (95% CI)*		2908	2.08	58	34	24	1	9431.17	0.82 (0.48–1.39)	98.4 (97.3–99)

*Based on random-effects *Poisson* regression, test for heterogeneity $P < 0.01$.

probing (Bianchi & Sanfilippo 2004; Botticelli et al. 2008; Prosper et al. 2010).

Bleeding and suppuration on probing

Three studies reported on the effectiveness of patients' self-performed oral hygiene (Bianchi & Sanfilippo 2004; Botticelli et al. 2008; Prosper et al. 2010). The prevalence of plaque accumulation on implants varied among the studies. In both studies of Prosper et al. (2010) and Botticelli et al. (2008), the sites with plaque accumulation were less than 20%. However, 40% of implant sites harboured plaque in the study of Bianchi & Sanfilippo (2004). As a result, BOP was more prevalent at implants in the latter study than in the two former studies (31% vs. 6–17%).

With the criteria defined above (Lang & Berglundh (2011), 31% of implants demonstrated peri-implant mucositis in the study by Bianchi & Sanfilippo (2004), while in the two other studies (Botticelli et al. 2008; Prosper et al. 2010), peri-implant mucositis was less prevalent.

Change in marginal bone levels

Seven studies with a mean follow-up time $\geq$3 years evaluated marginal bony alterations (Becker et al. 1998; Huys 2001; Bianchi & Sanfilippo 2004; Covani et al. 2004b; Botticelli et al. 2008; Mijiritsky et al. 2009; Prosper et al. 2010). With the exception that there was a 0.23 mm gain in the mean radiographic bone level in one study (Botticelli et al. 2008), immediate implants in most studies experienced marginal bone loss after being in service. However, in most of the cases, the loss was within the range that fulfilled one of the success criteria stated by Albrektsson et al. (1986), namely, that "after the first year of service, the annual vertical bone loss should not exceed 0.2 mm."

Covani et al. (2004b) reported that 4 years after implant placement immediately into

Table 4. Annual failure rates and survival of implants inserted in extraction sockets. (studies with mean follow-up time ≥ 3 years)

Study	Year of publication	Total no. of implants	Mean follow-up time	No. of failure	Before Loading	After loading	Loss to follow-up	Total implant exposure time (years)	Estimated failure rate (per 100 implant yeaers)	Estimated survival (%) after 4 years
Prosper et al.	2010	120	5	4	3	1	0	580.46	0.69	97.24
Mijiritsky et al.	2009	24	3.27	1	na	1	0	78.5	1.27	94.90
Botticelli et al.	2008	21	5	0	0	0	0	105	0	100
Covani et al.	2004	163	4	5	2	3	0	636.5	0.79	96.86
Bianchi et al.	2004	115	5.38	0	0	0	0	618.5	0	100
Goldstein et al.	2002	47	3.37	0	0	0	0	158.5	0	100
Huys	2001	556	7	19	19	0	0	3763.75	0.50	97.98
Becker et al.	1998	134	3.61	9	6	3	0	483.17	1.86	92.55
Lang et al.	1994	28	3.28	0	0	0	0	91.93	0	100
Summary estimate (95% CI)*		1208	4.43	38	30	8	0	6516.31	0.62 (0.31–1.23)	97.5 (95.2–98.8)

*Based on random-effects *Poisson* regression, test for heterogeneity $P < 0.01$.

Table 5. Comparison of annual failure rates and survival of implants inserted in extraction sockets – antibiotic uses (pre-surgical vs. post-surgical vs. pre- and post-surgical)

Study	Year of publica-tion	Total no. of implants	Mean follow-up time (years)	No. of failure at 1 year after implant placement	Before loading	After loading	Lost to follow-up	Total implant exposure time (years)	Estimated failure rate (per 100 implant years)	Estimated survival after 2 years (%)
Pre-surgical antibiotic use										
Del Fabbro et al.	2009	61	1.79	1	1	0	0	107.67	0.93	98.14
Mijiritsky et al.	2009	24	3.27	1	na	1	0	78.5	1.27	97.45
Lineboom et al.	2006	25	1	2	2	0	0	24	8.33	83.33
Becker et al.	1998	134	3.61	9	2	7	0	483.17	1.86	96.27
Summary estimate (95% CI)*		244	2.42	3.25	5	8	0	693.33	1.87 (1.09–3.23)	96.3 (93.7–97.8)
Post-surgical antibiotic use										
Calvo-Guirado et al.	2009	61	1	1	na	1	1	59.33	1.69	96.63
Siciliano et al.	2009	15	1	0	0	0	0	15	0	100
Kan et al.	2009	20	2.15	0	na	0	0	43	0	100
Cafiero et al.	2008	82	1	0	0	0	0	82	0	100
Fugazzotto	2008	341	2.72	2	1	1	0	929.06	0.22	99.57
Ribeiro et al.	2008	46	2.17	3	na	3	0	99.91	3	93.99
Cornelini et al.	2008	34	1	0	na	0	0	34	0	100
Kan et al.	2007	23	1	0	na	0	0	23	0	100
Covani et al.	2007	10	1	0	0	0	0	10	0	100
Kan et al.	2007	23	1	0	na	0	0	23	0	100
Cangini and Cornelini	2005	32	1	0	0	0	0	32	0	100
Cornelini et al.	2005	22	1	0	na	0	0	22	0	100
Covani et al.	2004	163	4	5	2	3	0	636.5	0.79	98.43
Kan et al.	2003	35	1.39	0	na	0	0	48.71	0	100
Lang et al.	1994	28	3.28	0	0	0	0	91.93	0	100
Summary estimate (95% CI)*		935	1.65	11	3	8	1	2149.44	0.51 (0.13–1.97)	99 (96.1–99.7)
Pre + post-surgical antibiotic use										
Prosper et al.	2010	120	5	4	1	3	0	580.46	0.69	98.62
Crespi et al.	2010	30	2	0	0	0	0	60	0	100
Crespi et al.	2009	64	2	0	na	0	0	128	0	100
Canullo et al.	2009	22	2.08	0	na	0	0	45.83	0	100
Crespi et al.	2008	40	2	0	0	0	0	80	0	100
De Rouck et al.	2008	30	1	1	na	1	0	29.08	3.44	93.12
Siegenthaler et al.	2007	29	1	0	0	0	0	29	0	100
Juodzbalys et al.	2007	14	2	0	0	0	0	28	0	100
Crespi et al.	2007	150	1.5	0	0	0	0	225	0	100
Barone et al.	2006	18	1	1	na	1	0	17.08	5.86	88.29
Ferrara et al.	2006	33	2.34	2	na	2	0	77.25	2.59	94.82
Vanden Bogaerde et al.	2005	50	1.5	0	0	0	0	75	0	100
Norton	2004	16	1.61	0	na	0	0	25.75	0	100
Becker et al.	1994	49	1.51	3	3	0	0	74.06	4.05	91.90
Summary estimate (95% CI)*		665	1.90	11	4	7	0	1474.51	0.75 (0.19–1.75)	98.5 (96.6–99.6)

*Based on fixed-effects *Poisson* regression, test for heterogeneity $P = 0.1$

Table 6. Summary of annual failure rates, relative failure rates and survival estimates for implants inserted in extraction sockets - antibiotic uses

Type of antibiotics use	Total number of implants	Total implant exposure time (years)	Mean follow-up time	Estimated annual failure rate†	2 year survival summary estimate (95% CI)†	Relative failure rate*	*P*-value*
Pre-surgical	244	693.33	2.42	1.87 (1.09–3.23)	96.3 (93.7–97.8)	1 (Ref.)	
Post-surgical	935	2149.44	1.65	0.51 (0.13–1.97)	99 (96.1–99.7)	0.27 (0.12–0.61)	0.002
Pre- and post-surgical	665	1474.51	1.9	0.75 (0.19–1.75)	98.5 (96.6–99.6)	0.40 (0.18–0.89)	0.024

*Based on multivariable fixed-effect *Poisson* regression.
†Based on fixed-effects *Poisson* regression.

Table 7. Comparison of annual failure rates and survival of implants inserted extraction sockets – reasons for extraction

Study	Year of publication	Total no. of implants	Mean follow-up time (year)	No. of failure at 1 year after implant placement	Before loading	After loading	Lost to follow-up	Total implant exposure time (years)	Estimated failure rate (per 100 implant years)	Estimated survival after 2 year (%)
Non-periodontal reasons										
Tortamano et al.	2010	12	1.5	0	na	0	0	18	0	100
Crespi et al.	2010	30	2	0	0	0	0	60	0	100
Calvo-Guirado et al.	2009	61	1	1	na	1	1	59.33	1.69	96.63
Siciliano et al.	2009	15	1	0	0	0	0	15	0	100
Lops et al.	2008	46	1.15	0	0	0	0	53.08	0	100
Cafiero et al.	2008	82	1	0	0	0	0	82	0	100
Ribeiro et al.	2008	46	2.17	3	na	3	0	99.91	3	93.99
Botticelli et al.	2008	21	5	0	0	0	0	105	0	100
Siegenthaler et al.	2007	29	1	0	0	0	0	29	0	100
Juodzbalys et al.	2007	14	2	0	0	0	0	28	0	100
Ferrara et al.	2006	33	2.34	2	na	2	0	77.25	2.59	94.82
Kan et al.	2003	35	1.39	0	na	0	0	48.71	0	100
Summary estimate (95% CI)*		424	1.80	6	0	6	1	675.28	0.81 (0.29–2.29)	98.4 (95.5–99.4)
Periodontal and non-periodontal reasons										
Gocen-Rohlig et al.	2010	20	2.33	0	0	0	0	46.67	0	100
Prosper et al.	2010	120	5	4	1	3	0	580.46	0.69	98.62
Mijiritsky et al.	2009	24	3.27	1	na	1	0	78.5	1.27	97.45
De Rouck et al.	2009	49	1.07	3	2	1	0	52.33	5.73	88.54
Crespi et al.	2009	64	2	0	na	0	0	128	0	100
Kan et al.	2009	20	2.15	0	na	0	0	43	0	100
Del Fabbro et al.	2009	61	1.79	1	1	0	0	107.67	0.93	98.14
Kahnberg	2009	40	2	0	0	0	0	80	0	100
Crespi et al.	2008	40	2	0	0	0	0	80	0	100
De Rouck et al.	2008	30	1	1	na	1	0	29.08	3.44	93.12
Cornelini et al.	2008	34	1	0	na	0	0	34	0	100
Covani et al.	2007	10	1	0	0	0	0	10	0	100
Kan et al.	2007	23	1	0	na	0	0	23	0	100
Cangini and Cornelini	2005	32	1	0	0	0	0	32	0	100
Cornelini et al.	2005	22	1	0	na	0	0	22	0	100
Norton	2004	16	1.61	0	na	0	0	25.75	0	100
Covani et al.	2004	163	4	5	2	3	0	636.5	0.79	98.43
Bianchi et al.	2004	115	5.38	0	0	0	1	618.5	0	100
Becker et al.	1998	134	3.61	9	2	7	0	483.17	1.86	96.27
Lang et al.	1994	28	3.28	0	0	0	0	91.93	0	100
Becker et al.	1994	49	1.51	3	3	0	0	74.06	4.05	91.90
Summary estimate (95% CI)*		1094	2.24	27	11	16	1	3276.61	0.92 (0.09–9.15)	98.2 (83.3–99.8)

*Based on random-effects *Poisson* regression, test for heterogeneity $P = 0.01$.

the extraction socket, 4.2% or 7 of 163 implants showed crestal bone contact apical to the first thread, among which six implants had bone contact between the first and second thread, and one implant presented bone loss up to the level of the third thread. Unfortunately, this study did not provide information on BOP.

Based on the limited studies and the inconsistent ways of assessing the soft tissues, it was difficult to estimate the prevalence of peri-implantitis.

Technical complications

Only three studies assessed technical complications that occurred in an observation period ≥ 3 years. Lang et al. (1994) reported that "the reconstructions were complication-free." Prosper et al. (2010) stated that "no pain or mobility of the definitive prosthesis was registered" in the 5-year follow-up period.

Covani et al. (2004b) provided more detailed information concerning prosthetic complications. In this 4-year study, no fractures of abutments and/or prosthetic screws were documented. No prostheses needed to be replaced. The only prosthetic complication that occurred (9.8% of implants) was the loosening of the abutment screw.

Table 8. Comparison of annual failure rates and survival of implants inserted extraction sockets – anterior vs. posterior

Study	Year of publication	Total no. of implants	Mean follow-up time (year)	No. of failure at 1 year after implant placement	Before loading	After loading	Lost to follow-up	Total implant exposure time	Estimated failure rate (per 100 implant years)	Estimated survival after 2 year (%)
Anterior										
Tortamano et al.	2010	12	1.5	0	0	0	0	18	0	100
Gocen-Rohlig et al.	2010	10	2.33	0	0	0	0	23.33	0	100
Crespi et al.	2010	15	2	0	0	0	0	30	0	100
Kan et al.	2009	20	2.15	0	na	0	0	43	0	100
Del Fabbro et al.	2009	21	1.79	0	0	0	0	37.63	0	100
Canullo et al.	2009	6	2.08	0	na	0	0	12.5	0	100
Calvo-Guirado et al.	2009	46	1	0	0	0	1	46	0	100
Mijiritsky et al.	2009	20	3.57	0	na	0	0	71.42	0	100
Botticelli et al.	2008	5	5	0	0	0	0	25	0	100
De Rouck et al.	2008	21	1	1	na	1	0	20.08	4.98	90.04
Cornelini et al.	2008	13	1	0	na	0	0	13	0	100
Crespi et al.	2008	24	2	0	0	0	0	48	0	100
Siegenthaler et al.	2007	14	1	0	0	0	0	14	0	100
Covani et al.	2007	5	1	0	0	0	0	5	0	100
Kan et al.	2007	23	1	0	na	0	0	23	0	100
Juodzbalys et al.	2007	14	2	0	0	0	0	28	0	100
Ferrara et al.	2006	26	2.38	2	na	2	0	61.83	3.23	93.53
Cangini and Cornelini	2005	15	1	0	0	0	0	15	0	100
Cornelini et al.	2005	9	1	0	na	0	0	9	0	100
Vanden Bogaerde et al.	2005	19	1.5	0	0	0	0	28.5	0	100
Norton	2004	15	1.58	0	na	0	0	23.75	0	100
Covani et al.	2004	82	4	2	1	1	0	321.83	0.62	98.76
Kan et al.	2003	35	1.39	0	na	0	0	48.71	0	100
Goldstein et al.	2002	16	2.77	0	0	0	0	44.33	0	100
Summary estimate (95% CI)*		486	1.92	5	1	4	1	1010.92	0.45 (0.15–1.36)	99.1 (97.3–99.7)
Posterior										
Prosper et al.	2010	120	5	4	1	3	0	580.46	0.69	98.62
Gocen-Rohlig et al.	2010	10	2.33	0	0	0	0	23.33	0	100
Crespi et al.	2010	15	2	0	0	0	0	30	0	100
Del Fabbro et al.	2009	40	1.79	1	1	0	0	70.04	1.43	97.14
Canullo et al.	2009	16	2.08	0	0	0	0	33.33	0	100
Mijiritsky et al.	2009	4	1.77	1	na	1	0	7.08	14.12	71.76
Calvo-Guirado et al.	2009	15	1	1	na	1	1	13.33	7.5	85
Siciliano et al.	2009	15	1	0	0	0	0	15	0	100
De Rouck et al.	2008	9	1	0	na	0	0	9	0	100
Cafiero et al.	2008	82	1	0	0	0	0	82	0	100
Cornelini et al.	2008	21	1	0	na	0	0	21	0	100
Fugazzotto	2008	341	2.72	2	1	1	0	929.06	0.22	99.57
Crespi et al.	2008	16	2	0	0	0	0	32	0	100
Botticelli et al.	2008	16	5	0	0	0	0	80	0	100
Siegenthaler et al.	2007	15	1	0	0	0	0	15	0	100
Covani et al.	2007	5	1	0	0	0	0	5	0	100
Ferrara et al.	2006	7	2.20	0	na	0	0	15.42	0	100
Cangini and Cornelini	2005	17	1	0	0	0	0	17	0	100
Cornelini et al.	2005	13	1	0	na	0	0	13	0	100
Vanden Bogaerde et al.	2005	31	1.5	0	0	0	0	46.5	0	100
Covani et al.	2004	81	4	3	1	2	0	314.67	0.95	98.09
Norton	2004	1	2	0	na	0	0	2	0	100
Fugazzotto et al.	2002	46	1.40	0	0	0	0	64.33	0	100
Goldstein et al.	2002	31	3.68	0	0	0	0	114.17	0	100
Summary estimate (95% CI)*		967	2.02	12	4	8	1	2532.72	0.54 (0.04–7.05)	98.9 (86.8–99.9)

*Based on random-effects *Poisson* regression, test for heterogeneity $P = 0.0488$.

Table 9. Comparison of annual failure rates and survival of implants inserted in extraction sockets – maxilla vs. mandible

Study	Year of publication	Total no. of implants	Mean follow-up time (year)	No. of failure at 1 year after implant placement	Before loading	After loading	Lost to follow-up	Total implant exposure time	Estimated failure rate (per 100 implant years)	Estimated survival after 2 year (%)
Maxilla										
Tortamano et al.	2010	12	1.5	0	na	0	0	18	0	100
Calvo-Guirado et al.	2009	61	1	1	na	1	1	59.33	1.69	96.63
De Rouck et al.	2009	49	1.07	3	2	1	0	52.33	5.73	88.54
Crespi et al.	2009	40	2	0	na	0	0	80	0	100
Kan et al.	2009	20	2.15	0	na	0	0	43	0	100
Del Fabbro et al.	2009	30	1.79	0	0	0	0	53.75	0	100
Canullo et al.	2009	22	2.08	0	na	0	0	45.83	0	100
Mijiritsky et al.	2009	24	3.27	1	na	1	0	78.5	1.27	97.45
Botticelli et al.	2008	16	5	0	0	0	0	80	0	100
Crespi et al.	2008	40	2	0	0	0	0	80	0	100
Ribeiro et al.	2008	46	2.17	3	na	3	0	99.91	3	93.99
Lops et al.	2008	32	1.15	0	0	0	0	36.92	0	100
De Rouck et al.	2008	30	1	1	na	1	0	29.08	3.44	93.12
Cafiero et al.	2008	21	1	0	0	0	0	21	0	100
Cornelini et al.	2008	27	1	0	na	0	0	27	0	100
Kan et al.	2007	23	1	0	na	0	0	23	0	100
Siegenthaler et al.	2007	23	1	0	0	0	0	23	0	100
Covani et al.	2007	7	1	0	0	0	0	7	0	100
Kan et al.	2007	23	1	0	na	0	0	23	0	100
Juodzbalys et al.	2007	14	2	0	0	0	0	28	0	100
Ferrara et al.	2006	33	2.34	2	na	2	0	77.25	2.59	94.82
Cangini and Cornelini	2005	15	1	0	0	0	0	15	0	100
Cornelini et al.	2005	19	1	0	na	0	0	19	0	100
Vanden Bogaerde et al.	2005	39	1.5	0	0	0	0	58.5	0	100
Tsirlis	2005	28	2	0	0	0	0	56	0	100
Norton	2004	16	1.61	0	na	0	0	25.75	0	100
Covani et al.	2004	95	4	2	1	1	0	373.75	0.54	98.93
Kan et al.	2003	35	1.39	0	na	0	0	48.71	0	100
Fugazzotto et al.	2002	46	1.40	0	0	0	0	64.33	0	100
Goldstein et al.	2002	47	3.37	0	0	0	0	158.5	0	100
Summary estimate (95% CI)*		933	1.79	13	3	10	1	1805.46	0.73 (0.06–8.28)	98.6 (84.7–99.9)
Mandible										
Gocen-Rohlig et al.	2010	20	2.33	0	0	0	0	46.67	0	100
Prosper et al.	2010	120	5	4	1	3	0	580.46	0.69	98.62
Crespi et al.	2009	24	2	0	na	0	0	48	0	100
Del Fabbro et al.	2009	31	1.79	1	1	0	0	53.92	1.85	96.29
Lops et al.	2008	14	1.15	0	0	0	0	16.15	0	100
Cafiero et al.	2008	61	1	0	0	0	0	61	0	100
Cornelini et al.	2008	7	1	0	na	0	0	7	0	100
Fugazzotto	2008	341	2.72	2	1	1	0	929.06	0.22	99.57
Botticelli et al.	2008	5	5	0	0	0	0	25	0	100
Siegenthaler et al.	2007	6	1	0	0	0	0	6	0	100
Covani et al.	2007	3	1	0	0	0	0	3	0	100
Cangini and Cornelini	2005	17	1	0	0	0	0	17	0	100
Cornelini et al.	2005	3	1	0	na	0	0	3	0	100
Vanden Bogaerde et al.	2005	11	1.5	0	0	0	0	16.5	0	100
Covani et al.	2004	68	4	3	1	2	0	262.75	0.38	99.24
Summary estimate (95% CI)*		731	2.10	10	4	6	0	2075.50	0.50 (0.17–1.52)	99 (97.0–99.7)

*Based on random-effects Poisson regression, test for heterogeneity $P = 0.05$.

In conclusion, there was insufficient data provided by the included papers to quantify technical/prosthetic complications.

Aesthetic outcomes

Only two studies (Bianchi & Sanfilippo 2004; Botticelli et al. 2008) evaluated the aesthetic results. In one study (Bianchi & Sanfilippo 2004), the buccal level of mucosal margin at prosthetic crown was compared with the level of the buccal gingival margin of the mesial and distal adjacent closest tooth crown. The threshold for the acceptable discrepancy was set at 1 mm. The data demonstrated complete success for the first 3 years, in the group of patients who received immediate implant placement and simultaneous connective tissue grafting, while only 80% of patients who were solely treated with immediate implants were considered successful. In the following 6 years, a small increase in the number of patients (<5%) who presented discrepancies of >1 mm was observed in both groups. The study concluded that soft tissue levels were generally stable following immediate implant placement, when connective tissue grafting was performed.

In the second study (Botticelli et al. 2008), the position of the mucosal margin during a 5-year period was followed. The mucosal margin moved 0.3 mm coronally at the proximal aspects, while there was an overall reces-

Table 10. Comparison of annual failure rates and survival of implants inserted in extraction sockets – loading protocol (immediate vs. conventional)

Study	Year of publication	Total no. of implants	Mean follow-up time (year)	No. of failure at 1 year after implant placement	Before loading	After loading	Lost to follow-up	Total implant exposure time	Estimated failure rate (per 100 implant years)	Estimated survival after 2 year (%)
Immediate loading										
Tortamano et al.	2010	12	1.5	0	na	0	0	18	0	100
Prosper et al.	2010	60	5	2	na	2	0	290.16	0.69	98.62
Mijiritsky et al.	2009	24	3.27	1	na	1	0	78.5	1.27	97.45
Calvo-Guirado et al.	2009	61	1	1	na	1	1	59.33	1.69	96.63
De Rouck et al.	2009	24	1	1	na	1	0	23.08	4.33	91.34
Crespi et al.	2009	64	2	0	na	0	0	128	0	100
Kan et al.	2009	20	2.15	0	na	0	0	43	0	100
Canullo et al.	2009	22	2.08	0	na	0	0	45.83	0	100
De Rouck et al.	2008	30	1	1	na	1	0	29.08	3.44	93.12
Cornelini et al.	2008	34	1	0	na	0	0	34	0	100
Crespi et al.	2008	20	2	0	na	0	0	40	0	100
Ribeiro et al.	2008	46	2.17	3	na	3	0	99.91	3	93.99
Crespi et al.	2007	150	1.5	0	na	0	0	225	0	100
Kan et al.	2007	23	1	0	na	0	0	23	0	100
Siegenthaler et al.	2007	7	1	0	na	0	0	7	0	100
Kan et al.	2007	23	1	0	na	0	0	23	0	100
Ferrara et al.	2006	33	2.34	2	na	2	0	77.25	2.59	94.82
Barone et al.	2006	18	1	1	na	1	0	17.08	5.86	88.29
Cornelini et al.	2005	22	1	0	na	0	0	22	0	100
Vanden Bogaerde et al.	2005	50	1.5	0	na	0	0	75	0	100
Tsirlis	2005	28	2	0	na	0	0	56	0	100
Norton	2004	16	1.61	0	na	0	0	25.75	0	100
Kan et al.	2003	35	1.39	0	na	0	0	48.71	0	100
Summary estimate (95% CI)*		822	1.72	12	na	12	1	1488.69	0.89 (0.18–4.40)	98.2 (91.6–99.6)
Conventional loading										
Vidal et al.	2010	54	1	0	0	0	0	54	0	100
Gocen-Rohlig et al.	2010	20	2.33	0	0	0	0	46.67	0	100
Crespi et al.	2010	30	2	0	0	0	0	60	0	100
Prosper et al.	2010	60	3	2	1	1	0	290.29	0.69	98.62
Del Fabbro et al.	2009	61	1.79	1	1	0	0	107.67	0.93	98.14
Kahnberg	2009	40	2	0	0	0	0	80	0	100
Cordaro et al.	2009	30	1.5	1	0	1	0	43.73	2.29	95.43
De Rouck et al.	2009	25	1.17	2	2	0	0	29.25	6.84	86.32
Siciliano et al.	2009	15	1	0	0	0	0	15	0	100
Botticelli et al.	2008	21	5	0	0	0	0	105	0	100
Lops et al.	2008	46	1.15	0	0	0	0	53.08	0	100
Cafiero et al.	2008	82	1	0	0	0	0	82	0	100
Fugazzotto	2008	341	2.72	2	1	1	0	929.06	0.22	99.57
Crespi et al.	2008	20	2	0	0	0	0	40	0	100
Siegenthaler et al.	2007	22	1	0	0	0	0	22	0	100
Covani et al.	2007	10	1	0	0	0	0	10	0	100
Juodzbalys et al.	2007	14	2	0	0	0	0	28	0	100
Lineboom et al.	2006	25	1	2	2	0	0	24	8.33	83.33
Cangini and Cornelini	2005	32	1	0	0	0	0	32	0	100
Fugazzotto et al.	2002	46	1.40	0	0	0	0	64.33	0	100
Covani et al.	2004	163	4	5	2	3	0	636.5	0.79	98.43
Bianchi et al.	2004	115	5.38	0	0	0	1	618.5	0	100
Goldstein et al.	2002	47	3.37	0	0	0	0	158.5	0	100
Huys	2001	556	7	19	19	0	0	3763.75	0.50	98.99
Becker et al.	1994	49	1.51	3	3	0	0	74.06	4.05	91.90
Lang et al.	1994	28	3.28	0	0	0	0	91.93	0	100
Becker et al.	1998	134	3.61	9	2	7	0	483.17	1.86	96.27
Summary estimate (95% CI)*		2086	2.34	46	33	13	1	7942.48	0.75 (0.40–1.40)	98.5 (97.2–99.2)

*Based on random-effects *Poisson* regression, test for heterogeneity $P < 0.01$.

sion of 0.4 mm at the buccal and 0.5 mm at the lingual aspects, respectively. At the 5-year examination, the marginal level of the mucosa was generally coronal to the finishing line of the restorations. However, 5 of 21 buccal sites (24%) exhibited soft tissue recession to the extent that the margins of the metal restorations were exposed.

In summary, 20–25% of the patients who were treated with implants immediately placed into extraction sockets suffered aesthetically from apical displacement of the mucosal margins, although soft tissue levels seemed to be stable in long term in the majority of patients. The paucity of existing studies with follow-up periods of $\geq$3 years reporting on aesthetic outcomes following immediate implant placement made it diffi-

cult to estimate the prevalence of aesthetic complications and to investigate factors that might affect aesthetic outcomes.

Soft tissue changes

Three studies (Kan et al. 2003; De Rouck et al. 2008a; De Rouck et al. 2009) provided data on the soft tissue level changes, at 3, 6 and 12 months following implant placement immediately into extraction sockets and immediate provisional restoration, in relation to the pre-operative status in the anterior maxilla.

While the first two studies (Kan et al. 2003; De Rouck et al. 2008a) were prospective studies examining implants placed and restored immediately after tooth extraction, the latter study (De Rouck et al. 2009) was an RCT comparing the impact of immediate and delayed restorations on the soft and hard tissues following implantation. To obtain weighted means from comparable data, information from the immediate restoration group was extracted. The chi-squared tests showed that data from these three studies concerning changes in mesial and distal papilla heights and buccal mucosal levels at any examination time were homogeneous.

Alterations in the mid-buccal soft tissue level, and mesial and distal papilla heights were evaluated by measuring the distance from a reference line in one study (Kan et al. 2003). Acrylic stents, indented with mesial, buccal and distal grooves, were utilized to assess the papilla and mid-facial mucosal level in the two other studies (De Rouck et al. 2008a, 2009).

Fig. 3 shows the alterations in the mesial and distal papillae heights, and the mid-facial mucosal level in the first year following immediate implant placement and immediate restoration. Most of the soft tissue changes occurred in the first 3 months. Mesial and distal papillae shrank by 0.41 ± 0.32 mm (Q = 0.15, P = 0.93) and 0.34 ± 0.36 mm (Q = 0.08, P = 0.96), respectively, while the buccal mucosal level was displaced apically by 0.43 ± 0.38 mm (Q = 0.01, P = 0.995), when compared to the pre-surgical level. Soft tissues became stable after 6 months. At the end of the first year, 0.49 ± 0.31 mm (Q = 0.03, P = 0.99), 0.36 ± 0.33 mm (Q = 0.01, P = 0.99) and 0.51 ± 0.38 mm (Q = 0.02, P = 0.99) had been lost at mesial papilla, distal papilla and mid-facial mucosa, respectively.

Soft tissue alterations (mesial, distal and buccal), in the case of conventional loading, were evaluated by Cordaro et al. (2009), where 3 months of either submerged or non-submerged healing was allowed before implants were loaded with provisional restorations. The measurements were taken at the time of provisional installation, and repeated at 3 and 15 months. This study used the incisal margin of adjacent teeth as the reference. As no statistically significant differences were found at any sites between the submerged and non-submerged implant groups, weighted means at each examination visit were calculated for the three sites. When compared to the pre-surgical soft tissue levels, the greatest loss was recorded at the time of provisional restoration (mesial papilla: −0.95 mm, distal papilla: −0.87 mm, buccal: −0.79 mm), after which, little changes had taken place (Fig. 4).

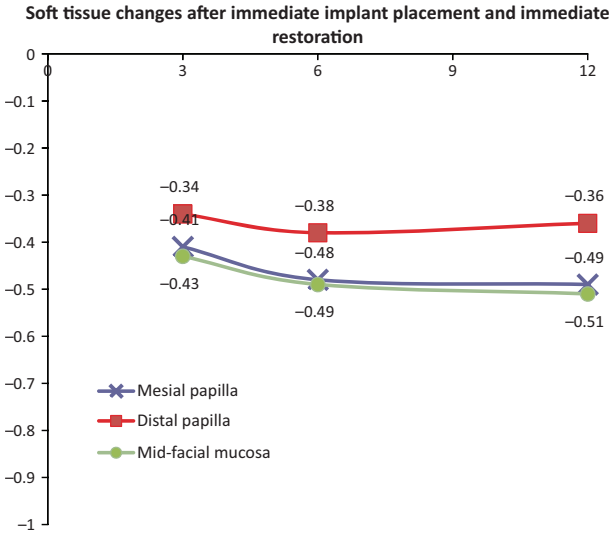

Fig. 3. Soft tissue changes in the first year after immediate implant placement and immediate restoration.

When soft tissue alterations upon immediate restoration were compared to those after delayed restoration, mean papilla shrinkage was about twice as high in the delayed restoration group (DRG) as the immediate restoration group (IRG) at 3 months after provisional restorations (De Rouck et al. 2009). However, in the following 9 months, papillae in the DRG showed tendency to fill the proximal spaces, and the differences between the groups became smaller. On the other hand, mid-facial soft tissue loss showed little or no variation over time in both groups. The apical displacement of the buccal mucosal level was always about 2–3 times the magnitude in the DRG compared to the IRG during the 1-year observation period. It was concluded that this difference favoured immediate restoration (De Rouck et al. 2009) (Fig. 5a–c).

Papilla fill

Five studies provided information on the papilla fill after immediate implant placement. Implants in three studies (Cornelini et al. 2005; Kan et al. 2007a; Cornelini et al.

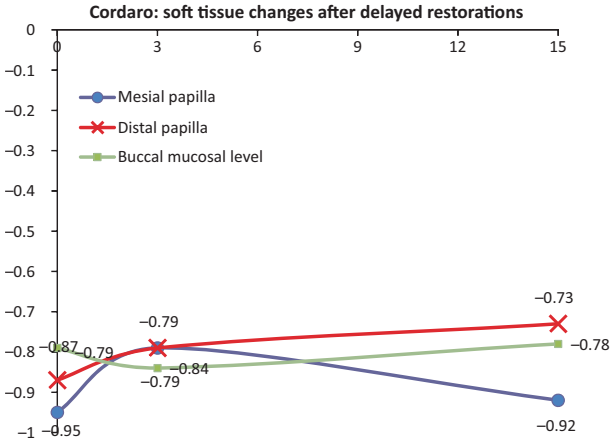

Fig. 4. Soft tissue changes after immediate implant placement and conventional loading [months after provisionals] (Cordaro et al. 2009): provisionals were installed 3 months after implant placement.

2008) were immediately restored, while implants in the other two studies (Lindeboom et al. 2006a; Juodzbalys & Wang 2007) were conventionally restored. All of them used the papilla index (Jemt 1997) to describe the fullness of the papillary fill.

The former three studies involved a total of 156 papillae. At the end of the observation period, 51% of the papillae achieved a score 2, i.e. the papilla was greater than half the height of the proximal space. The remaining 49% achieved a score 3, i.e. the papilla fills the entire proximal space. Fifty-one papillae were assessed after conventional loading. Forty-five percent belonged to score 2 and 55% achieved score 3.

Kan et al. (2007a) also investigated the change of distribution of papilla fill within the first year following immediate implant placement and immediate restoration. Of the 44 papillae examined, more than 90% scored 2 or 3 at every examination visit, and the number of papillae achieving score 3 continued to increase from implant placement and provisional insertion up until 6 months, after which papillae seemed to be stable (Fig. 6).

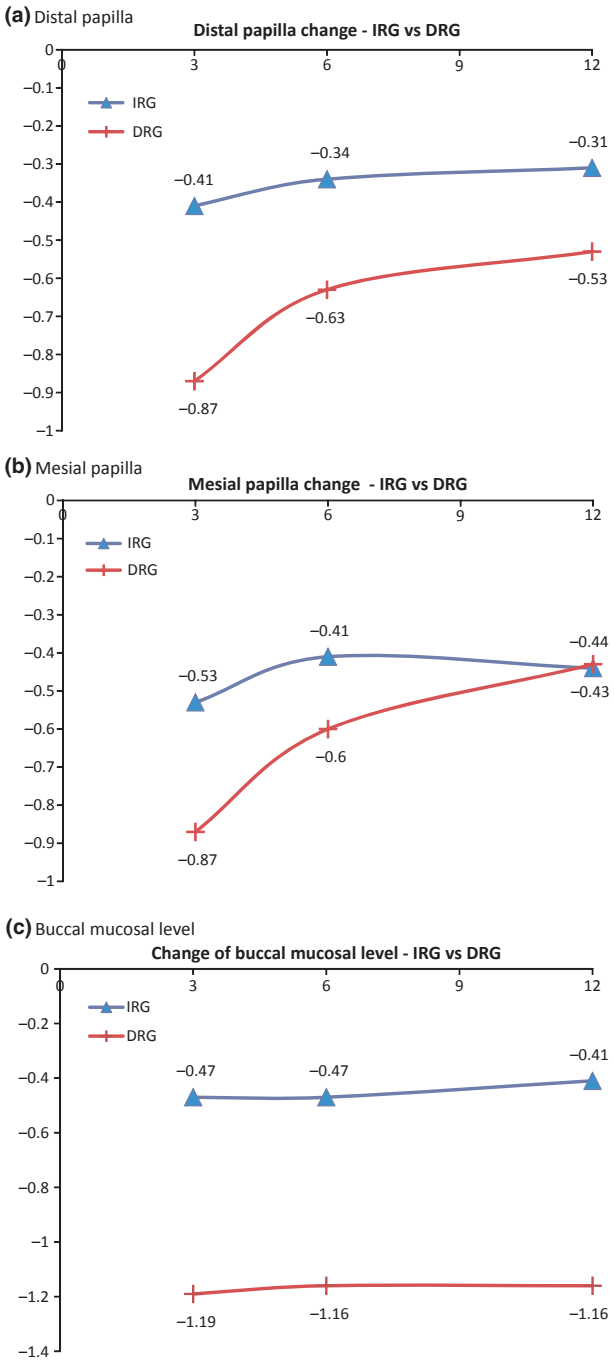

Fig. 5. Soft tissue changes – immediate restoration group (IRG) vs. delayed restoration group (DRG) (De Rouck et al. 2009). (a) Distal papilla. (b) Mesial papilla. (c) Buccal mucosal level.

Pink Aesthetic Score (PES)

Only one study in the 46 included evaluated soft tissues using the PES (Juodzbalys & Wang 2007). Fourteen implants were placed in the region of upper incisors in 12 patients. GBR technique was employed. In case of soft tissue deficiency, connective tissue graft obtained from the palatal vault was used to cover the implant. Implants were firstly restored with provisional restorations at 6 month, then with definitive crowns at 12 month. One year after definitive crown cementation, the mean PES was 11.1. Incomplete mesial and distal papillae (64.3%), and alveolar process deficiency (42.9%) were common, and a minor discrepancy of buccal mucosal level of 1–2 mm was observed in 21.4% of cases.

Hard tissue change

Immediate implant placement and immediate loading

Generally, immediate implants in most studies experienced bone loss. The 1-year studies showed that the loss was less than 1 mm (range: gain 1 mm–loss 0.98 mm) in the first year, and longer-term studies demonstrated that after the first functioning year bone levels became stable.

De Rouck et al. (2008a, 2009) described the longitudinal radiographic marginal bony changes at 3, 6 and 12 months after immediate implant placement and immediate provisional restoration. The weighted means showed that from 3 to 12 months, there was a continuous loss of marginal bone from 0.51 ± 0.24 mm ($Q = 0.05$, $P = 0.83$) to 0.95 ± 0.35 mm ($Q = 0.01$, $P = 0.93$) at the mesial site, and from 0.52 ± 0.46 mm ($Q = 0.01$, $P = 0.91$) to 0.79 ± 0.39 mm ($Q = 0.0001$, $P = 0.99$) at the distal site. Half of the bone loss measured in the first year occurred in the first 3 months (Fig. 7).

Three studies (Calvo-Guirado et al. 2009; Crespi et al. 2009a; Canullo et al. 2009a) reported changes of marginal bone levels around immediately placed and immediately restored implants using platform-switching method. In the study of Calvo-Guirado et al. (2009), the mean bone loss after 1 year of function was 0.08 mm on the mesial surfaces and 0.09 mm on the distal surfaces. The small bony changes were in accordance with those reported in the RCT by Canullo et al.

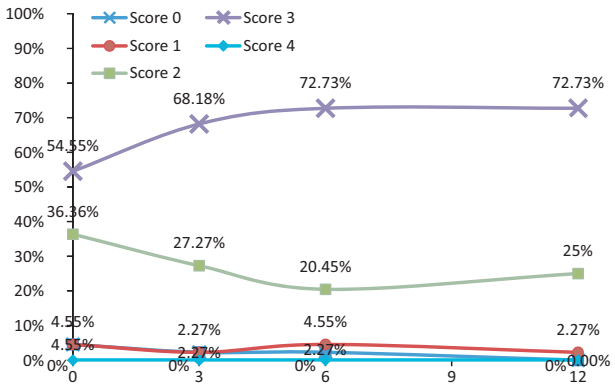

Fig. 6. Change of distribution of papilla fill in the first year following immediate implant placement and immediate restoration. (Kan et al. 2007a,b)

(2009a), which showed that after about 2 years of loading, the platform-switching group experienced bone loss of 0.25 mm mesially and 0.36 mm distally; the bone loss was more significant in the platform-matching group, reaching 1.13 mm and 1.25 mm on mesial and distal surfaces, respectively. On the contrary, in the study by Crespi et al. (2009a), no significant differences in the bony changes between the two groups were found. The bone loss ranged 0.73–0.84 mm at the 1-year follow-up and 0.68–0.80 mm at the end of second year.

Immediate implant placement and conventional loading

Authors used different baselines to measure bony alterations around implants loaded conventionally. Some used the bone level at the time of implant placement as the baseline, while the others chose the bone level at the time of implant loading to be the baseline.

For those with baseline at implant placement, bone loss of 1.01, 1.16 and 0.05 mm after 5 years, 21 months and 15 months of loading were reported, respectively (Crespi et al. 2008; Cordaro et al. 2009; Prosper et al. 2010).

Three studies used the bone level at the time of implant loading as the baseline (Juodzbalys & Wang 2007; Botticelli et al. 2008; Gokcen-Rohlig et al. 2010). Juodzbalys & Wang (2007) concluded that there was 1.16 mm bone loss 1 year after prosthetic restoration. Also, Gokcen-Rohlig et al. (2010) revealed bone loss of 0.72 mm and 1.36 mm at 1-year and 2-year follow-up, respectively. It was reported that two of four implants in one patient, which were used to support a fixed complete denture, experienced suppuration on probing; however, the suppuration resolved following local debridement and institution of strict oral hygiene practices. It was unclear if the substantial bone loss observed during the second year of function was due to biological complications or overloading. On the other hand, Botticelli et al. (2008) reported a mean bone gain of 0.2 mm after 5 years of loading (range: 0.22 mm loss to 0.41 mm gain). The minimal bony changes were attributed to the carefully supervised oral hygiene programme throughout the whole observation period, with low plaque (11–17%) and bleeding (15–20%) scores at all follow-up visits.

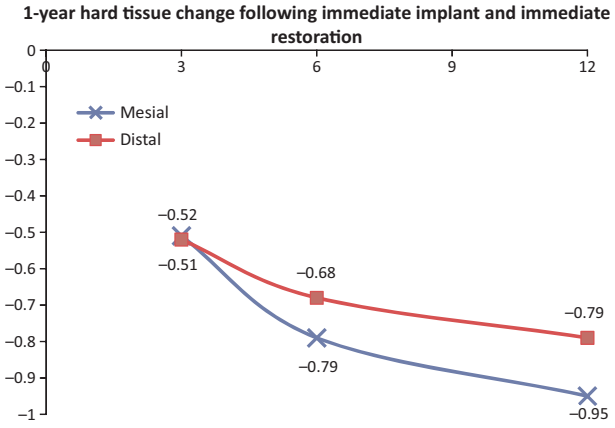

Fig. 7. Hard tissue changes in the first year following immediate implant placement and immediate restoration.

Discussion

This systematic review showed that implants placed immediately in fresh extraction sockets yielded a low annual failure rate of 0.82% (95% CI: 0.48–1.39%) translating to a 2-year survival rate of 98.4%. It should be noted that this systematic review assumed a constant annual failure rate throughout the follow-up time after implant placement. With the knowledge that most implant failures occur in the first year, and that the current review has an annual failure rate based on studies with a mean observation period of 2 years, the rate derived should not be extrapolated to longer follow-up times. Therefore, studies with a mean follow-up period of 3 years or longer were analysed separately, reaching the 4-year implant survival rate of 97.5%. This percentage is comparable to the 96.8% 5-year survival rate of implants supporting single crowns reported in a previous systematic review (Jung et al. 2008).

In reference to the Third ITI Consensus Conference (Hämmerle et al. 2004), placement of implants is categorized by the healing timing following extraction as Type 1 immediate (within 24 h of extraction), Type 2 early (4–8 weeks after extraction), Type 3 early-delayed (12–16 weeks after extraction) and Type 4 late (more than 6 months). This classification is based on the time that elapsed after tooth extraction approximating the soft and hard tissue characteristics of healing sockets according to the morphologic, dimensional and histologic changes. In this systematic review, the survival rate of Type 1 placements was subject to evaluation.

However, a number of factors may affect the outcomes of procedures other than the timing of implant placement alone. Upon the timing of implantation, the type of the bone, the location and dimension of the edentulous area and the history of oral diseases are influential and should be considered in the assessment. On the other hand, the surgical protocol involved many steps influencing the outcomes as well. The approach chosen to perform the implant placement, such as with or without flap access, the selection of the implant type, the decision for the necessity of regenerative procedures and the selection of regeneration materials, the determination of the timing may all influence the outcomes of such procedures. Among the 46 studies in

this systematic review, as many variables as possible were addressed. Nonetheless, five variables were discretely analysed.

Antibiotics

Infection should ideally be prevented after implant surgery. One of the proposed methods to minimize infection is the prescription of antibiotics to subjects undergoing implant surgery. The choice of antibiotics should be that it covers a reasonable bacterial spectrum to limit potential pathogens from colonizing in the vicinity of the surgical sites. When comparing subjects who had received a single dose pre-operatively, 5–7 days post-operatively, and a single dose pre-plus 5–7 days post-operative course of antibiotics, the estimated annual failure rates were 1.87%, 0.51% and 0.75% respectively. The annual implant failure rate in patients who were only given the single-dose of antibiotics pre-operatively was statistically significantly greater. This demonstrated that secondary to the prescription of an effective antibiotic, the duration of usage might be of importance. A single dose of antibiotics prior to surgery did not sustain the suppression of bacterial levels below the critical threshold throughout the healing period, but provision of antibiotics for 5–7 days after surgery may have helped to prevent post-operative infection, and hence, contribute to higher implant survival rates. However, these findings should be interpreted with caution, as the number of implants included in the single-dose pre-operative antibiotics group was substantially fewer.

Reasons for extraction

Implant sites with a history of periodontal disease may yield decreased survival rates. Many studies showed significantly more biological complications (Karoussis et al. 2003), greater peri-implant marginal bone loss (Mengel et al. 2007; De Boever et al. 2009), and increased implant failure rates (Hardt et al. 2002) in periodontitis susceptible subjects than periodontitis non-susceptible subjects. Furthermore, a recent review indicated that subjects with a history of periodontitis might be at greater risk for peri-implant infections (Renvert & Persson 2009). So, the comparison between implants placed into extraction sockets for non-periodontally related and periodontally related reasons was attempted in the present review. Unfortunately, not a single prospective study reported on a group of subjects with teeth extracted solely due to periodontal disease. Therefore, the comparison between implants placed in extraction sockets for non-periodontally related reasons, vs. mixed periodontal and non-periodontal reasons, was attempted. The two examined groups yielded comparable implant survival rates, although that of the non-periodontal group was slightly higher.

Site (maxilla/mandible)

Primary stability is of paramount importance for implant survival. Secondary to the dimensions of the extraction socket, the relative proportion of the load-bearing lamellar bone vs. cancellous bone also determines primary stability. As the mandible is comprised of a larger proportion of lamellar bone than in the maxilla, it is speculated that implant survival rates are correspondingly more favourable in the mandible. Accordingly, the 933 implants placed in the maxilla had an estimated annual failure rate of 0.73% compared to the 731 implants housed in the mandible, where the annual failure rate was 0.50%. This difference, however, was not statistically significant. One possible explanation could be that most of the studies adhered to a strict surgical protocol, where immediate implants were installed with a minimal insertion torque, and 3–4 mm apical bony engagement was ensured. Therefore, primary stability was achieved for all of the implants.

Site (anterior/posterior)

Due to the wider socket dimensions in multi-rooted tooth sites, it was speculated that there is a decreased amount of implant surface in direct contact with the adjacent bone walls. This might impede the achievement of optimal primary stability. However, as evidenced in this review, the difference in survival rates between implants placed in anterior single-rooted and posterior multi-rooted sockets was negligible. This could again, be attributed to the surgical protocol, where minimal insertion torque and engagement of bone apical to the socket was propagated. Moreover, usage of different diameter implants matched to the various socket dimensions could have contributed to the observed minimal difference.

Loading

Corroborating the findings by Gallucci et al. (2009), the utilized loading protocols did not result in any significant difference with regard to survival rates. Immediately loaded and conventionally loaded implants had reported implant survival rates of 98.2% and 98.5%, respectively after a 2-year observation period. In most of the studies reporting on immediate loading, the inserted restorations were free of contacts in centric occlusion and during excursive movements; utilizing such an occlusal scheme, micromovements of implants were certainly limited. Therefore, it is not surprising to note that the differences in survival rates between the two groups with varying loading protocols were not significant.

Success

A successful treatment should be the treatment with absence of any biological, technical and aesthetic complications. Since all these complications take time to develop, this systematic review assessed a total of nine studies with the mean follow-up time of 3 years or more for the estimation of the success rates of implant-related therapy.

Biological complications

Peri-implant mucositis and peri-implantitis have been shown to be prevalent. A systematic review (Zitzmann & Berglundh 2008) concluded that peri-implant mucositis occurred in approximately 80% of the subjects and in 50% of the implants; while peri-implantitis was found in 28% and $\geq$56% of subjects and in up to 43% of implant sites.

Diagnosis of peri-implant diseases required assessment of the presence or absence of bleeding on probing (BOP) in the peri-implant soft tissues, and changes in the level of crestal bone (Lang & Berglundh 2011). Three of the nine studies reported on BOP. In one study (Bianchi & Sanfilippo 2004), 31% of the implants showed signs of peri-implant mucositis.

Seven studies described hard tissue conditions. An unusual amount of marginal bone loss was seen in 4.3% of implants in the study of Covani et al. (2004a,b). However, in the absence of the report on BOP, it was difficult to estimate the prevalence of peri-implantitis.

Technical complications

Three studies assessed technical complications, among which two were free from this type of complication and one study (Covani et al. 2004b) had loosening of abutment screws occurring in 9.8% of implants supporting single crowns during the 4 years of function. This finding is comparable to that reported in the systematic review on implant-supported single crowns (Jung et al. 2008), which demonstrated a cumulative incidence of screw or abutment loosening of 12.7% in 5 years. The technical complications in implant-supported reconstructions are generally three times as high as those in tooth-supported reconstructions (Pjetursson

et al. 2007). This may be explained by the ankylotic union of implants and the bone, and the lacking of a periodontal ligament around implants, subsequently resulted in the increased threshold to mechanorecptive responses.

Aesthetic complications

Although not included in previous descriptions of implant success criteria (Albrektsson et al. 1986), the aesthetic aspect of implant-supported restorations has attracted more attention in recent years. Despite the high survival rate of immediate implants, which has been addressed in this systematic review, soft tissue alterations, especially the buccal marginal mucosal recession, appeared to be inevitable. About 20% of patients in the two included studies with follow-up time ≥ 3 years (Bianchi & Sanfilippo 2004; Botticelli et al. 2008) suffered from restorations with limited aesthetic outcomes due to buccal soft tissue recession. It was in accordance with a recent follow-up study by Kan et al. (2011), which stated that while the mean aesthetic satisfaction rating by patients was almost perfect (9.9 of 10) at the 1-year recall, 4 of 35 patients (11%) complained of unsatisfactory restorations caused by facial gingival recession after a longer period of observation (mean 4 years, range: 2–8.2 years). Three of these subjects agreed to undergo additional guided bone regeneration and connective tissue grafting surgeries to correct the problem.

When immediate implant placement is indicated, careful case selection and cautious treatment planning are essential to minimize aesthetic complications. Buccal soft tissue recession has been shown to be closely related to the thin tissue biotype (Kan et al. 2011) and buccally positioned implants (Chen et al. 2007). In case of thin tissue biotype, connective tissue grafting may have to be performed (Bianchi & Sanfilippo 2004).

In recent years, several indices have been developed to provide guidance on objective and comprehensive assessment of aesthetic outcomes of an implant restoration. They include the Pink Esthetic Score (Fürhauser et al. 2005), the Implant Crown Aesthetic Index (Meijer et al. 2005) and the modified PES/White Esthetic Score (WES) (Belser et al. 2009). However, none of the long-term studies in this systematic review evaluated the aesthetic outcomes using any of these indices. In the future, more routine utilization of these indices is recommended for aesthetic monitoring.

Tissue changes

Soft tissue change

It was observed in three studies (Kan et al. 2003; De Rouck et al. 2008a, 2009) that the bulk of the soft tissue changes occurred during the first 3 months of healing after immediate implant placement and immediate restoration. Change of a smaller magnitude was exhibited in the following 3 months but stabilized after the first 6 months. At the end of the first year, the weighted mean loss at mesial papilla, distal papilla and mid-facial mucosa were 0.49 mm, 0.36 mm and 0.51 mm, respectively.

In a recent publication, Kan et al. (2011) followed up the same patient population as the study published in 2003 for 2–8.2 years (mean 4 years) and reported the soft tissue changes beyond the first year evaluation. When compared to the pre-surgical status, mesial and distal papillae lost height of 0.53 mm and 0.39 mm at first year follow-up; and lost 0.22 mm and 0.21 mm at the last examination appointment. The significantly smaller loss in papilla height over time demonstrated that papillae might have the capacity of continuous regrowing following implant restoration. It is also important to note that gingival biotype did not significantly influence the papilla level changes. Both biotypes showed loss in height of 0.21 mm at last examination visit. The papillary height might be more likely to be affected by factors such as proximal bone level of neighbouring teeth and the distance between the implant and adjacent tooth.

On the other hand, significantly more recession was reported at the facial mucosa at the last examination visit than the first-year follow-up (−1.13 mm vs. −0.55 mm), and significantly more apical displacement occurred in patients with thin gingival biotype than those with thick gingival biotype (−1.50 mm vs. −0.56 mm). In a closer look at the mean facial gingival level changes at the 1-year and final (mean of 4 years) examinations, the subjects with a thin biotype had a greater 1-year mean recession (−0.75 ± 0.59 mm) than the final recession observed in subjects who carry a thick biotype at (−0.56 ± 0.46 mm). Needless to say, the subjects with a thin biotype had the most recession at the final observation (−1.5 ± 0.88 mm). Therefore, it is speculated that these limited aesthetic results were mainly witnessed in subjects with a thin biotype and only gradually manifested at a later life of the immediate implant supported restoration caused by progressive facial gingival recession.

The above results showed that although the greatest changes in soft tissues took place in the first 6 months following immediate implant placement and immediate restoration, soft tissue remodelling might continue over the years. While mesial and distal papillae had tendencies to gain height, buccal mucosal recession might get more pronounced over time.

Apical displacement of the mucosa was also inevitable in the case of delayed loading. Cordaro et al. (2009) concluded that the greatest loss was recorded at the time of provisional restoration, which was carried out 3 months after implant installation (mesial papilla: −0.95 mm, distal papilla: −0.87 mm, buccal: −0.79 mm). In the following 9 months of the study, little changes had taken place (Fig. 3).

One randomized clinical trial (De Rouck et al. 2009) compared longitudinal changes of papilla height and position of the buccal mucosa between immediately and conventionally restored implants after immediate implant placement. Papilla shrinkage and the apical displacement of buccal mucosa were of a lesser extent in immediate restored implant group at the 3-month follow-up. Nevertheless, at the 12-month re-examination, the two groups yielded comparable results when examining the change in papilla height. However, the differences in the position of the buccal mucosa persisted throughout the 12-month observation period. The authors thus concluded that immediate restoration of immediate implants might help limit buccal recession, but more randomized clinical trials of longer follow-up period are required before any definitive conclusions can be drawn on this issue.

In addition to the dimensional changes of soft tissues, the prevalence of mucosal recession should also be noted. Chen et al. (2007a, b) investigated this aspect among immediately placed delayed restored implants. In this prospective clinical study, 30 patients were randomly assigned to one of the three groups: (i) bone graft group (BG), (ii) bone graft and resorbable membrane group (BG+M), and (iii) non-grafted group (control). After 6 months of initial healing, 10 of 30 sites (33.3%) showed buccal marginal tissue recession (range: 1–3 mm), where three were from the BG group, four from the BG+M group and three from the control group. Five of the 10 patients with recession and two patients without recession then received connective tissue grafts to repair or prevent the

recession. At the time of final crown installation at 8 months, 8 of 30 sites exhibited marginal tissue recession when compared to contralateral teeth and thus suboptimal aesthetic results, among which three sites had previously received connective tissue grafts.

The current evidence indicated that implants placed in extraction sockets were not able to prevent soft tissue loss, especially the buccal marginal tissue recession. The amount of soft tissue alterations, however, was determined by many factors. While potential benefits of immediate restoration of an implant required further investigation, some fundamental factors should not be overlooked to minimize recession. The prospective study mentioned (Chen et al. 2007) demonstrated a significant relationship between the frequency of recession and the bucco-lingual position of the implants. Six of the eight implants, which showed marginal tissue recession, were placed at or buccal to the reference line joining the buccal cervical margins of adjacent teeth. Similarly, a retrospective study (Chen et al. 2009) also noted that implants placed more buccally experienced greater recession than implants placed lingually (−6.9% vs. −2.6%).

This latter concept has also been confirmed with re-entry surgery at 4 months in a randomized controlled clinical trial of implants installed immediately into extraction sockets (Tomasi et al. 2010).

Furthermore, recession of >5% was more prevalent at sites with thin periodontal biotypes than at those with a thick biotype. Therefore, when immediate implant placement is indicated, careful pre-surgical examination of future implant sites and placement of implants in the prosthetically correct position should be carried out to achieve and maintain satisfactory aesthetic outcomes.

Hard tissue change

As with the soft tissue changes, most of the marginal bone loss was found in the first 3 months following immediate implant placement and immediate restoration. At the end of the first year, the bone loss was generally less than 1 mm. One possible means to minimize the hard tissue changes, in short-tem, could be the use of platform-switching technique, where a wider-diameter implant is restored with a narrower-diameter abutment. In one randomized clinical controlled trial, significantly less mean bone resorption occurred adjacent to platform-switched abutment restorations than that found at sites using platform-matched abutments (Canullo et al. 2009a). However, in another RCT, no such differences were demonstrated (Crespi et al. 2009a). Hence, more clinical trials are required to confirm the possible benefits of the platform-switching technique.

In the long run, good oral hygiene is a pre-requisite for maintaining bone levels. With low plaque and mucositis levels, bone levels even improved (mean gain of 0.2 mm) after 5 years of implant functioning (Botticelli et al. 2008).

Conclusion

1. The estimated annual failure rate of implants placed in extraction sockets was 0.82% (95% CI: 0.48–1.39%) translating to a 2-year survival rate of 98.4% (97.3–99%).
2. The estimated annual implant failure rate was lower after a 5–7 days post-operative antibiotic course (0.51%) than a single dose of pre-operative antibiotics (1.87%) ($P = 0.002$).
3. Scarce data concerning biological complications were available in long-term (≥ 3 years) studies. Future research should pay more attention to evaluate peri-implant tissues by periodontal probing and radiographs.
4. Technical complications were not commonly reported in studies with follow-up time of 3 years or more.
5. About 20% of patients who underwent immediate implant placement and delayed restorations suffered from suboptimal aesthetic outcomes due to buccal soft tissue recession in studies with observation period of 3 years or more.
6. It has been shown in a 1-year RCT that immediate restoration after immediate implant placement might help limit buccal mucosal recession, but more long-term RCTs are required to confirm this potential benefit. On the other hand, the influence of factors, such as gingival biotypes and bucco-lingual position of implants, on buccal soft tissue levels should not be overlooked.
7. To date the use of platform-switching technique to reduce marginal bone resorption is controversial and needs further investigation. However, good OH is still a pre-requisite for maintaining bone levels in the long run.

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References

Abrahammsson, I., Berglundh, T., Linder, E., Lang, N.P. & Lindhe, J. (2004) Early bone formation adjacent to rough and turned endosseous implant surfaces. An experimental study in the dog. *Clinical Oral Implants Research* **15**: 381–392.

Adell, R., Lekholm, U., Rockler, B. & Branemark, P.I. (1981) A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. *International Journal of Oral Surgery* **10**: 387–416.

Albrektsson, T., Zarb, G., Worthington, P. & Eriksson, A.R. (1986) The long-term efficacy of currently used dental implants: a review and proposed criteria of success. *The International Journal of Oral & Maxillofacial Implants* **1**: 11–25.

Araujo, M.G., Sukekava, F., Wennstrom, J.L. & Lindhe, J. (2005) Ridge alterations following implant placement in fresh extraction sockets: an experimental study in the dog. *Journal of Clinical Periodontology* **32**: 645–652.

Barone, A., Rispoli, L., Vozza, I., Quaranta, A. & Covani, U. (2006) Immediate restoration of single implants placed immediately after tooth extraction. *Journal of Periodontology* **77**: 1914–1920.

Becker, B.E., Becker, W., Ricci, A. & Geurs, N. (1998) A prospective clinical trial of endosseous screw-shaped implants placed at the time of tooth extraction without augmentation. *Journal of Periodontology* **69**: 920–926.

Becker, W., Dahlin, C., Becker, B.E., Lekholm, U., van Steenberghe, D., Higuchi, K. & Kultje, C. (1994) The use of e-ptfe barrier membranes for bone promotion around titanium implants placed into extraction sockets: a prospective multicenter study. *The International Journal of Oral & Maxillofacial Implants* **9**: 31–40.

Bianchi, A.E. & Sanfilippo, F. (2004) Single-tooth replacement by immediate implant and connective tissue graft: a 1-9-year clinical evaluation. *Clinical Oral Implants Research* **15**: 269–277.

Botticelli, D., Berglundh, T., Buser, D. & Lindhe, J. (2003) The jumping distance revisited: an experimental study in the dog. *Clinical Oral Implants Research* **14**: 35–42.

Botticelli, D., Renzi, A., Lindhe, J. & Berglundh, T. (2008) Implants in fresh extraction sockets: a prospective 5-year follow-up clinical study. *Clinical Oral Implants Research* **19**: 1226–1232.

Brägger, U., Hämmerle, C.H. & Lang, N.P. (1996) Immediate transmucosal implants using the principle of guided tissue regeneration (ii). A cross-sectional study comparing the clinical outcome 1 year after immediate to standard implant placement. *Clinical Oral Implants Research* **7**: 268–276.

Branemark, P.I., Adell, R., Breine, U., Hansson, B. O., Lindstrom, J. & Ohlsson, A. (1969) Intra-osseous anchorag of dental prostheses I. Experimental studies. *Scandinavian Journal of Plastic Reconstructive Surgery*, **3**: 81–100.

Buser, D., Schenk, R.K., Steinemann, S., Fiorellini, J.P., Fox, C.H. & Stich, H. (1991) Influence of surface characteristics on bone integration of titanium implants. A histomorphometric study in miniature pigs. *Journal of Biomedical Materials Research* **25**: 889–902.

Cafiero, C., Annibali, S., Gherlone, E., Grassi, F.R., Gualini, F., Magliano, A., Romeo, E., Tonelli, P., Lang, N.P. & Salvi, G.E. (2008) Immediate transmucosal implant placement in molar extraction sites: a 12-month prospective multicenter cohort study. *Clinical Oral Implants Research* **19**: 476–482.

Calvo-Guirado, J.L., Ortiz-Ruiz, A.J., Lopez-Mari, L., Delgado-Ruiz, R., Mate-Sanchez, J. & Bravo Gonzalez, L.A. (2009) Immediate maxillary restoration of single-tooth implants using platform switching for crestal bone preservation: a 12-month study. *The International Journal of Oral & Maxillofacial Implants* **24**: 275–281.

Cangini, F. & Cornelini, R. (2005) A comparison between enamel matrix derivative and a bioabsorbable membrane to enhance healing around transmucosal immediate post-extraction implants. *Journal of Periodontology* **76**: 1785–1792.

Canullo, L., Goglia, G., Iurlaro, G. & Iannello, G. (2009a) Short-term bone level observations associated with platform switching in immediately placed and restored single maxillary implants: a preliminary report. *International Journal of Prosthodontics* **22**: 277–282.

Canullo, L., Iurlaro, G. & Iannello, G. (2009b) Double-blind randomized controlled trial study on post-extraction immediately restored implants using the switching platform concept: soft tissue response. Preliminary report. *Clinical Oral Implants Research* **20**: 414–420.

Carlsson, L., Rostlund, T., Albrektsson, B. & Albrektsson, T. (1988) Removal torques for polished and rough titanium implants. *The International Journal of Oral & Maxillofacial Implants* **3**: 21–24.

Chen, S.T., Darby, I.B. & Reynolds, E.C. (2007) A prospective clinical study of non-submerged immediate implants: clinical outcomes and esthetic results. *Clinical Oral Implants Research* **18**: 552–562.

Chen, S.T., Darby, I.B., Reynolds, E.C. & Clement, J.G. (2009) Immediate implant placement postextraction without flap elevation. *Journal of Periodontology* **80**: 163–172.

Cordaro, L., Torsello, F. & Roccuzzo, M. (2009) Clinical outcome of submerged vs. Non-submerged implants placed in fresh extraction sockets. *Clinical Oral Implants Research* **20**: 1307–1313.

Cornelini, R., Barone, A. & Covani, U. (2008) Connective tissue grafts in postextraction implants with immediate restoration: a prospective controlled clinical study. *Practical Procedures & Aesthetic Dentistry* **20**: 337–343.

Cornelini, R., Cangini, F., Covani, U. & Wilson, T. G. Jr (2005) Immediate restoration of implants placed into fresh extraction sockets for single-tooth replacement: a prospective clinical study. *International Journal of Periodontics & Restorative Dentistry* **25**: 439–447.

Covani, U., Bortolaia, C., Barone, A. & Sbordone, L. (2004a) Bucco-lingual crestal bone changes after immediate and delayed implant placement. *Journal of Periodontology* **75**: 1605–1612.

Covani, U., Crespi, R., Cornelini, R. & Barone, A. (2004b) Immediate implants supporting single crown restoration: a 4-year prospective study. *Journal of Periodontology* **75**: 982–988.

Covani, U., Marconcini, S., Galassini, G., Cornelini, R., Santini, S. & Barone, A. (2007) Connective tissue graft used as a biologic barrier to cover an immediate implant. *Journal of Periodontology* **78**: 1644–1649.

Crespi, R., Cappare, P. & Gherlone, E. (2009a) Radiographic evaluation of marginal bone levels around platform-switched and non-platform-switched implants used in an immediate loading protocol. *The International Journal of Oral & Maxillofacial Implants* **24**: 920–926.

Crespi, R., Cappare, P. & Gherlone, E. (2010) Fresh-socket implants in periapical infected sites in humans. *Journal of Periodontology* **81**: 378–383.

Crespi, R., Cappare, P., Gherlone, E. & Romanos, G.E. (2007) Immediate occlusal loading of implants placed in fresh sockets after tooth extraction. *The International Journal of Oral & Maxillofacial Implants* **22**: 955–962.

Crespi, R., Cappare, P., Gherlone, E. & Romanos, G.E. (2008) Immediate versus delayed loading of dental implants placed in fresh extraction sockets in the maxillary esthetic zone: a clinical comparative study. *The International Journal of Oral & Maxillofacial Implants* **23**: 753–758.

De Boever, A.L., Quirynen, M., Coucke, W., Theuniers, G. & De Boever, J.A. (2009) Clinical and radiographic study of implant treatment outcome in periodontally susceptible and non-susceptible patients: a prospective long-term study. *Clinical Oral Implants Research* **20**: 1341–1350.

De Rouck, T., Collys, K. & Cosyn, J. (2008a) Immediate single-tooth implants in the anterior maxilla: a 1-year case cohort study on hard and soft tissue response. *Journal of Clinical Periodontology* **35**: 649–657.

De Rouck, T., Collys, K. & Cosyn, J. (2008b) Single-tooth replacement in the anterior maxilla by means of immediate implantation and provisionalization: a review. *The International Journal of Oral & Maxillofacial Implants* **23**: 897–904.

De Rouck, T., Collys, K., Wyn, I. & Cosyn, J. (2009) Instant provisionalization of immediate single-tooth implants is essential to optimize esthetic treatment outcome. *Clinical Oral Implants Research* **20**: 566–570.

Del Fabbro, M., Boggian, C. & Taschieri, S. (2009) Immediate implant placement into fresh extraction sites with chronic periapical pathologic features combined with plasma rich in growth factors: preliminary results of single-cohort study. *Journal of Oral and Maxillofacial Surgery* **67**: 2476–2484.

Esposito, M., Grusovin, M.G., Polyzos, I.P., Felice, P. & Worthington, H.V. (2010) Timing of implant placement after tooth extraction: Immediate, immediate-delayed or delayed implants? A cochrane systematic review *European Journal of Oral Implantology* **3**: 189–205.

Ferrara, A., Galli, C., Mauro, G. & Macaluso, G.M. (2006) Immediate provisional restoration of postextraction implants for maxillary single-tooth replacement. *International Journal of Periodontics & Restorative Dentistry* **26**: 371–377.

Fugazzotto, P.A. (2002a) Implant placement in maxillary first premolar fresh extraction sockets: description of technique and report of preliminary results. *Journal of Periodontology* **73**: 669–674.

Fugazzotto, P.A. (2008) Implant placement at the time of mandibular molar extraction: description of technique and preliminary results of 341 cases. *Journal of Periodontology* **79**: 737–747.

Fürhauser, R., Florescu, D., Benesch, T., Haas, R., Mailath, G. & Watzek, G. (2005) Evaluation of soft tissue around single-tooth implant crowns: the pink esthetic score. *Clinical Oral Implants Research* **16**: 639–644.

Gallucci, G.O., Morton, D. & Weber, H.P. (2009) Loading protocols for dental implants in edentulous patients. *The International Journal of Oral & Maxillofacial Implants* **24**(Suppl.): 132–146.

Gokcen-Rohlig, B., Meric, U. & Keskin, H. (2010) Clinical and radiographic outcomes of implants immediately placed in fresh extraction sockets. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics* **109**: e1–7.

Goldstein, M., Boyan, B.D. & Schwartz, Z. (2002) The palatal advanced flap: a pedicle flap for primary coverage of immediately placed implants. *Clinical Oral Implants Research* **13**: 644–650.

Hämmerle, C.H., Chen, S.T. & Wilson, T.G., Jr (2004) Consensus statements and recommended clinical procedures regarding the placement of implants in extraction sockets. *The International Journal of Oral & Maxillofacial Implants* **19**(Suppl.): 26–28.

Hardt, C.R., Grondahl, K., Lekholm, U. & Wennstrom, J.L. (2002) Outcome of implant therapy in relation to experienced loss of periodontal bone support: a retrospective 5- year study. *Clinical Oral Implants Research* **13**: 488–494.

Huys, L.W. (2001) Replacement therapy and the immediate post-extraction dental implant. *Implant Dentistry* **10**: 93–102.

Jansen, J.A., van de Waerden, J.P., Wolke, J.G. & de Groot, K. (1991) Histologic evaluation of the osseous adaptation to titanium and hydroxyapatite-coated titanium implants. *Journal of Biomedical Materials Research*, **25**: 973–989.

Jemt, T. (1997) Regeneration of gingival papillae after single-implant treatment. *International Journal of Periodontics & Restorative Dentistry* **17**: 326–333.

Jung, R.E., Pjetursson, B.E., Glauser, R., Zembic, A., Zwahlen, M. & Lang, N.P. (2008) A systematic

review of the 5-year survival and complication rates of implant-supported single crowns. *Clinical Oral Implants Research*, **19**: 119–130.

Juodzbalys, G. & Wang, H.L. (2007) Soft and hard tissue assessment of immediate implant placement: a case series. *Clinical Oral Implants Research* **18**: 237–243.

Kahnberg, K.E. (2009) Immediate implant placement in fresh extraction sockets: a clinical report. *The International Journal of Oral & Maxillofacial Implants* **24**: 282–288.

Kan, J.Y., Rungcharassaeng, K., Liddelow, G., Henry, P. & Goodacre, C.J. (2007a) Periimplant tissue response following immediate provisional restoration of scalloped implants in the esthetic zone: a one-year pilot prospective multicenter study. *Journal of Prosthetic Dentistry* **97**: S109–118.

Kan, J.Y., Rungcharassaeng, K. & Lozada, J. (2003) Immediate placement and provisionalization of maxillary anterior single implants: 1-year prospective study. *The International Journal of Oral & Maxillofacial Implants* **18**: 31–39.

Kan, J.Y., Rungcharassaeng, K., Lozada, J.L. & Zimmerman, G. (2011) Facial gingival tissue stability following immediate placement and provisionalization of maxillary anterior single implants: a 2- to 8-year follow-up. *The International Journal of Oral & Maxillofacial Implants* **26**: 179–187.

Kan, J.Y., Rungcharassaeng, K., Morimoto, T. & Lozada, J. (2009) Facial gingival tissue stability after connective tissue graft with single immediate tooth replacement in the esthetic zone: consecutive case report. *Journal of Oral and Maxillofacial Surgery* **67**: 40–48.

Kan, J.Y., Rungcharassaeng, K., Sclar, A. & Lozada, J.L. (2007b) Effects of the facial osseous defect morphology on gingival dynamics after immediate tooth replacement and guided bone regeneration: 1-year results. *Journal of Oral Maxillofacial Surgery* **65**: 13–19.

Karoussis, I.K., Salvi, G.E., Heitz-Mayfield, L.J., Bragger, U., Hammerle, C.H. & Lang, N.P. (2003) Long-term implant prognosis in patients with and without a history of chronic periodontitis: a 10-year prospective cohort study of the ITI dental implant system. *Clinical Oral Implants Research* **14**: 329–339.

Kirkwood, B.R. & Sterne, J.A.C. (2003a) Essential Medical Statistics. Oxford: Blackwell Science Ltd, chapter 24: Poisson regression

Kirkwood, B.R. & Sterne, J.A.C. (2003b) Essential Medical Statistics. Oxford: Blackwell Science Ltd, chapter 26: Survival analysis: displaying and comparing survival patterns.

Klokkevold, P.R., Nishimura, R.D., Adachi, M. & Caputo, A. (1997) Osseointegration enhanced by chemical etching of the titanium surface. A torque removal study in the rabbit. *Clinical Oral Implants Research* **8**: 442–447.

Lang, N.P. & Berglundh, T. (2011) Periimplant diseases: where are we now?–consensus of the seventh european workshop on periodontology. *Journal of Clinical Periodontology* **38**(Suppl. 11): 178–181.

Lang, N.P., Brägger, U., Hämmerle, C.H. & Sutter, F. (1994) Immediate transmucosal implants using the principle of guided tissue regeneration. I. Rationale, clinical procedures and 30-month results. *Clinical Oral Implants Research* **5**: 154–163.

Lazzara, R.J., Testori, T., Trisi, P., Porter, S.S. & Weinstein, R.L. (1999) A human histologic analysis of osseotite and machined surfaces using implants with 2 opposing surfaces. *The International Journal of Periodontics & Restorative Dentistry* **19**: 117–129.

Lindeboom, J.A., Tjiook, Y. & Kroon, F.H. (2006a) Immediate placement of implants in periapical infected sites: a prospective randomized study in 50 patients. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics* **101**: 705–710.

Lops, D., Chiapasco, M., Rossi, A., Bressan, E. & Romeo, E. (2008) Incidence of inter-proximal papilla between a tooth and an adjacent immediate implant placed into a fresh extraction socket: 1-year prospective study. *Clinical Oral Implants Research* **19**: 1135–1140.

Meijer, H.J.A., Stellingsma, K., Meijndert, L. & Raghoebar, G.M. (2005) A new index for rating aesthetics of implant supported single crowns and adjacent soft tissues. The Implant Crown Aesthetic Index: A polite study on validation of a new index. *Clinical Oral Implants Research*, **16**: 645–649.

Mengel, R., Behle, M. & Flores-de-Jacoby, L. (2007) Osseointegrated implants in subjects treated for generalized aggressive periodontitis: 10-year results of a prospective, long-term cohort study. *Journal of Periodontology* **78**: 2229–2237.

Mijiritsky, E., Mardinger, O., Mazor, Z. & Chaushu, G. (2009) Immediate provisionalization of single-tooth implants in fresh-extraction sites at the maxillary esthetic zone: up to 6 years of follow-up. *Implant Dentistry* **18**: 326–333.

Norton, M.R. (2004) A short-term clinical evaluation of immediately restored maxillary tioblast single-tooth implants. *The International Journal of Oral & Maxillofacial Implants* **19**: 274–281.

Pjetursson, B.E., Bragger, U., Lang, N.P. & Zwahlen, M. (2007) Comparison of survival and complication rates of tooth-supported fixed dental prostheses (FDPs) and implant-supported FDPs and single crowns (SCs). *Clinical Oral Implants Research* **18**(Suppl. 3): 97–113.

Pjetursson, B.E., Tan, K., Lang, N.P., Bragger, U., Egger, M. & Zwahlen, M. (2004) A systematic review of the survival and complication rates of fixed partial dentures (fpds) after an observation period of at least 5 years. *Clinical Oral Implants Research* **15**: 625–642.

Prosper, L., Crespi, R., Valenti, E., Cappare, P. & Gherlone, E. (2010) Five-year follow-up of wide-diameter implants placed in fresh molar extraction sockets in the mandible: immediate versus delayed loading. *The International Journal of Oral & Maxillofacial Implants* **25**: 607–612.

Renvert, S. & Persson, G.R. (2009) Periodontitis as a potential risk factor for peri-implantitis. *Journal of Clinical Periodontology* **36**(Suppl. 10): 9–14.

Ribeiro, F.S., Pontes, A.E., Marcantonio, E., Piattelli, A., Neto, R.J. & Marcantonio, E. Jr (2008) Success rate of immediate nonfunctional loaded single-tooth implants: immediate versus delayed implantation. *Implant Dentistry* **17**: 109–117.

Salvi, G.E., Gallini, G. & Lang, N.P. (2004) 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. *Clinical Oral Implants Research* **15**: 142–149.

Schulte, W., Kleineikenscheidt, H., Lindner, K. & Schareyka, R. (1978) [The Tübingen immediate implant in clinical studies]. *Deutsche Zahnarztliche Zeitschrift* **33**: 348–359.

Siciliano, V.I., Salvi, G.E., Matarasso, S., Cafiero, C., Blasi, A. & Lang, N.P. (2009) Soft tissues healing at immediate transmucosal implants placed into molar extraction sites with buccal self-contained dehiscences. A 12-month controlled clinical trial. *Clinical Oral Implants Research* **20**: 482–488.

Siegenthaler, D.W., Jung, R.E., Holderegger, C., Roos, M. & Hammerle, C.H. (2007) Replacement of teeth exhibiting periapical pathology by immediate implants: a prospective, controlled clinical trial. *Clinical Oral Implants Research* **18**: 727–737.

Tomasi, C., Sanz, M., Cecchinato, D., Pjetursson, B., Ferrus, J., Lang, N.P. & Lindhe, J. (2010) Bone dimensional variations at implants placed in fresh extraction sockets: a multilevel multivariate analysis. *Clinical Oral Implants Research* **21**: 30–36.

Tortamano, P., Camargo, L.O., Bello-Silva, M.S. & Kanashiro, L.H. (2010) Immediate implant placement and restoration in the esthetic zone: a prospective study with 18 months of follow-up. *The International Journal of Oral & Maxillofacial Implants* **25**: 345–350.

Tsirlis, A.T. (2005) Clinical evaluation of immediate loaded upper anterior single implants. *Implant Dentistry* **14**: 94–103.

Vanden Bogaerde, L., Rangert, B. & Wendelhag, I. (2005) Immediate/early function of branemark system tiunite implants in fresh extraction sockets in maxillae and posterior mandibles: an 18-month prospective clinical study. *Clinical Implant Dentistry and Related Research* **7**(Suppl. 1): S121–130.

Vidal, R., Greenwell, H., Hill, M., Papageorgakopoulos, G. & Scheetz, J.P. (2010) Success rate of immediate implants placed and restored by novice operators. *Implant Dentistry* **19**: 81–90.

Weber, H.P., Morton, D., Gallucci, G.O., Roccuzzo, M., Cordaro, L. & Grutter, L. (2009) Consensus statements and recommended clinical procedures regarding loading protocols. *The International Journal of Oral & Maxillofacial Implants* **24**(Suppl.): 180–183.

Wells, G.A., Shea, B., O'Connell, D., Peterson, J., Welch, V. & Losos, M. (2009) The Newcastle-Ottawa Scale (NOS) for assessing the quality of nonrandomized studies in meta-analyses. Available from: URL: http://www.ohri.ca/programs/clinical_epidemiology/oxford. htm

Zitzmann, N.U. & Berglundh, T. (2008) Definition and prevalence of peri-implant diseases. *Journal of Clinical Periodontology* **35**: 286–291.

List of excluded full text articles and the reason for exclusion

Achilli, A., Tura, F. & Euwe, E. (2007) Immediate/early function with tapered implants supporting maxillary and mandibular posterior fixed partial dentures: preliminary results of a prospective multicenter study. *Journal of Prosthetic Dentistry* **97**: S52–58. *Exclusion criteria: not reporting on immediate implants.*

Acocella, A., Bertolai, R. & Sacco, R. (2010) Modified insertion technique for immediate implant placement into fresh extraction socket in the first maxillary molar sites: a 3-year prospective study. *Implant Dentistry* **19**: 220–228. *Exclusion criteria: simultaneous implant placement and transalveolar sinus lift.*

Arvidson, K., Esselin, O., Felle-Persson, E., Jonsson, G., Smedberg, J.I. & Soderstrom, U. (2008) Early loading of mandibular full-arch bridges screw retained after 1 week to four to five monotype implants: 3-year results from a prospective multicentre study. *Clinical Oral Implants Research* **19**: 693–703. *Exclusion criteria: not reporting on immediate implants.*

Barone, A., Cornelini, R., Ciaglia, R. & Covani, U. (2008) Implant placement in fresh extraction sockets and simultaneous osteotome sinus floor elevation: a case series. *International Journal of Periodontics & Restorative Dentistry* **28**: 283–289. *Exclusion criteria: simultaneous implant placement and transalveolar sinus lift.*

Becker, W., Dahlin, C., Lekholm, U., Bergstrom, C., van Steenberghe, D., Higuchi, K. & Becker, B.E. (1999) Five-year evaluation of implants placed at extraction and with dehiscences and fenestration defects augmented with eptfe membranes: results from a prospective multicenter study. *Clinical Implant Dentistry and Related Research* **1**: 27–32. *Exclusion criteria: unaccounted high drop-outs (≥20%).*

Becker, W., Sennerby, L., Bedrossian, E., Becker, B. E. & Lucchini, J.P. (2005) Implant stability measurements for implants placed at the time of extraction: a cohort, prospective clinical trial. *Journal of Periodontology* **76**: 391–397. *Exclusion criteria: mean follow-up time < 1 year.*

Becker, W. & Wong, J. (2003) Early functional loading in the fully edentulous mandible after mandibular resection and reconstruction due to an ameloblastoma: case report. *Clinical Implant Dentistry & Related Research* **5**: 47–51. *Exclusion criteria: not reporting on immediate implants.*

Belser, U.C., Grutter, L., Vailati, F., Bornstein, M. M., Weber, H.P. & Buser, D. (2009) 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. *Journal of Periodontology* **80**: 140–151. *Exclusion criteria: not reporting on immediate implants.*

Bersani, E., Coppede, A.R. & de Paula Pinto Prata, H.H. (2010) Immediate loading of implants placed in fresh extraction sockets in the molar area with flapless and graftless procedures: a case series. *International Journal of Periodontics & Restorative Dentistry* **30**: 291–299. *Exclusion criteria: unknown mean follow-up time.*

Block, M.S., Mercante, D.E., Lirette, D., Mohamed, W., Ryser, M. & Castellon, P. (2009) Prospective evaluation of immediate and delayed provisional single tooth restorations. *Journal of Oral and Maxillofacial Surgery* **67**: 89–107. *Exclusion criteria: unknown number of implants in the immediate implant group that were being followed up.*

Blus, C. & Szmukler-Moncler, S. (2006) Split-crest and immediate implant placement with ultrasonic bone surgery: a 3-year life-table analysis with 230 treated sites. *Clinical Oral Implants Research* **17**: 700–707. *Exclusion criteria: not reporting on immediate implants.*

Buchs, A.U., Levine, L. & Moy, P. (2001) Preliminary report of immediately loaded altiva natural tooth replacement dental implants. *Clinical Implant Dentistry & Related Research* **3**: 97–106. *Exclusion criteria: not reporting on immediate implants.*

Calandriello, R., Tomatis, M. & Rangert, B. (2003a) Immediate functional loading of branemark system implants with enhanced initial stability: a prospective 1- to 2-year clinical and radiographic study. *Clinical Implant Dentistry & Related Research* **5**(Suppl 1): 10–20. *Exclusion criteria: not reporting on immediate implants.*

Calandriello, R., Tomatis, M., Vallone, R., Rangert, B. & Gottlow, J. (2003b) Immediate occlusal loading of single lower molars using branemark system wide-platform tiunite implants: an interim report of a prospective open-ended clinical multicenter study. *Clinical Implant Dentistry & Related Research* **5**(Suppl. 1): 74–80. *Exclusion criteria: not reporting on immediate implants.*

Cannizzaro, G. & Leone, M. (2003) Restoration of partially edentulous patients using dental implants with a microtextured surface: a prospective comparison of delayed and immediate full occlusal loading. *The International Journal of Oral & Maxillofacial Implants* **18**: 512–522. *Exclusion criteria: not reporting on immediate implants.*

Cannizzaro, G., Leone, M., Consolo, U., Ferri, V. & Esposito, M. (2008a) Immediate functional loading of implants placed with flapless surgery versus conventional implants in partially edentulous patients: a 3-year randomized controlled clinical trial. *The International Journal of Oral & Maxillofacial Implants* **23**: 867–875. *Exclusion criteria: not reporting on immediate implants.*

Cannizzaro, G., Leone, M. & Esposito, M. (2008b) Immediate versus early loading of two implants placed with a flapless technique supporting mandibular bar-retained overdentures: a single-blinded, randomised controlled clinical trial. *European Journal of Oral Implantology* **1**: 33–43. *Exclusion criteria: unknown survival rate of immediate implants; no separate report of the survival rate of immediate implants from other types of implant placement.*

Cannizzaro, G., Torchio, C., Felice, P., Leone, M. & Esposito, M. (2010) Immediate occlusal versus non-occlusal loading of single zirconia implants. A multicentre pragmatic randomised clinical trial. *European Journal of Oral Implantology* **3**: 111–120. *Exclusion criteria: not reporting on immediate implants.*

Cannizzaro, G., Torchio, C., Leone, M. & Esposito, M. (2008c) Immediate versus early loading of flapless-placed implants supporting maxillary full-arch prostheses: a randomised controlled clinical trial. *European Journal of Oral Implantology* **1**: 127–139. *Exclusion criteria: not reporting on immediate implants.*

Casap, N., Zeltser, C., Wexler, A., Tarazi, E. & Zeltser, R. (2007) Immediate placement of dental implants into debrided infected dentoalveolar sockets. *Journal of Oral and Maxillofacial Surgery* **65**: 384–392. *Exclusion protocol: unknown loading protocol.*

Castellon, P. & Yukna, R.A. (2004) Immediate dental implant placement in sockets augmented with htr synthetic bone. *Implant Dentistry* **13**: 42–48. *Exclusion criteria: unknown mean follow-up time.*

Chaushu, G., Chaushu, S., Tzohar, A. & Dayan, D. (2001) Immediate loading of single-tooth implants: Immediate versus non-immediate implantation. A clinical report. *The International Journal of Oral & Maxillofacial Implants* **16**: 267–272. *Exclusion criteria: mean follow-up time < 1 year.*

Chen, S.T., Darby, I.B. & Reynolds, E.C. (2007) A prospective clinical study of non-submerged immediate implants: clinical outcomes and esthetic results. *Clinical Oral Implants Research* **18**: 552–562. *Exclusion criteria: no report on the survival rate of immediate implants.*

Chiapasco, M., Abati, S., Romeo, E. & Vogel, G. (2001) Implant-retained mandibular overdentures with branemark system mkii implants: a prospective comparative study between delayed and immediate loading. *The International Journal of Oral & Maxillofacial Implants* **16**: 537–546. *Exclusion criteria: not reporting on immediate implants.*

Cooper, L.F., Rahman, A., Moriarty, J., Chaffee, N. & Sacco, D. (2002) Immediate mandibular rehabilitation with endosseous implants: simultaneous extraction, implant placement, and loading. *The International Journal of Oral & Maxillofacial Implants* **17**: 517–525. *Exclusion criteria: unknown mean follow-up time.*

Cornelini, R., Cangini, F., Covani, U., Barone, A. & Buser, D. (2004) Immediate restoration of single-tooth implants in mandibular molar sites: a 12-month preliminary report. *The International Journal of Oral & Maxillofacial Implants* **19**: 855–860. *Exclusion criteria: not reporting on immediate implants.*

Cornelini, R., Cangini, F., Covani, U., Barone, A. & Buser, D. (2006) Immediate loading of implants with 3-unit fixed partial dentures: A 12-month clinical study. *The International Journal of Oral & Maxillofacial Implants* **21**: 914–918. *Exclusion criteria: not reporting on immediate implants.*

Crespi, R., Cappare, P. & Gherlone, E. (2009b) Dental implants placed in extraction sites grafted

with different bone substitutes: radiographic evaluation at 24 months. *Journal of Periodontology* **80**: 1616–1621. *Exclusion criteria: not reporting on immediate implants.*

da Cunha, H.A., Francischone, C.E., Filho, H.N. & de Oliveira, R.C. (2004) A comparison between cutting torque and resonance frequency in the assessment of primary stability and final torque capacity of standard and tiunite single-tooth implants under immediate loading. *The International Journal of Oral & Maxillofacial Implants* **19**: 578–585. *Exclusion criteria: not reporting on immediate imiplants.*

Danza, M., Guidi, R. & Carinci, F. (2009) Spiral family implants inserted in postextraction bone sites. *Implant Dentistry* **18**: 270–278. *Exclusion criteria: unknown number of subjects with immediate implant.*

Degidi, M., Iezzi, G., Perrotti, V. & Piattelli, A. (2009) Comparative analysis of immediate functional loading and immediate nonfunctional loading to traditional healing periods: a 5-year follow-up of 550 dental implants. *Clinical Implant Dentistry & Related Research* **11**: 257–266. *Exclusion criteria: unknown number of subjects with immediate implant.*

Degidi, M., Piattelli, A. & Carinci, F. (2006a) Parallel screw cylinder implants: comparative analysis between immediate loading and two-stage healing of 1,005 dental implants with a 2-year follow up. *Clinical Implant Dentistry & Related Research* **8**: 151–160. *Exclusion criteria: not reporting on immediate implants.*

Degidi, M., Piattelli, A., Gehrke, P., Felice, P. & Carinci, F. (2006b) Five-year outcome of 111 immediate nonfunctional single restorations. *Journal of Oral Implantology* **32**: 277–285. *Exclusion criteria: patients of age < 18 years were included.*

Donati, M., La Scala, V., Billi, M., Di Dino, B., Torrisi, P. & Berglundh, T. (2008) Immediate functional loading of implants in single tooth replacement: a prospective clinical multicenter study. *Clinical Oral Implants Research* **19**: 740–748. *Exclusion criteria: not reporting on immediate implants.*

Drago, C.J. & Lazzara, R.J. (2004) Immediate provisional restoration of osseotite implants: a clinical report of 18-month results. *The nternational Journal of Oral & Maxillofacial Implants* **19**: 534–541. *Exclusion criteria: Sample size (subject) <10 in the immediate implant group.*

Erakat, M.S., Chuang, S.K., Yoo, R.H., Weed, M. & Dodson, T.B. (2008) Immediate loading of splinted locking-taper implants: 1-year survival estimates and risk factors for failure. *The International Journal of Oral & Maxillofacial Implants* **23**: 105–110. *Exclusion criteria: mean follow-up time < 1 year.*

Ericsson, I., Nilson, H., Lindh, T., Nilner, K. & Randow, K. (2000) Immediate functional loading of Branemark single tooth implants. An 18 months' clinical pilot follow-up study. *Clinical Oral Implants Research* **11**: 26–33. *Exclusion criteria: not reporting on immediate implants.*

Fischer, K., Backstrom, M. & Sennerby, L. (2009) Immediate and early loading of oxidized tapered implants in the partially edentulous maxilla: a 1-year prospective clinical, radiographic, and resonance frequency analysis study. *Clinical Implant Dentistry & Related Research* **11**: 69–80. *Exclusion criteria: not reporting on immediate implants.*

Francetti, L., Agliardi, E., Testori, T., Romeo, D., Taschieri, S. & Del Fabbro, M. (2008) Immediate rehabilitation of the mandible with fixed full prosthesis supported by axial and tilted implants: Interim results of a single cohort prospective study. *Clinical Implant Dentistry & Related Research* **10**: 255–263. *Exclusion criteria: not reporting on immediate implants.*

Fugazzotto, P.A. (2002b) Immediate implant placement following a modified trephine/osteotome approach: success rates of 116 implants to 4 years in function. *The International Journal of Oral & Maxillofacial Implants* **17**: 113–120. *Exclusion criteria: not reporting on immediate implants.*

Fugazzotto, P.A. (2006) Implant placement at the time of maxillary molar extraction: technique and report of preliminary results of 83 sites. *Journal of Periodontology* **77**: 302–309. *Exclusion criteria: simultaneous implant placement and transalveolar sinus lift.*

Galli, F., Capelli, M., Zuffetti, F., Testori, T. & Esposito, M. (2008) Immediate non-occlusal vs. Early loading of dental implants in partially edentulous patients: a multicentre randomized clinical trial. Peri-implant bone and soft-tissue levels. *Clinical Oral Implants Research* **19**: 546–552. *Exclusion criteria: unknown survival rate of immediate implants; no separate report of the survival rate of immediate implants from other types of implant placement.*

Ganeles, J., Zollner, A., Jackowski, J., ten Bruggenkate, C., Beagle, J. & Guerra, F. (2008) Immediate and early loading of straumann implants with a chemically modified surface (slactive) in the posterior mandible and maxilla: 1-year results from a prospective multicenter study. *Clinical Oral Implants Research* **19**: 1119–1128. *Exclusion criteria: not reporting on immediate implants.*

Gatti, C. & Chiapasco, M. (2002) Immediate loading of branemark implants: a 24-month follow-up of a comparative prospective pilot study between mandibular overdentures supported by conical transmucosal and standard mk ii implants. *Clinical Implant Dentistry & Related Research* **4**: 190–199. *Exclusion criteria: not reporting on immediate implants.*

Gatti, C., Haefliger, W. & Chiapasco, M. (2000) Implant-retained mandibular overdentures with immediate loading: a prospective study of iti implants. *The International Journal of Oral & Maxillofacial Implants* **15**: 383–388. *Exclusion criteria: Sample size (subject) <10 in the immediate implant group.*

Glauser, R., Ree, A., Lundgren, A., Gottlow, J., Hammerle, C.H. & Scharer, P. (2001) Immediate occlusal loading of branemark implants applied in various jawbone regions: a prospective, 1-year clinical study. *Clinical Implant Dentistry & Related Research* **3**: 204–213. *Exclusion criteria: unknown survival rate of immediate implants; no separate report of the survival rate of immediate implants from other types of implant placement.*

Glauser, R., Ruhstaller, P., Windisch, S., Zembic, A., Lundgren, A., Gottlow, J. & Hammerle, C.H. (2005) Immediate occlusal loading of branemark system tiunite implants placed predominantly in soft bone: 4-year results of a prospective clinical study. *Clinical Implant Dentistry & Related Research* **7**(Suppl. 1): S52–59. *Exclusion criteria: unknown number of subjects with immediate implant.*

Glauser, R., Zembic, A., Ruhstaller, P. & Windisch, S. (2007) Five-year results of implants with an oxidized surface placed predominantly in soft quality bone and subjected to immediate occlusal loading. *Journal of Prosthetic Dentistry* **97**: S59–68. *Exclusion criteria: not reporting on immediate implants.*

Gomez-Roman, G., Kruppenbacher, M., Weber, H. & Schulte, W. (2001) Immediate postextraction implant placement with root-analog stepped implants: surgical procedure and statistical outcome after 6 years. *The International Journal of Oral & Maxillofacial Implants* **16**: 503–513. *Exclusion criteria: unknown survival rate of implants in extraction sockets; no separate report of the survival rate of implants in extraction sockets from implants at explantation sites.*

Groisman, M., Frossard, W.M., Ferreira, H.M., de Menezes Filho, L.M. & Touati, B. (2003) Single-tooth implants in the maxillary incisor region with immediate provisionalization: 2-year prospective study. *Practical Procedures & Aesthetic Dentistry* **15**: 115–122; quiz 126. *Exclusion criteria: unknown age of the patients.*

Grunder, U., Polizzi, G., Goene, R., Hatano, N., Henry, P., Jackson, W.J., Kawamura, K., Kohler, S., Renouard, F., Rosenberg, R., Triplett, G., Werbitt, M. & Lithner, B. (1999) A 3-year prospective multicenter follow-up report on the immediate and delayed-immediate placement of implants. *The International Journal of Oral & Maxillofacial Implants* **14**: 210–216. *Exclusion protocol: unknown loading protocol.*

Guncu, M.B., Aslan, Y., Tumer, C., Guncu, G.N. & Uysal, S. (2008) In-patient comparison of immediate and conventional loaded implants in mandibular molar sites within 12 months. *Clinical Oral Implants Research* **19**: 335–341. *Exclusion criteria: not reporting on immediate implants.*

Guncu, G.N., Tozum, T.F., Guncu, M.B., Yamalik, N. & Tumer, C. (2009) A 12-month evaluation of nitrite oxide metabolism around immediate and conventionally loaded dental implants. *Implant Dentistry* **18**: 27–37. *Exclusion criteria: not reporting on immediate implants.*

Hall, J.A., Payne, A.G., Purton, D.G., Torr, B., Duncan, W.J. & De Silva, R.K. (2007) Immediately restored, single-tapered implants in the anterior maxilla: prosthodontic and aesthetic outcomes after 1 year. *Clinical Implant Dentistry & Related Research* **9**: 34–45. *Exclusion criteria: not reporting on immediate implants.*

Hassan, K.S. (2009) Autogenous bone graft combined with polylactic polyglycolic acid polymer for treatment of dehiscence around immediate dental implants. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics* **108**: e19–25. *Exclusion criteria: mean follow-up time < 1 year.*

Hassan, K.S., Kassim, A. & Al Ogaly, A.U. (2008) A comparative evaluation of immediate dental implant with autogenous versus synthetic guided bone regeneration. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontics* **106**: e8–e15. *Exclusion protocol: unknown loading protocol.*

Horwitz, J., Zuabi, O. & Machtei, E. (2008) Radiographic changes around immediately restored dental implants in periodontally susceptible patients: 1-year results. *The International Journal of Oral & Maxillofacial Implants* **23**: 531–538. *Exclusion criteria: unknown number of subjects with immediate implant.*

Horwitz, J., Zuabi, O., Peled, M. & Machtei, E.E. (2007) Immediate and delayed restoration of dental implants in periodontally susceptible patients: 1-year results. *The International Journal of Oral & Maxillofacial Implants* **22**: 423–429. *Exclusion criteria: unknown number of subjects with immediate implant.*

Hruska, A., Borelli, P., Bordanaro, A.C., Marzaduri, E. & Hruska, K.L. (2002) Immediate loading implants: a clinical report of 1301 implants. *Journal of Oral Implantology* **28**: 200–209. *Exclusion criteria: not reporting on immediate implants.*

Hui, E., Chow, J., Li, D., Liu, J., Wat, P. & Law, H. (2001) Immediate provisional for single-tooth implant replacement with branemark system: preliminary report. *Clinical Implant Dentistry & Related Research* **3**: 79–86. *Exclusion criteria: <10 subjects with follow-up time > 1 year.*

Ibanez, J.C. & Jalbout, Z.N. (2002) Immediate loading of osseotite implants: two-year results. *Implant Dentistry* **11**: 128–136. *Exclusion criteria: not reporting on immediate implants.*

Ibanez, J.C., Tahhan, M.J., Zamar, J.A., Menendez, A.B., Juaneda, A.M., Zamar, N.J. & Monqaut, J.L. (2005) Immediate occlusal loading of double acid-etched surface titanium implants in 41 consecutive full-arch cases in the mandible and maxilla: 6- to 74-month results. *Journal of Periodontology* **76**: 1972–1981. *Exclusion criteria: not reporting on immediate implants.*

Jaffin, R., Kolesar, M., Kumar, A., Ishikawa, S. & Fiorellini, J. (2007) The radiographic bone loss pattern adjacent to immediately placed, immediately loaded implants. *The International Journal of Oral & Maxillofacial Implants* **22**: 187–194. *Exclusion criteria: no report on the survial rate of immediate implants.*

Jaffin, R.A., Kumar, A. & Berman, C.L. (2000) Immediate loading of implants in partially and fully edentulous jaws: a series of 27 case reports. *Journal of Periodontology* **71**: 833–838. *Exclusion criteria: not reporting on immediate implants.*

Jo, H.Y., Hobo, P.K. & Hobo, S. (2001) Freestanding and multiunit immediate loading of the expandable implant: an up-to-40-month prospective survival study. *Journal of Prosthetic Dentistry* **85**: 148–155. *Exclusion criteria: unknown number of subjects with immediate implant.*

Lindeboom, J.A., Frenken, J.W., Dubois, L., Frank, M., Abbink, I. & Kroon, F.H. (2006b) Immediate loading versus immediate provisionalization of maxillary single-tooth replacements: a prospective randomized study with biocomp implants. *Journal of Oral and Maxillofacial Surgery* **64**: 936–942. *Exclusion criteria: not reporting on immediate implants.*

Locante, W.M. (2004) Single-tooth replacements in the esthetic zone with an immediate function implant: a preliminary report. *Journal of Oral Implantology* **30**: 369–375. *Exclusion criteria: patients of age < 18 years were included.*

Longoni, S., Sartori, M., Apruzzese, D., Davide, R. & Baldoni, M. (2007) Immediate loading: a simple protocol to create a passively fitting provisional fixed implant-supported complete denture in 1 day. *International Journal of Periodontics & Restorative Dentistry* **27**: 369–377. *Exclusion criteria: unknown number of immediate implants.*

Luongo, G., Di Raimondo, R., Filippini, P., Gualini, F. & Paoleschi, C. (2005) Early loading of sand-blasted, acid-etched implants in the posterior maxilla and mandible: a 1-year follow-up report from a multicenter 3-year prospective study. *The International Journal of Oral & Maxillofacial Implants* **20**: 84–91. *Exclusion criteria: not reporting on immediate implants.*

Machtei, E.E., Frankenthal, S., Blumenfeld, I., Gutmacher, Z. & Horwitz, J. (2007) Dental implants for immediate fixed restoration of partially edentulous patients: a 1-year prospective pilot clinical trial in periodontally susceptible patients. *Journal of Periodontology* **78**: 1188–1194. *Exclusion criteria: not reporting on immediate implants.*

Malo, P., de Araujo Nobre, M. & Rangert, B. (2007) Implants placed in immediate function in periodontally compromised sites: a five-year retrospective and one-year prospective study. *Journal of Prosthetic Dentistry* **97**: S86–95. *Exclusion criteria: unknown number of subjects with immediate implant.*

Malo, P., Friberg, B., Polizzi, G., Gualini, F., Vighagen, T. & Rangert, B. (2003) Immediate and early function of branemark system implants placed in the esthetic zone: a 1-year prospective clinical multicenter study. *Clinical Implant Dentistry & Related Research* **5**(Suppl. 1): 37–46. *Exclusion protocol: unknown loading protocol.*

Malo, P. & Nobre, M. (2008) Flap vs. Flapless surgical techniques at immediate implant function in predominantly soft bone for rehabilitation of partial edentulism: a prospective cohort study with follow-up of 1 year. *European Journal of Oral Implantology* **1**: 293–304. *Exclusion criteria: not reporting on immediate implants.*

Mannai, C. (2006) Early implant loading in severely resorbed maxilla using xenograft, autograft, and platelet-rich plasma in 97 patients. *Journal of Oral and Maxillofacial Surgery* **64**: 1420–1426. *Exclusion criteria: not reporting on immediate implants.*

Martinez-Gonzalez, J.M., Barona-Dorado, C., Cano-Sanchez, J., Florez-Rodriguez, M. & Cantero-Alvarez, M. (2005) Clinical and radiographic behaviour of 290 dental implants with a surface treated with hydrofluoric acid and passivated with hydrofluoric and nitric acid: early loading results after 2 years. *Medicina Oral, Patologia Oral y Cirugia Bucal* **10**: 355–361. *Exclusion criteria: not reporting on immediate implants.*

Mazor, Z. & Cohen, D.K. (2003) Preliminary 3-dimensional surface texture measurement and early loading results with a microtextured implant surface. *The International Journal of Oral & Maxillofacial Implants* **18**: 729–738. *Exclusion criteria: not reporting on immediate implants.*

Merli, M., Merli, A., Bernardelli, F., Lombardini, F. & Esposito, M. (2008) Immediate versus early non-occlusal loading of dental implants placed flapless in partially edentulous patients. One-year results from a randomised controlled trial. *European Journal of Oral Implantology* **1**: 207–220. *Exclusion criteria: unknown number of immediate implants.*

Nemcovsky, C.E., Artzi, Z., Moses, O. & Gelernter, I. (2002) Healing of marginal defects at implants placed in fresh extraction sockets or after 4-6 weeks of healing. A comparative study. *Clinical Oral Implants Research* **13**: 410–419. *Exclusion criteria: mean follow-up time < 1 year.*

Nikellis, I., Levi, A. & Nicolopoulos, C. (2004) Immediate loading of 190 endosseous dental implants: a prospective observational study of 40 patient treatments with up to 2-year data. *The International Journal of Oral & Maxillofacial Implants* **19**: 116–123. *Exclusion criteria: not reporting on immediate implants.*

Noelken, R., Morbach, T., Kunkel, M. & Wagner, W. (2007) Immediate function with nobelperfect implants in the anterior dental arch. *International Journal of Periodontics & Restorative Dentistry* **27**: 277–285. *Exclusion criteria: unknown survival rate of immediate implants; no separate report of the survival rate of immediate implants from other types of implant placement.*

Ormianer, Z., Garg, A.K. & Palti, A. (2006) Immediate loading of implant overdentures using modified loading protocol. *Implant Dentistry* **15**: 35–40. *Exclusion criteria: not reporting on immediate implants.*

Ostman, P.O., Hellman, M., Albrektsson, T. & Sennerby, L. (2007) Direct loading of nobel direct and nobel perfect one-piece implants: a 1-year prospective clinical and radiographic study. *Clinical Oral Implants Research* **18**: 409–418. *Exclusion criteria: unknown survival rate of immediate implants; no separate report of the survival rate of immediate implants from other types of implant placement.*

Ostman, P.O., Hellman, M. & Sennerby, L. (2008) Immediate occlusal loading of implants in the partially edentate mandible: a prospective 1-year radiographic and 4-year clinical study. *The International Journal of Oral & Maxillofacial Implants* **23**: 315–322. *Exclusion criteria: not reporting on immediate implants.*

Palattella, P., Torsello, F. & Cordaro, L. (2008) Two-year prospective clinical comparison of immediate replacement vs. Immediate restoration of single tooth in the esthetic zone. *Clinical Oral Implants Research* **19**: 1148–1153. *Exclusion criteria: Sample size (subject) <10 in the immediate implant group.*

Paolantonio, M., Dolci, M., Scarano, A., d'Archivio, D., di Placido, G., Tumini, V. & Piattelli, A. (2001) Immediate implantation in fresh extraction sockets. A controlled clinical and histological study in man. *Journal of Periodontology* **72**: 1560–1571. *Exclusion criteria: unknown loading protocol.*

Penarrocha-Diago, M., Carrillo-Garcia, C., Boronat-Lopez, A. & Garcia-Mira, B. (2008) Comparative study of wide-diameter implants placed after dental extraction and implants positioned in mature bone for molar replacement. *The International Journal of Oral & Maxillofacial Implants* **23**: 497–501. *Exclusion criteria: Sample size (subject) <10 in the immediate implant group.*

Petrungaro, P.S. (2008) An update on implant placement and provisionalization in extraction, edentulous, and sinus-grafted sites. A clinical report on 3200 sites over 8 years. *The Compendium of Continuing Education in Dentistry* **29**: 288–294. 296, 298-300. *Exclusion criteria: follow-up time < 1 year.*

Prosper, L., Gherlone, E.F., Redaelli, S. & Quaranta, M. (2003) Four-year follow-up of larger-diameter implants placed in fresh extraction sockets using a resorbable membrane or a resorbable alloplastic material. *The International Journal of Oral & Maxillofacial Implants* **18**: 856–864. *Exclusion criteria: simultaneous implant placement and transalveolar sinus lift.*

Proussaefs, P. & Lozada, J. (2004) Immediate loading of hydroxyapatite-coated implants in the maxillary premolar area: three-year results of a pilot study. *Journal of Prosthetic Dentistry* **91**: 228–233. *Exclusion criteria: not reporting on immediate implants.*

Rao, W. & Benzi, R. (2007) Single mandibular first molar implants with flapless guided surgery and immediate function: preliminary clinical and radiographic results of a prospective study. *Journal of Prosthetic Dentistry* **97**: S3–S14. *Exclusion criteria: not reporting on immediate implants.*

Rocci, A., Martignoni, M. & Gottlow, J. (2003a) Immediate loading of branemark system tiunite and machined-surface implants in the posterior mandible: a randomized open-ended clinical trial. *Clinical Implant Dentistry & Related Research* **5** (Suppl. 1): 57–63. *Exclusion criteria: not reporting on immediate implants.*

Rocci, A., Martignoni, M. & Gottlow, J. (2003b) Immediate loading in the maxilla using flapless surgery, implants placed in predetermined positions, and prefabricated provisional restorations: a retrospective 3-year clinical study. *Clinical Implant Dentistry & Related Research* **5**(Suppl. 1): 29–36. *Exclusion criteria: not reporting on immediate implants.*

Romanos, G.E. & Nentwig, G.H. (2006) Immediate versus delayed functional loading of implants in the posterior mandible: a 2-year prospective clinical study of 12 consecutive cases. *International Journal of Periodontics & Restorative Dentistry* **26**: 459–469. *Exclusion criteria: not reporting on immediate implants.*

Romanos, G.E. & Nentwig, G.H. (2009) Immediate functional loading in the maxilla using implants with platform switching: five-year results. *The International Journal of Oral & Maxillofacial Implants* **24**: 1106–1112. *Exclusion criteria: Sample size (subject) <10 in the immediate implant group.*

Rosenquist, B. & Ahmed, M. (2000) The immediate replacement of teeth by dental implants using homologous bone membranes to seal the sockets: clinical and radiographic findings. *Clinical Oral Implants Research* **11**: 572–582. *Exclusion criteria: follow-up time < 1 year.*

Rosenquist, B. & Grenthe, B. (1996) Immediate placement of implants into extraction sockets: implant survival. *The International Journal of Oral & Maxillofacial Implants* **11**: 205–209. *Exclusion criteria: patients of age < 18 years were included.*

Ryser, M.R., Block, M.S. & Mercante, D.E. (2005) Correlation of papilla to crestal bone levels around single tooth implants in immediate or delayed crown protocols. *Journal of Oral and Maxillofacial Surgery* **63**: 1184–1195. *Exclusion criteria: not reporting on immediate implants.*

Schincaglia, G.P., Marzola, R., Giovanni, G.F., Chiara, C.S. & Scotti, R. (2008) Replacement of mandibular molars with single-unit restorations supported by wide-body implants: Immediate versus delayed loading. A randomized controlled study. *The International Journal of Oral & Maxillofacial Implants* **23**: 474–480. *Exclusion criteria: not reporting on immediate implants.*

Schincaglia, G.P., Marzola, R., Scapoli, C. & Scotti, R. (2007) Immediate loading of dental implants supporting fixed partial dentures in the posterior mandible: a randomized controlled split-mouth study–machined versus titanium oxide implant surface. *The International Journal of Oral & Maxillofacial Implants* **22**: 35–46. *Exclusion criteria: not reporting on immediate implants.*

Schnitman, P.A., Wohrle, P.S., Rubenstein, J.E., DaSilva, J.D. & Wang, N.H. (1997) Ten-year results for Branemark implants immediately loaded with fixed prostheses at implant placement. *The International Journal of Oral & Maxillofacial Implants* **12**: 495–503. *Exclusion criteria: Sample size (subject) <10 in the immediate implant group.*

Schwartz-Arad, D. & Chaushu, G. (1998) Full-arch restoration of the jaw with fixed ceramometal prosthesis. *The International Journal of Oral & Maxillofacial Implants* **13**: 819–825. *Exclusion criteria: unknown survival rate of immediate implants; no separate report of the survival rate of immediate implants from other types of implant placement.*

Schwartz-Arad, D., Grossman, Y. & Chaushu, G. (2000) The clinical effectiveness of implants placed immediately into fresh extraction sites of molar teeth. *Journal of Periodontology* **71**: 839–844. *Exclusion criteria: patients of age < 18 years were included.*

Schwartz-Arad, D., Laviv, A. & Levin, L. (2007) Survival of immediately provisionalized dental implants placed immediately into fresh extraction sockets. *Journal of Periodontology* **78**: 219–223. *Exclusion criteria: simultaneous implant placement and transalveolar sinus lift.*

Schwartz-Arad, D., Yaniv, Y., Levin, L. & Kaffe, I. (2004) A radiographic evaluation of cervical bone loss associated with immediate and delayed implants placed for fixed restorations in edentulous jaws. *Journal of Periodontology* **75**: 652–657. *Exclusion criteria: unknown survival rate of immediate implants; no separate report of the survival rate of immediate implants from other types of implant placement.*

Shiigai, T. (2007) Pilot study in the identification of stability values for determining immediate and early loading of implants. *Journal of Oral Implantology* **33**: 13–22. *Exclusion criteria: not reporting on immediate implants.*

Simsek, B. & Simsek, S. (2003) Evaluation of success rates of immediate and delayed implants after tooth extraction. *Chinese Medical Journal* **116**: 1216–1219. *Exclusion criteria: unknown loading protocol.*

Smith, R.B., Tarnow, D.P., Brown, M., Chu, S. & Zamzok, J. (2009) Placement of immediate implants and a fixed provisional restoration to replace the four mandibular incisors. *The Compendium of Continuing Education in Dentistry* **30**: 408–410, 413-405; quiz 416, 418.*Exclusion: unknown age of patients.*

Sullivan, D., Vincenzi, G. & Feldman, S. (2005) Early loading of osseotite implants 2 months after placement in the maxilla and mandible: a 5-year report. *The International Journal of Oral & Maxillofacial Implants* **20**: 905–912. *Exclusion criteria: not reporting on immediate implants.*

Tealdo, T., Bevilacqua, M., Pera, F., Menini, M., Ravera, G., Drago, C. & Pera, P. (2008) Immediate function with fixed implant-supported maxillary dentures: a 12-month pilot study. *Journal of Prosthetic Dentistry* **99**: 351–360. *Exclusion criteria: unknown survival rate of immediate implants; no separate report of the survival rate of immediate implants from other types of implant placement.*

Testori, T., Galli, F., Capelli, M., Zuffetti, F. & Esposito, M. (2007) Immediate nonocclusal versus early loading of dental implants in partially edentulous patients: 1-year results from a multicenter, randomized controlled clinical trial. *The International Journal of Oral & Maxillofacial Implants* **22**: 815–822.

Turkyilmaz, I. (2006) A 3-year prospective clinical and radiologic analysis of early loaded maxillary dental implants supporting single-tooth crowns. *International Journal of Prosthodontics* **19**: 389–390. *Exclusion criteria: not reporting on immediate implants.*

Vanden Bogaerde, L., Pedretti, G., Dellacasa, P., Mozzati, M. & Rangert, B. (2003) Early function of splinted implants in maxillas and posterior mandibles using branemark system machined-surface implants: an 18-month prospective clinical multicenter study. *Clinical Implant Dentistry & Related Research* **5**(Suppl. 1): 21–28. *Exclusion criteria: not reporting on immediate implants.*

Vanden Bogaerde, L., Pedretti, G., Dellacasa, P., Mozzati, M., Rangert, B. & Wendelhag, I. (2004) Early function of splinted implants in maxillas and posterior mandibles, using Branemark system TiUnite implants: an 18-month prospective clinical multicenter study. *Clinical Implant Dentistry & Related Research* **6**: 121–129. *Exclusion criteria: not reporting on immediate implants.*

Villa, R. & Rangert, B. (2005) Early loading of interforaminal implants immediately installed after extraction of teeth presenting endodontic and periodontal lesions. *Clinical Implant Dentistry & Related Research* **7**(Suppl. 1): S28–35. *Exclusion criteria: unknown number of immediate implants.*

Villa, R. & Rangert, B. (2007) Immediate and early function of implants placed in extraction sockets of maxillary infected teeth: a pilot study. *Journal of Prosthetic Dentistry* **97**: S96–S108. *Exclude: unknown age of patients.*

Weischer, T., Kandt, M. & Reidick, T. (2005) Immediate loading of mandibular implants in compromised patients: preliminary results. *International Journal of Periodontics & Restorative Dentistry* **25**: 501–507. *Exclusion criteria: sample size (subject) <10 in the immediate implant group.*

Zembic, A., Glauser, R., Khraisat, A. & Hammerle, C.H. (2010) Immediate vs. Early loading of dental implants: 3-year results of a randomized controlled clinical trial. *Clinical Oral Implants Research* **21**: 481–489. *Exclusion criteria: sample size (subject) <10 in the immediate implant group.*

Zollner, A., Ganeles, J., Korostoff, J., Guerra, F., Krafft, T. & Bragger, U. (2008) Immediate and early non-occlusal loading of straumann implants with a chemically modified surface (slactive) in the posterior mandible and maxilla: interim results from a prospective multicenter randomized-controlled study. *Clinical Oral Implants Research* **19**: 442–450. *Exclusion criteria: not reporting on immediate implants.*