Immediate Loading of Postextraction Implants in the Esthetic Area: Systematic Review of the Literature

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ABSTRACT

Purpose: The purpose of the present systematic review was to estimate the survival rate of implants placed in fresh extraction sockets and immediately restored. Secondary aims were to compare it with the survival rate of implants placed in healed ridges and of implants restored according to a delayed protocol as well as to assess the influence of several other confounding factors on the clinical outcomes.

Methods: An electronic search was performed on MEDLINE, EMBASE, and CENTRAL databases in order to identify prospective clinical studies published from 1990 to October 2012. A hand search was also done. Studies were selected according to specific inclusion criteria. The effect of the following parameters on 1-year implant survival (IS) was statistically evaluated: study design, risk of bias, prosthesis type, type of loading (occlusal or nonocclusal), type of incision (flap or flapless), presence of infection, and grafting material. A meta-analysis of studies comparing immediately restored implants placed in fresh postextraction sockets versus healed ridges was conducted.

Results: Seven randomized trials, three controlled trials, and 35 case series were included, accounting for 1170 patients and 1974 postextraction implants immediately restored. Twenty-eight studies had a low risk of bias. The overall 1-year IS was 97.6%. All failures occurred within 1 year of function. Meta-analysis showed a significant better outcome for implants placed in healed ridge (IS = 99.4%) as compared with postextraction implants (IS = 95.6%). No other parameter had a significant effect on clinical outcomes. Most variables, among which the esthetic aspect, could not be assessed as they were not systematically reported.

Conclusion: Though the conventional protocol still represents the gold standard, immediate restoration of implants placed in fresh extraction sites displayed an excellent implant prognosis. Such clinical approach can be successfully adopted in order to minimize the treatment time with a relevant impact on patient's satisfaction.

KEY WORDS: dental implants, immediate implants, immediate loading, postextraction socket, systematic review

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INTRODUCTION

The loss of one or more teeth causes extensive resorption of the alveolar process as a result of physiological events. Such resorption is more pronounced buccally than at the lingual/palatal side.[1–5] Parallel to the ridge profile alteration, the socket undergoes wound healing process that involves both hard and soft tissue, though the remodeling process may continue long after completion of bone formation within the socket.[6,7]

The preservation of hard and soft tissue after tooth loss in order to allow for restoration of function and aesthetics by means of implant treatment is one of the most challenging aims of clinicians. Different techniques

have been adopted for preserving the postextraction alveolar ridge morphology,[8,9] for example: (1) guided bone regeneration with resorbable or nonresorbable membranes;[10,11] (2) grafting the socket with autogenous bone,[12] bone substitutes,[13–19] or platelet concentrates;[20–27] (3) less invasive surgical approach by avoiding flap elevation in order to preserve bone vascularization;[28–30] (4) immediate implant placement;[31–34] and (4) different combinations of the above options.[7,8]

A few studies suggested that immediate placement of an implant in the fresh extraction socket per se cannot avoid bone resorption.[35,36] In fact, a number of technical or biological factors seem to be involved in the hard and soft tissue healing dynamics after tooth extraction. Some examples are: implant positioning within the socket,[37] the time elapsing from implant placement and restoration, the presence of active infection, the reason for tooth extraction (periodontal, endodontic, or endo-periodontal infection, caries, trauma, vertical, or horizontal root fracture), and the initial thickness of the alveolar bone wall at the facial side.[38–40] Furthermore, the expertise of the operator may affect the outcome of postextraction implants, especially when the esthetic region is involved.[41]

The current classification of implants in postextraction sockets is based on the time elapsing between tooth extraction and implant placement and consists of the following four situations. Type I: implants placed immediately into fresh extraction sockets as part of the same surgical procedure; Type II: implants placed after complete soft tissue coverage of the socket (4–8 weeks following tooth extraction); Type III: implants placed in a socket with consistent clinical or radiographic bone fill (after 12–16 weeks); and Type IV: implants placed in a completely healed edentulous site (after more than 16 weeks).[42,43] It has been underlined that for Type I implants the risk for developing soft tissue recession is higher as compared with other situations. Furthermore, in early-placed implants (Types II–III), the use of bone grafting seems to provide better hard tissue dimensions and less postoperative complications than in delayed implants (Type IV).[42,43]

The timing of implant restoration is also important in view of the current trend toward the decrease of the total treatment time while keeping clinical and aesthetic outcomes at the highest possible level. A recent systematic review evaluated the outcomes of immediate restoration/loading of single implants immediately placed in postextraction sockets.[44] That review confirmed the potential advantages offered by such bimodal option but emphasized that the risk of implant failure is higher as compared with immediately restored/loaded implants placed in healed ridges. The same conclusion was reported by a recent large retrospective study in which, based on a multivariate Cox regression model, the combination of immediate implant placement and immediate restoration significantly increased the failure rate as compared with standard delayed protocols, especially in the maxilla.[45] In view of the increasing number of clinical reports on this subject, and of the variable indications provided by different published studies, we felt important to perform an updated review of the literature, in order to see if some relevant questions can be answered to, based on the current available evidence.

The main aim of the present systematic review was to estimate the survival rate of implants placed in fresh extraction sockets and immediately restored, after at least 1 year of function. Secondary aims were to compare the clinical outcomes of such protocol with those of standard protocols such as delayed placement in healed ridges and delayed loading and to assess the influence of various confounding factors on the survival rate of implants immediately placed and restored. The main specific questions of the review were: what is the prognosis of implants immediately placed in postextraction sockets and immediately restored? Is it comparable with that of implants placed in healed ridges and with that of implants restored according to a delayed protocol? What is the influence of the main confounding factors on the clinical outcome of implants placed and restored immediately? Does the study design affect the estimation of implant prognosis?

MATERIALS AND METHODS

An electronic search was conducted on MEDLINE, EMBASE, and CENTRAL databases in order to identify clinical studies published from 1990 to October 2012. The search terms used were "dental implants," "extraction socket*," "immediate implant*," "immediate loading," "immediate restoration*," "Immediate placement*," "immediate installation*," and "fresh extraction socket*" alone or combined with the Boolean operator "AND."

The references of the selected articles and of the reviews resulting from the electronic search were also

examined. In addition, a hand search of issues from 1995 to October 2012, including the section "Early view" when present, was undertaken on the following journals: *Clinical Implant Dentistry and Related Research*, *Clinical Oral Implants Research*, *Implant Dentistry*, *European Journal of Oral Implantology*, *International Journal of Oral and Maxillofacial Implants*, *International Journal of Periodontics and Restorative Dentistry*, *Journal of Clinical Periodontology*, *Journal of Periodontology*, and *Journal of Prosthetic Dentistry*.

Inclusion Criteria

The studies to be included in this systematic review had to met the following inclusion criteria:

- prospective longitudinal studies (randomized clinical trials [RCT], controlled clinical trials [CCT], case-control studies, and prospective case series [PCS]);
- at least 10 patients treated with implants immediately placed in postextraction sites (Type I according to the Hammerle 2004 classification[39]) and restored immediately (within 48 hours of surgery);
- patients older than 18 years;
- follow-up time of at least 1 year after implant placement;
- immediate implants placed in the aesthetic zone (anterior maxilla); and
- studies presenting data regarding success or survival of immediate implants.

When papers from the same group of authors were identified, with very similar databases of patients, materials, methods, and outcomes, the authors were contacted to clarify whether the pool of patients was indeed the same. In case of multiple publications relative to different aspects or phases of the same study, only the most relevant to the present review were considered.

Selection of the Studies

Two reviewers (MDF and VC) independently screened the titles and the abstracts of the articles initially retrieved through the electronic search. The reviewers were previously calibrated by assessing a sample of 20 articles. The concordance between reviewers was assessed by means of the Cohen's Kappa index. In case of disagreement, a joint decision was taken by discussion. The full texts of all studies of possible relevance were independently assessed by the same two reviewers to check if they met all inclusion criteria. For articles excluded at this stage, the reason for exclusion was noted.

Data Extraction

Data were extracted by two reviewers independently (MDF and VC). Cases of disagreement were subject to joint evaluation by the reviewers until an agreement was reached. The following variables were extracted from each included study: study design, setting, number of patients, number of implants and number of restorations at entry and at the final follow-up, patients demographics (age, gender, and number of smokers), follow-up duration, number of dropouts, reason and time of failures, reason for extraction, implant location, prosthesis type, type of loading (occlusal or nonocclusal), type of incision (flap or flapless), implant type, presence of infection at surgery, grafting material, marginal bone level changes, soft tissue changes, aesthetic evaluation, and type and number of complications.

The following methodological parameters were also recorded: for randomized studies, the random sequence generation method and allocation concealment; for all studies: blinding of outcome assessment, completeness of the outcome data, comparability of the study groups at entry, clear definition of selection criteria, reason for extraction, recall rate (it was assumed adequate if dropout <20%), reason for withdrawal (when applicable), sample size (it was assumed adequate if >20 patients treated), and length of follow-up period (it was assumed adequate if >2 years).

Methodological Quality Assessment

The methodological quality of the selected studies was evaluated independently and in duplicate by two reviewers (MDF and VC) according to the above methodological parameters. All the criteria were assessed as adequate, unclear, or inadequate. The authors of the identified RCTs were contacted in request for clarifications or for providing missing information as needed.

In order to summarize the validity of studies, they were grouped into the following categories: (1) RCTs: (a) low risk of bias if at least six of the quality criteria were judged adequate; and (b) high risk of bias if no more than five quality criteria were judged adequate. If both the random sequence generation and the allocation

concealment were judged inadequate, the RCT was classified at high risk of bias, independent of the other parameters. Criteria for assessing the risk of bias of RCTs in the present review were adapted from the guidelines reported in the Cochrane Handbook.[46] (2) Nonrandomized studies: as not all parameters could be judged in all studies (e.g., some were comparative and other not, and some had dropouts and other not), an individual scoring system was adopted. The following score was given to each item: adequate = 1, unclear = 0.5, and inadequate = 0. A study was considered at low risk of bias if the total score amounted to at least 2/3 of the maximum possible score. Otherwise, it was classified at high risk of bias. In case of discrepancy between the two reviewers, an agreement was reached by discussion. If needed, a third reviewer was consulted (ST) until consensus was achieved.

Data Analysis

In order to make comparisons between studies with different follow-up duration, the statistics was made considering the 1-year data for all studies. All comparisons of 1-year implant survival between subgroups for the main variables (type of restoration, type of incision, type of occlusion, use of graft, graft type, presence of infected sites, study design, and risk of bias) were made by using Pearson's chi-squared test. The comparisons were also made taking into consideration the risk of bias of the studies. A probability level of $p = .05$ was considered as the significance threshold.

A meta-analysis was attempted for comparative studies reporting data on the same outcome, if there was sufficient homogeneity among studies. The main comparisons were between immediate and delayed placement of immediately restored (loaded) implants and between immediate and delayed restoration (loading) of immediately placed implants. Another comparison was represented by platform switched versus nonplatform switched implants. For meta-analysis as well as for assessment of the risk of bias of the RCTs, the software RevMan was used (Review Manager [RevMan] Version 5.0, 2008, The Nordic Cochrane Center, The Cochrane Collaboration, Copenhagen, Denmark).

RESULTS

Figure 1 is a flow chart of the article selection process. The initial electronic search provided 458 items. Nineteen more articles were identified through the hand-

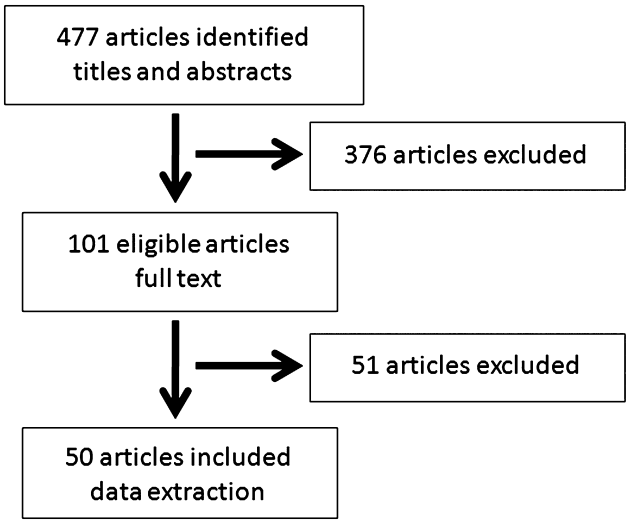

Figure 1 Flowchart summarizing the article selection process.

search. After screening of the titles and abstracts, 376 articles were excluded because they did not meet the inclusion criteria or were not strictly pertinent to the aims of this review. The Kappa score was 0.85, showing excellent agreement between reviewers. A total of 101 articles were eligible and underwent full-text evaluation. Of these, 51 articles were excluded because of not fulfilling the inclusion criteria. The reasons for exclusion are listed in Table 1. A separate list of the excluded studies is added after the reference list.[32,47–96] A total of 50 articles were finally included for data analysis.[97–146] In this case, the Kappa score was 0.92, again showing excellent agreement between reviewers. The trend of included articles per year of publication is illustrated in Figure 2. Eleven of the selected articles were multiple reports of five studies, therefore a total of 44 clinical studies were considered.

The characteristics of the 44 included studies are summarized in Table 2. There were six RCTs (13.6%), three CCTs (6.8%), and 35 PCSs (79.6%). A total of 1170 patients and 1974 implants immediately placed in fresh extraction sockets in the esthetic region and immediately restored were considered for data analysis. The overall implant survival was 97.62% after 1 year of function (range 78.6–100%).

Assessment of Risk of Bias

Of the seven randomized trials, five were judged as having a low risk of bias and two as having a high risk of bias. Figure 3 summarizes the results of risk of bias assessment for each item considered. Of the remaining

TABLE 1 Excluded Articles and Reason for Exclusion

Article	Reason(s)
Jung et al. 2012[48]	1
Meltzer 2012[49]	2
Mozzati et al. 2012[50]	2
Balshi et al. 2011[51]	5
Daif et al. 2011[52]	4
Liñares et al. 2011[53]	6
Rodrigo et al 2011[54]	3
Bogaerde et al. 2010[55]	3, 5
Deng et al. 2010[56]	3
Laviv et al. 2010[57]	3
Shibly et al. 2010[58]	3
Shibly et al. 2010[59]	3
Zafiropoulos et al. 2010[60]	2
Smith et al. 2009[61]	7
Cornelini et al 2008[62]	3
Erakat et al. 2008[63]	2, 3
Evans et al. 2008[32]	1, 2
Mankoo 2008[64]	1, 3
Palattella et al. 2008[65]	8
Petrungaro 2008[66]	3
Tealdo et al. 2008[67]	3, 5
Cannizzaro et al. 2007[68]	5
Canullo & Rasperini 2007[69]	8
Chen et al. 2007[70]	1
Finne et al. 2007[71]	3, 5
Horwitz et al. 2007[72]	3
Lang et al. 2007[73]	9
Nordin et al. 2007[74]	1
West & Oates 2007[75]	1
Lindeboom et al. 2006[47]	1
Ormianer & Palti 2006[76]	3, 5
Ormianer et al. 2006[77]	3, 5
Rabel & Köhler 2006[78]	3, 5
Cangini & Cornelini 2005[79]	1
Vanden Bogaerde et al. 2005[80]	3
Covani et al. 2004[81]	1
Drago & Lazzara 2004[82]	8
Glauser et al. 2004[83]	3, 5
Maló et al. 2003[84]	3
Simsek & Simsek 2003[85]	1
Wolfinger et al. 2003[86]	5
Calvo Guirado et al. 2002[87]	1
Cooper et al. 2002[88]	3, 4, 7
Fugazzotto 2002[89]	1
Fugazzotto 2002[90]	1
Goldstein et al. 2002[91]	1
Colomina 2001[92]	1
Gomez-Roman et al. 2001[93]	1
Hui et al 2001[94]	8
Polizzi et al. 2000[95]	1
Rosenquist & Ahmed 2000[96]	1

1: not a study on immediate loading.
2: retrospective study.
3: incomplete data reported.
4: less than 1-year follow-up.
5: not separated analysis of results (immediate and delayed implants).
6: not a human study.
7: mostly mandibular teeth.
8: too few cases of immediately restored immediate implants.
9: not a study on implant survival.

37 nonrandomized studies, according to the individual scoring system adopted, 23 studies were judged as having a low risk of bias and 14 studies as having a high risk of bias. All studies at low risk of bias are identified with an asterisk in the "Study design" column in Table 2.

Analysis of Variables Possibly Affecting the Outcome

Table 3 reports the most significant comparisons. Some articles had to be excluded from specific comparisons because they did not provide sufficient details. There was a significant difference in implant survival between single-tooth and multiple implant-supported rehabilitations, in favor of the latter ($p = .001$). Such finding, however, was confirmed only by studies at low risk of bias ($p = .004$), while those at high risk of bias showed no significant difference in implant survival between the two types of restoration ($p = .95$). There was also a significant better outcome ($p = .02$) in favor of occlusally loaded rehabilitations that were mostly constituted by fixed partial prostheses, as compared with nonocclusally loaded prostheses (represented exclusively by single-tooth restorations). When splitting studies at high risk and low risk of bias, no significant difference in outcome was found as related to occlusion. No significant effect was found in relation with incision type, presence of infection, and study design. The overall outcome was also independent on the risk of bias of the studies.

Of the 47 failures reported, 45 (95.7%) occurred within the first 6 months, and other two failures occurred between 6 and 12 months of placement. No failure was reported later than 1 year.

Meta-Analysis of Subset of Comparative Studies

Figure 4 is a forest plot of the studies reporting a comparison between immediately restored implants placed either in fresh postextraction sockets or in healed ridges. There was a significant better outcome in favor of the implants placed in healed ridges (99.4% of implant survival) as compared with postextraction implants (95.6% of implant survival) ($p = .004$). The funnel plot did not show asymmetry, indicating an absence of publication bias (Figure 5). The analog forest plot made on a patient basis (not shown) gave similar results with a significant better outcome favoring patients with implants placed in healed ridges ($p = .007$).

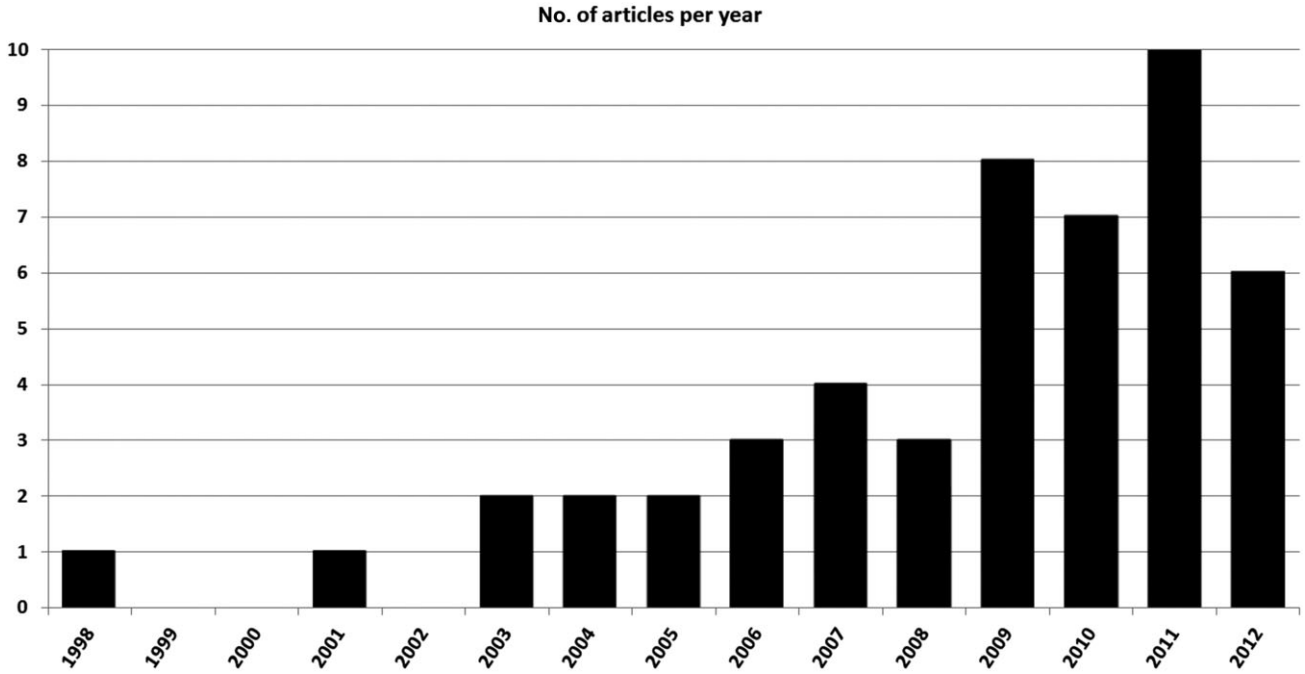

Figure 2 Trend of the number of selected articles published over the years.

The meta-analysis regarding immediate versus delayed restoration of immediate implants involved only two randomized studies,[124,128] but only one[124] had estimable outcomes, as the other reported no implant failures in both groups. The result was slightly (but not significantly) in favor of the immediately restored implants ($p = .58$, data not shown).

The meta-analysis regarding platform switched versus nonplatform switched implants involved three RCTs,[107,122,123] but only one had estimable outcomes,[107] as the other two reported no implant failures in both groups. The result was slightly (but not significantly) in favor of the nonplatform switched implants ($p = .49$, data not shown).

Other Variables

Regarding peri-implant bone level change, all studies showed values well comparable with those historically observed for the standard and immediate loading procedures. Those studies that compared delayed loading versus immediate loading, as well as those comparing delayed placement versus immediate placement, did not show significant differences concerning peri-implant bone change.

Thirty studies (68.2%) evaluated soft tissue parameters, reporting generally good outcomes, with slight mucosal recession in some cases, mostly less than 1 mm at 1 year postsurgery. Only three studies (6.8%) adopted specific aesthetic indexes[102,105,108] such as the pink esthetic score developed in 2005 by Furhauser.[147] These studies reported on a very small proportion of patients and implants as compared with the overall database (only 5.0% at patient level and 3.4% at implant level).

Very few complications were reported in 16 studies (36.4%), mostly represented by occlusal screw loosening.

DISCUSSION

The distribution of the included articles over the years shows that there is a growing interest toward the clinical approach evaluated by the present systematic review. The overall implant survival of immediately placed and restored implants is excellent, suggesting that such clinical approach can be successfully adopted in order to minimize the treatment time without reducing predictability with respect to standard protocols.

When examining subgroups, some clinically relevant indications emerged even though most of them should be confirmed by specific comparative studies. The type of incision did not affect implant survival though cases that adopted the flapless approach displayed a slightly better outcome. There was no significant difference in clinical outcome as related to the graft type, and neither between grafted cases and cases in

TABLE 2 Overview of the Included Studies

Reference, Year of Publication	Study Design	Follow-Up Duration, Mo (Range)	No. of Patients II-IP	No. of Implants II-IP	Implant Survival %	Implant Type/Brand	Prosthesis Type	Flap/ Flapless	Occlusal/ Nonocclusal	Grafting Material	1-Year Bone Loss, Mean ± SD, mm (II-IP)	Esthetics/Soft Tissue Evaluation
Barbier et al. 2012[97]	PCS*	18	20	59	100	OsseoSpeed Astra Tech	FFP	Flap	Centric occlusion	ABC	0.35 ± 0.29	No
Cabello et al. 2012*[98]	PCS	12	14	14	100	Straumann	ST	Flapless	Nonocclusal	None	NR	Yes
Crespi et al. 2012[99]	PCS	24	15	20	100	Sweden & Martina	ST	Flapless	Centric occlusion	None	0.81 ± 0.49	Yes
De Bruyn et al. 2012*[100] Raes et al. 2011[110] Cooper et al. 2010[114]	CCT*	36	55	58	94.8	OsseoSpeed Astra Tech	ST	Flap	Nonocclusal	None	1.30 ± 2.52	Yes
Degidi et al. 2012[101]	PCS	12	69	69	100	Ankylos Dentsply	ST	Flapless	Nonocclusal	ABB + collagen	0.76 ± 0.96	No
Noelken et al. 2012[102] Noelken et al. 2007[133]	PCS*	65(55–78)	13	21	95.2	Nobel Biocare	14 ST, 6 FPP	20 Flapless, 1 flap	Nonocclusal	ABC	1.6/5 y	Yes (PES)
Brown & Payne 2011[103]	PCS*	12	25	26	92.3	Southern Implants	ST	26 Flapless	Nonocclusal	None	0.2 ± 0.6 (gain)	Yes
Chung et al. 2011[104]	PCS	12	10	10	90.0	Osseotite Biomet 3i	ST	Flapless	Nonocclusal	ABB	0.31	Yes
Cosyn et al. 2011[105] De Rouck et al. 2008[129]	PCS*	36	30	30	96.7	Replace Nobel Biocare	ST	Flap	Nonocclusal	ABB	m) 0.98 ± 0.50 d) 0.78 ± 0.55	Yes (PES)
Kan et al. 2011[106] Kan et al. 2003[144]	PCS*	48(24–98)	35	35	100	Replace Nobel Biocare	ST	Flapless	Nonocclusal	ABC	m) 0.26 ± 0.40 d) 0.22 ± 0.28	Yes
Pieri et al. 2011[107]	RCT*	12	38	38	97.4	Samo Smiler Biospark	ST	Flapless	Nonocclusal	ABB	0.19 ± 0.17	Yes
Raes et al. 2011[108] Raes et al. 2011[109]	PCS*	12	16	16	93.8	OsseoSpeed Astra Tech	ST	5 Flap 11 flapless	Nonocclusal	None	II) 0.85 ± 0.60 DI) 0.49 ± 0.25	Yes (PES)
Tripodakis & Nakou 2011[111]	PCS	12	10	20	100	MK IV Nobel Biocare	ST	Flapless	Nonocclusal	NR	NR	NR
Tsuda et al. 2011[112]	PCS	12	10	10	90.0	OsseoSpeed Astra Tech	ST	Flap	Nonocclusal	ABB	0.14 ± 0.33	Yes
Canullo et al. 2010[113]	RCT*	36	25	25	100	Sweden & Martina	ST	Flapless	Nonocclusal	HA + collagen	0.43/0.33	NR
Crespi et al. 2010[115]	PCS*	48	29	164	100	Sweden & Martina	FPP, FFP	Flapless	Centric occlusion	None	A) 0.85 ± 0.23/4 y B) 0.99 ± 0.58/4 y	Yes
Crespi et al. 2010[116]	PCS*	48	37	275	99.3	Sweden & Martina	FPP, FFP	Flapless	Centric occlusion	None	0.79 ± 0.38/4 y	NR
Malchiodi et al. 2010[117]	PCS*	60	70	158	98.7	Pitt-Easy Oraltronics	30 ST, FPP, FFP	Flapless	Nonocclusal	None	1.2 ± 0.2/5 y	Yes
Tortamano et al. 2010[118]	PCS	18	12	12	100	Straumann	ST	Flapless	Nonocclusal	None	NR	Yes
Valentini et al. 2010[119]	PCS*	34(12–50)	10	16	100	TiOblast Astra Tech	ST	Flapless	Nonocclusal	ABB	Negligible	Yes
Block et al. 2009[120]	RCT*	24	26	51	92.2	Certain Biomet 3i	ST	Flapless	Nonocclusal	FDBA	0.61 ± 1.1	None
Calvo-Guirado et al. 2009[121]	PCS*	12	50	61	98.4	Prevail Biomet 3i	ST	Flapless	Nonocclusal	None	0.09	Yes

TABLE 2 *Continued*

Reference, Year of Publication	Study Design	Follow-Up Duration, Mo (Range)	No. of Patients II-IP	No. of Implants II-IP	Implant Survival %	Implant Type/Brand	Prosthesis Type	Flap/ Flapless	Occlusal/ Nonocclusal	Grafting Material	1-Year Bone Loss, Mean ± SD, mm (II-IP)	Esthetics/Soft Tissue Evaluation
Canullo et al. 2009[122]	RCT*	25(22–27)	22	22	100	Sweden & Martina	ST	Flapless	Nonocclusal	ABB + BG	NR	Yes
Crespi et a. 2009[123]	RCT	24	30	40	100	Sweden & Martina	ST	Flapless	Centric occlusion	None	ps) 0.82 ± 0.40 nps) 0.78 ± 0.49	None
De Rouck et al. 2009[124]	RCT*	12	24	24	95.8	Replace Nobel Biocare	ST	Minimal flap	Nonocclusal	ABB + BG	m) 0.92 ± 0.49 d) 0.79 ± 0.54	Yes
Kan et al. 2009[125]	PCS*	26(12–48)	20	20	100	Replace Nobel Biocare	ST	Flapless	Nonocclusal	ABB	0.54 ± 0.42	Yes
Mijiritsky et al. 2009[126]	PCS*	41(24–72)	16	24	95.8	Frialit-2 Dentsply	ST	Flapless	Nonocclusal	ABC	0.9 ± 1.1/2-6 y	None
Pieri et al. 2009[127]	PCS*	19(12–31)	23	23	95.7	NR	FFP	Flap	Centric occlusion	ABB + ABC	0.57 ± 0.27	None
Crespi et al. 2008[128]	RCT	24	20	20	100	Sweden & Martina	ST	DL: flap IP: flapless	Centric occlusion	None	1.02 ± 0.53/2 y	Yes
Ribeiro et al. 2008[130]	CCT*	27(18–38)	NR	46	93.5	Conexão Sistema de Prótese Ltda	ST	DI: flap II: flapless	Nonocclusal	None	<1.5	None
Crespi et al. 2007[131]	PCS	18	27	101	100	Sweden & Martina	9 ST, 15 FPP 11 FFP	Flap	Centric occlusion	ABC	m) 0.65 ± 0.58 d) 0.84 ± 0.69	None
Kan et al. 2007[132]	PCS*	12	19	23	100	Nobel Biocare	ST	NR	Nonocclusal	None	1.0 ± 3.6	Yes
Villa & Rangert 2007[134]	PCS	12	33	76	97.4	MKIII-IV & Speedy Nobel Biocare	12 ST, 9 FPP, 12 FFP	47 Flap 29 flapless	20 Occlusal 13 non occl.	ABC/ABC + ABG	0.91 ± 1.50	None
Rompen et al. 2007[135]	PCS	24	NR	25	100	Replace Nobel Biocare	NR	Flapless	Nonocclusal	None	Not apparent	Yes
Barone et al. 2006[136]	PCS	12	18	13	92.3	Sweden & Martina	ST	Flapless	Nonocclusal	None	0.4	Yes
Ferrara et al. 2006[137]	PCS*	48	33	33	93.9	Friatec	ST	Flapless	Nonocclusal	ABC	Not apparent	Yes
Degidi et al. 2006[138]	PCS*	60	67	67	92.5	different brands	ST	Flap	Nonocclusal	None	0.6 ± 0.2 (II + DI)	Yes
Cornelini et al. 2005[139]	PCS*	12	19	19	100	Straumann	ST	Flap	Nonocclusal	BioGide	0.5	Yes
Tsirlis 2005[140]	PCS	24	NR	28	100	Biomet 3i, Friatec	ST	Flap	Nonocclusal	Biogran + BG	0.75 ± 1.05	Yes
Norton 2004[141]	PCS*	16(8–27)	16	16	100	Astra Tech	ST	Flapless/limited flap	Nonocclusal	None	0.40	None
Locante 2004[142]	PCS*	24	46	46	97.8	Stabledent	ST	Flap	Centric occlusion	Osteogen	NR	None
Groisman et al. 2003[143]	PCS	24	92	92	93.5	Replace Nobel Biocare	ST	Flapless	Nonocclusal	ABC	<2 mm/2 y	Yes
Chaushu et al. 2001[145]	PCS*	13(6–24)	12	14	78.6	Steri-Oss AlphaBio	ST	Flapless	Centric occlusion	ABC	Not beyond IAJ	None
Wöhrle 1998[146]	PCS	18(9–36)	14	14	100	Replace Sterioss	ST	Flapless	Nonocclusal	ABC	<1.0	Yes

*Studies with low risk of bias.

ABB, anorganic bovine bone (Bio-Oss); ABC, autogenous bone chips; BG, Bio-Gide membrane; CCT, controlled clinical trial; DI, delayed implant placement; DL, delayed loading; FDBA, mineralized freeze-dried bone allograft; FFP, fixed full prosthesis; FPP, fixed partial prosthesis; HA, hydroxyapatite; IAJ, implant/abutment junction; II, immediate implant placement; IP immediate provisionalization; mo, months; NR, not reported; PCS, prospective clinical study; PES, pink esthetic score; RCT, randomized clinical trial; SD, standard deviation; ST, Single Tooth; m) = mesial; d) = distal; A) = keratinized mucosa ≥2 mm; B) = keratinized mucosa <2 mm; ps) = platform switching; nps) = non platform switching; for multiple publications of the same study the longest follow-up is indicated.

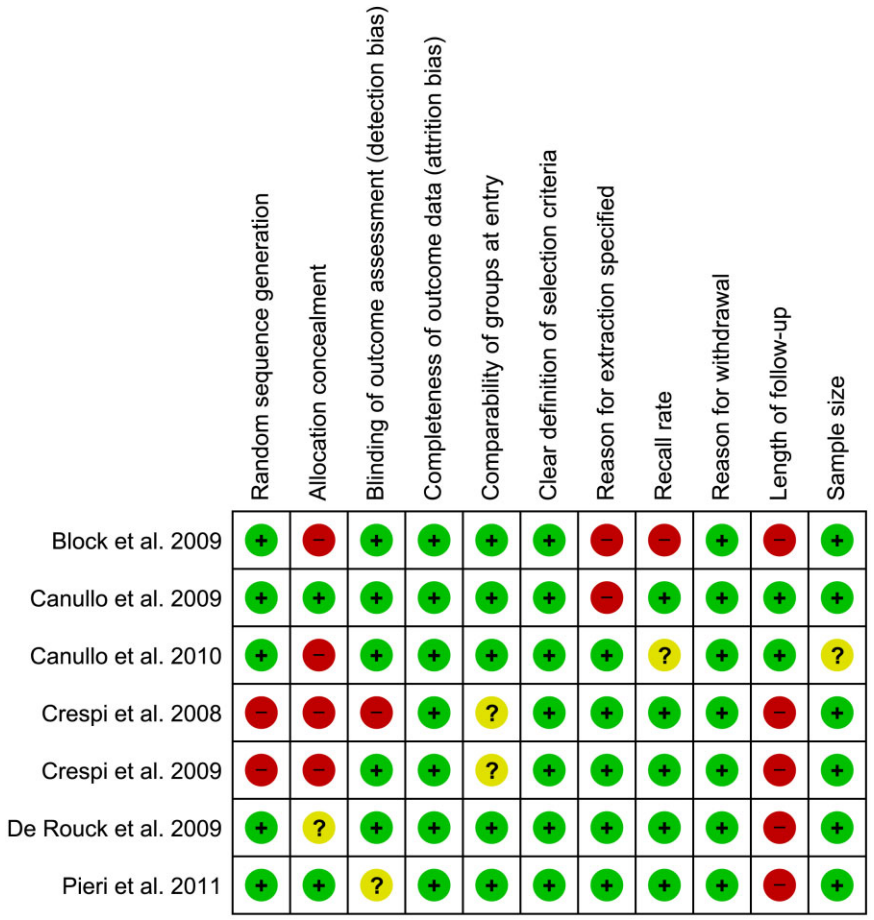

Figure 3 Risk-of-bias graph: judgments of review authors about each risk-of-bias item presented as percentages across all included randomized studies. Green circle = adequate, yellow circle = unclear, red circle = inadequate.

which no graft was used. The presence of infection apparently did not affect the implant survival, though implants immediately placed in infected extraction sites and loaded immediately were considerably less numerous than noninfected cases (371 vs 1603). Furthermore, cases restored in centric occlusion displayed a significant better result as compared with cases restored without occlusion. Though this may appear a misleading result, a further subgroup analysis showed that the large majority of cases placed in occlusion (86.7%) were partial or full-fixed prostheses, while only 13.3% was represented by single-tooth restorations. Interestingly, no effect of the study design ($p = .5$) nor of the risk of bias ($p = .99$) was found. This would suggest that the healing process leading to osseointegration of an implant placed in a patient can be considered independent of the type of study to which the patient belongs.

The meta-analysis showed that the survival of immediately loaded implants placed in fresh postextraction sockets, though excellent, is inferior as compared with implants placed in healed ridges, in agreement with the finding of previous systematic reviews.[41]

Many other confounding factors exist that might potentially affect the clinical outcome such as the patient's age, gender, smoking status, systemic and local condition, the study selection criteria, the implant features, the surgical protocol, the positioning depth and axis of the implant into the alveolar socket, the residual thickness of the vestibular plate, the occlusal antagonist, the prosthesis retention mode, the surgeon's expertise and dexterity, and the patient's compliance. It was not possible to evaluate the effect of all these variables mainly because they were not systematically reported in the studies evaluated. It is recommended that future studies will report details on all possible confounding factors, in order to estimate their effect on the observed results. We wish also to underline that in the absence of patients individual data all systematic reviews have to deal with mean values and proportions for most variables, as reported at study level, and in many instances it

TABLE 3 Results of the Statistical Comparison of the Main Variables

Variable	Comparison	No. of Studies	No. Implants II IL	1-Year Implant Survival	*p* Value
Study type	RCT	7	220	97.27%	0.53
	CCT	2	104	94.23%	
	PCS	35	1650	97.88%	
Quality of the study	Low risk of bias	28	1410	97.45%	0.99
	High risk of bias	16	564	98.05%	
Incision type	Flap	13	512	97.07%	0.91
	Flapless	30	1402	97.86%	
Graft type	100% ABC	9	393	96.69%	0.55
	100% ABB	8	170	97.06%	
	Other type	5	173	96.53%	
	None	20	1074	98.04%	
Infection	Infected	3	371	98.92%	0.50
	Noninfected	41	1603	97.32%	
Prosthesis type	ST	39	1097	96.48%	0.001
	FFP or FFP	8	807	99.38%	
Loading	Occlusal	10	762	99.08%	0.02
	Nonocclusal	33	1136	96.65%	
Combined parameters	ST-occlusal	6	149	97.32%	0.98 (ST-o vs ST-no)
	ST-nonocclusal	32	946	96.30%	
	FPP-occlusal	5	613	99.51%	0.18 (ST-o vs FPP-o)
	FPP-nonocclusal	0	0	NE	

NE, not evaluated; other abbreviations are the same as Table 2.

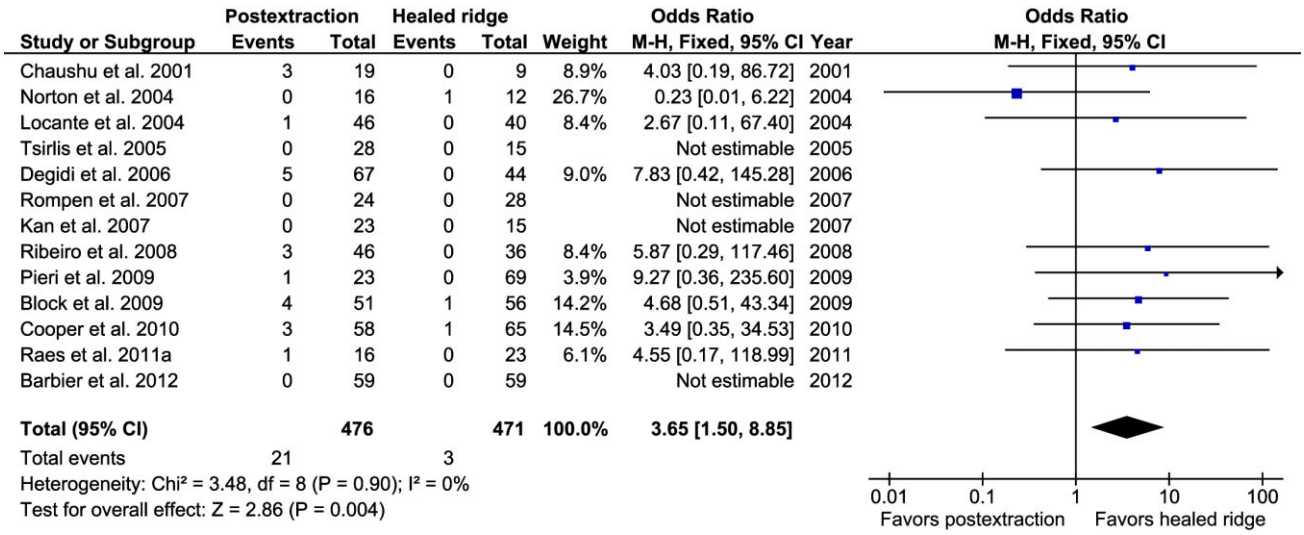

Figure 4 Forest plot of studies that evaluated the survival of immediately loaded implants inserted in either postextraction sockets or healed ridges. For each study, the odds ratio (OR, squares) along with 95% confidence intervals (CI, horizontal bars) are indicated. The diamond indicates the overall estimate of treatment effect, and its width indicates the overall 95% CIs. The vertical line represents absence of treatment effect. M-H = Mantel–Haenszel method; d.f. = degrees of freedom; I = index for assessing heterogeneity in a meta-analysis.

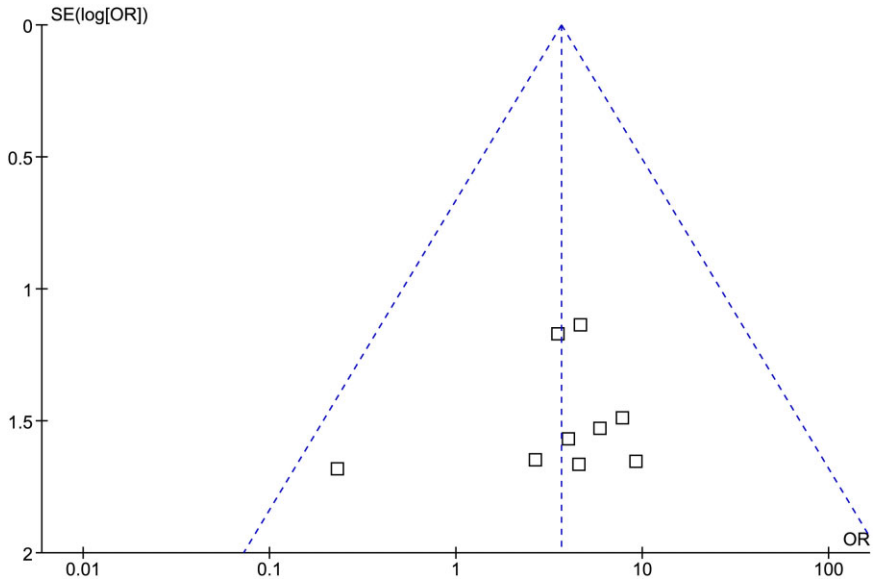

Figure 5 Funnel plot of studies that evaluated the survival of immediately loaded implants inserted in either postextraction sockets or healed ridges. The lateral dotted lines represent confidence intervals, and the central one represents the mean value. OR = odds ratio.

is difficult, if not impossible, to draw conclusions regarding the influence of individual factors (at patient level) on the general outcomes.

Most clinicians are concerned of adopting immediate implant therapy in the presence of fractured or infected teeth because of possible biological complications.

The placement of an implant soon after the extraction of a fractured tooth may be a challenging procedure due to the frequent existence of bone defects caused by the inflammatory reaction following the development of a bacterial biofilm in the fracture space and/or by bacterial spread from the fracture.[148–150] In fact, the communication between root canal and periodontal space may rapidly lead to a fast bone resorption process that may be detrimental to the aesthetic aspect and whose clinical and radiographic features will depend on the type, extent, and duration of the fracture.[148,151] Implant therapy is considered the treatment of choice for fractured teeth replacement; however, timing and surgical approach should be carefully evaluated based on the residual bone volume and the presence of active infection.[42]

The latter in fact has traditionally been considered a contraindication to immediate implant placement in fresh extraction socket. The reason for recommending that in such cases implant placement should be postponed is related to the possible contamination of the implant during early healing for the potential presence of remnants of the preexisting infection[152,153] A clinical study showed reduced success rate and a high incidence of postoperative infection when implants are placed in sites affected by periodontitis.[154] However, more recent animal studies showed that implants placed in sites with experimentally induced periapical and periodontal lesions may osseointegrate.[155–159] Even though it has been histologically demonstrated that socket healing in infected sites is slower as compared with healthy sites,[160] a growing body of clinical evidence shows that implant placement in infected sites may be as well successful when a strict surgical protocol is followed.[47,161–163] The present review found no differences in outcome as related to the presence of infection, though this result should be considered with caution due to the limited proportion of infected cases in the included studies.

It would be interesting to evaluate the effect of different causes for extraction on the outcome of treatment but, unfortunately, none of the included studies specified such details in relation to implant failures or complications. Future studies should address this aspect by providing specific information.

The aesthetic aspect of implant-supported rehabilitation is becoming more and more important to the success of the therapy and fundamental when anterior regions are involved. In the aesthetic region, a main challenge for the restorative dentist is to provide patients

with a crown and peri-implant soft tissue that is in harmony with the adjacent teeth, thereby restoring at the same time function and aesthetics. The achievement of aesthetic success may depend on several factors, among which: proper three-dimensional implant positioning,[164] maintenance of the crestal anatomy at the buccal side,[165] and tissue biotype.[166]

The present review found very few articles assessing the esthetic aspect by means of specific tools, confirming what was found by another systematic review by Atieh.[45] That review showed that, in spite of the claims of esthetic advantage with immediate placement and restoration protocols, in most of the included articles, the aesthetic outcome was not systematically evaluated. This could be due to the lacking of a general consensus regarding the criteria for assessing aesthetics in implant therapy, though several indexes have been proposed in the past.[147,167–169] In view of the increasing importance of esthetics in dental implant therapy, it is mandatory that future studies systematically address this aspect.

Another potential advantage that is claimed by the immediate placement and restoration protocol is the preservation of the alveolar ridge. Though it was not a specific aim of the present review, the authors noted that it was not systematically addressed by all the included studies, and there was some heterogeneity in mean marginal bone changes among studies, as can be seen from Table 2.

CONCLUSION

Based on a sample of nearly 2000 implants, the mean weighted implant survival of immediately restored implants immediately placed in extraction sites in the esthetic region is 97.60%, suggesting that such clinical approach is well documented and can be successfully adopted in order to minimize the treatment time. However, the meta-analysis showed that the outcome of immediate implants resulted inferior to that of implants placed in healed ridges. Therefore, parallel to the advantages brought about by immediate implant placement and restoration, the patient and the practitioner must be aware of the risks that such treatment may imply.

The type of study design, the type of incision, the grafting material, and the presence of infection apparently did not affect the implant survival.

The systematic adoption of specific indexes for the evaluation of aesthetic outcomes is recommended.

Due to the wide range of survival rates observed in the systematic review (78.6–100%), the generalization from the results of the included trials to ordinary clinical practice should be made with extreme caution.

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