Review

Crestal Bone Level Changes Around Immediately Placed Implants: A Systematic Review and Meta-Analyses With at Least 12 Months' Follow-Up After Functional Loading

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Background: Immediate implant placement (IIP) is a successful treatment and has the advantages of reducing time and increasing patient satisfaction. However, achieving predictable esthetic results with IIP presents a challenge because of naturally occurring bone loss postextraction. Therefore, the focused question of this systematic review is: What is the effect of IIP on crestal bone level (CBL) changes after at least 12 months of functional loading?

Methods: Extensive literature review of the Cochrane and MEDLINE electronic databases and a manual search up to November 2012 identified eligible studies. Two reviewers independently assessed the study data and methodologic quality using data extraction and assessment forms.

Results: Electronic and manual searches identified 648 relevant publications. A total of 57 articles satisfied the inclusion criteria. Sixteen studies had test and control groups; therefore, meta-analyses could be performed. The results demonstrated better CBL preservation around IIP compared with implant placement in healed/native bone at 12 months [CBL difference of –0.242 (95% confidence interval [CI], –0.403 to –0.080; $P = 0.003$)]. Similarly, platform switching around IIP showed better results compared with non–platform switching (CBL difference of –0.770 [95% CI, –1.153 to –0.387; $P < 0.001$]). There was no difference in mean CBL changes with regard to one-stage or two-stage IIP protocol (–0.017 [95% CI, –0.249 to 0.216; $P = 0.85$]) or the use of immediate or delayed immediate implant loading (0.002 [95% CI, –0.269 to 0.272; $P = 0.99$]).

Conclusions: Meta-analyses showed less CBL loss around IIP compared with implant placement in healed bone. Platform-switched implants showed greater crestal bone preservation than non–platform-switched implants. There was no significant difference in CBL with one- versus two-stage placement or use of immediate versus delayed IIP loading. Although there were statistically significant differences favoring IIP, the small differences may not be clinically relevant. Although IIP showed favorable outcomes for CBL changes, these results should be interpreted with caution because of high heterogeneity among studies. *J Periodontol 2014;85:1537-1548.*

KEY WORDS

Alveolar bone loss; dental implants; meta-analysis; review, systematic, tooth extraction.

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Traditionally, timing of dental implant placement after tooth extraction has varied over time.[1] In the 1980s, implant loading was typically delayed up to 12 months for implant osseointegration.[2-4] Advancements in implant surface technology with increased patient expectations helped reduce the total time from extraction to final restoration. This trend gave rise to the idea of immediate implant placement (IIP) for shorter time intervals. Meaningful discussions of IIP are difficult due to lack of appropriate language defining time of placement. Although many early implant placement protocols exist, the proposed classifications by Hammerle et al.[5] and Esposito et al.[1] (see supplementary Table 1 in online *Journal of Periodontology*) are widely accepted today.

The first report of IIP was published in 1976 using a step thread tapered implant design placed immediately into fresh extraction sockets.[6] In a 1989 study, Lazzara concluded that immediate implants helped preserve the integrity of the extraction socket in humans.[7] Although a few studies[8,9] appear to support Lazarra's conclusion, the majority[10-13] show that IIP alone cannot prevent bone loss after tooth extraction. This problem is exacerbated by faster bone resorption of buccal bone compared with the lingual plate postextraction.[10-13] Marginal and facial bone loss can negatively impact the final esthetics of IIP. Crestal bone loss increases the risk of midfacial recession, papillary loss, and display of a gray hue of underlying implants.[13-15]

Ideal three-dimensional placement of the IIP can be complicated by socket anatomy that makes the outcome less desirable. Although primary implant stability is a major determining factor in IIP success, several other factors are important in determining crestal bone level (CBL) changes around IIP. These factors may include platform switching (PS),[16] time of loading,[17-20] one- or two-stage placement,[21,22] number of remaining bony walls postextraction,[23,24] the gap between implant and buccal bone, and the need for bone augmentation.[25,26]

Marginal CBL changes around delayed implants are reported to be greatest during the first year of function (1.0 to 1.5 mm) followed by an annual rate of 0.1 to 0.2 mm.[2-4] Earlier studies showed greater CBL loss with machined-surface implants compared with recent investigations of roughened surfaces (CBL loss = 0.22 ± 0.42 mm at 12 months and 0.18 ± 0.88 mm at 5-year follow-up).[27] Despite attempts, no studies have successfully used a meta-analysis format to evaluate CBL changes in IIP to date.[26,28] The most recent systematic review examined survival rates of IIP but did not report CBL changes. Those analyses found higher survival rates for implants placed in healed bone (99.4%) compared with IIP (95.6%).[29] The primary reason for inability to perform a meta-analysis was high heterogeneity among the studies where the main objective was to evaluate the survival and success of IIP.[26,28,29] Hence, the specific objectives of the current systematic review and meta-analyses is to analyze CBL changes around IIP (Type I and immediate) based on different surgical and implant-related factors.

Focused Question

What is the effect of IIP on CBL changes after at least 12 months of functional loading?

MATERIALS AND METHODS

Data Sources and Search

The current systematic review and meta-analyses were conducted according to the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA) statement[30] and the Cochrane Collaboration recommendations.[31] Data collection methodology fulfilled the criteria of the Methodological Expectations of Cochrane Intervention Reviews (MECIR).[32] A search of the National Center for Biotechnology Information PubMed, MEDLINE, and the Cochrane Collaboration Library was performed independently by two reviewers (BK and MS). Disagreements between reviewers during data collection and quality assessment were resolved by discussion. All evaluated publications were restricted to the English language from 1966 to November 2012. Additionally, a manual search was conducted of bibliographies of reviews and clinical trials related to IIP.

Study Selection and Interventions

To be eligible for inclusion, publications had to report radiographic CBL changes and be: 1) conducted on human individuals; 2) published in English; 3) of at least 12 months' duration of functional loading with rough surface immediate or Type I implants; and 4) randomized, controlled, or prospective clinical trials (RCTs, CCTs, or PCTs). Publications were excluded if they: 1) did not match the inclusion criteria; 2) reported data on one-piece or machined-surface implants; or 3) had missing data relevant to the systematic review.

The following search terminology was performed using Boolean operators: ("dental implants") OR ("dental" AND "implants") OR ("dental" AND "implant") OR ("dental implant" OR "endosseous") AND ("immediate" AND "tooth extraction") OR ("tooth" AND "extraction" AND "Placement") OR ("Implant esthetic" OR "Implant esthetics") AND ("marginal bone level" OR "crestal bone level") OR ("bone level" AND "marginal" OR "crestal").

Data Extraction and Collection

A data-extraction form was developed to collect the following study information: 1) author and publication year; 2) study type and randomization method; 3) treatment groups; 4) patient and implant sample size; 5) CBL change and implant initial stability; 6) PS and non–platform switching (NPS) IIP; 7) occlusal protocol, definitive restoration type, and time of IIP loading; 8) augmentation procedure and materials used; 9) extraction socket morphology, IIP site, and position; 10) one- or two-stage IIP; 11) implant survival and success rates; and 12) follow-up period. All data were screened and assessed independently by two reviewers (BK and MS) following the MECIR recommendations[32] and PRISMA[30] guidelines. Corresponding authors were contacted for clarification when relevant data were missing from a publication. The primary study outcome was CBL changes around implants with: 1) IIP in extraction sockets versus implants placed in healed/native bone; 2) IIP using PS versus IIP using NPS; 3) one-stage IIP versus two-stage IIP; and 4) IIP with immediate loading versus IIP with delayed loading.

Most studies used standardized periapical radiographs to assess the CBL changes, whereas one used non-standardized radiographs.[33] The long-cone paralleling technique was used for standardized radiographs with implant platform serving as a reference point for measuring CBL changes. In all 16 studies, an independent, well-trained, and calibrated researcher for each respective study analyzed the radiographs.

Statistical Analyses

Mean CBL changes for mesial and distal sites were the basis for data analyses. Overall means for mesial and distal bone loss, when reported separately, were calculated using statistical software.[‖34] Weighted mean differences (WMDs) and 95% confidence intervals (CIs) were calculated. Statistically significant differences were reported when $P<0.05$. Meta-analyses were performed with a statistical software program that also produced Forest plots.[¶] Meta-analyses were estimated using a fixed random-effects model. Test of null hypotheses was evaluated by a two-tailed z score. The 95% CIs were calculated around WMDs. Heterogeneity was assessed by the Q statistic and I^2 measurement. The Q statistic measures whether included studies measure the same effect, whereas the I^2 measure quantifies the percentage of variability in studies that cannot be ascribed to chance alone.[35] Significant heterogeneity was noted when $P<0.1$. I^2 values ranged from 0% to 100%, with values of >75% indicating significant heterogeneity. In contrast, 0% for I^2 indicates no variability.[35]

Quality Assessment

Methodologic quality assessment was conducted independently by two reviewers (BK and MS) based on the Cochrane Assessment of Allocation Concealment[36] and the Jadad Score Calculation.[37] The Cochrane Assessment of Allocation Concealment evaluated the validity and randomization of studies, assigning grades ranging from A to D. Grade A indicates no risk for bias, Grade B is unclear risk for bias, and studies with Grades C and D have high risk for bias. The Jadad method assigns a score ranging from 0 to 5 points. A score of 3 to 5 indicates a higher-quality study, whereas studies with scores of 0 to 2 represent lower quality.

RESULTS

The electronic searches identified 593 possible publications. An additional 55 articles were retrieved through a manual search of bibliographies of reviews and clinical trials for a total of 648 relevant publications. After review of abstracts and titles, 135 pertinent studies were selected for full-text review. Of the 135 studies, 78 were excluded because they failed to meet the inclusion criteria. The remaining 57 studies reported data that satisfied the initial inclusion criteria. A total of 16 studies had test and control groups; hence, they could be evaluated via meta-analyses (Fig. 1). Interobserver agreement between reviewers was calculated using the κ statistic. κ was 0.98 and 0.92 for initial assessment of articles for full review (n = 57/648) and final inclusion in the meta-analyses (n = 16/57), respectively. The characteristics of the 16 studies[23,33,38-51] are summarized in Table 1.

Description of Studies and Methodologic Quality

Of the 16 included studies, six were RCTs,[23,33,38-41] one was a CCT,[42] and nine were PCTs.[43-51] The RCTs scored high (Grade A, score 5) according to the Cochrane Assessment of Allocation Concealment[36] and the Jadad Score calculation,[37] whereas the CCT and most of the PCTs scored lower (Grade C to D, score 1 to 2). Two PCTs[45,49] scored high on both scales (Grade B and A, score 3 and 4, respectively) (Table 1). The 16 studies included 760 patients (ages 18 to 94 years) with 12 to 60 months' follow-up. Of the 1,088 implants, 695 were placed immediately into extraction sockets versus 393 in healed/native bone.

Meta-Analyses

IIP in extraction sockets versus implants placed in healed/native bone. Eight studies[33,42,43,46-50] compared IIP in extraction sockets to implants placed in healed/native bone. Implant placement times in healed/native bone ranged between 2 and 5 months in three studies[33,43,49] and after an unspecified healing period in five studies.[42,46-48,50] Seven of the eight

‖ Pooling the Means, and Variances; University of Baltimore; Baltimore, MD.
¶ Number Crunchers, NCSS, Kaysville, UT.

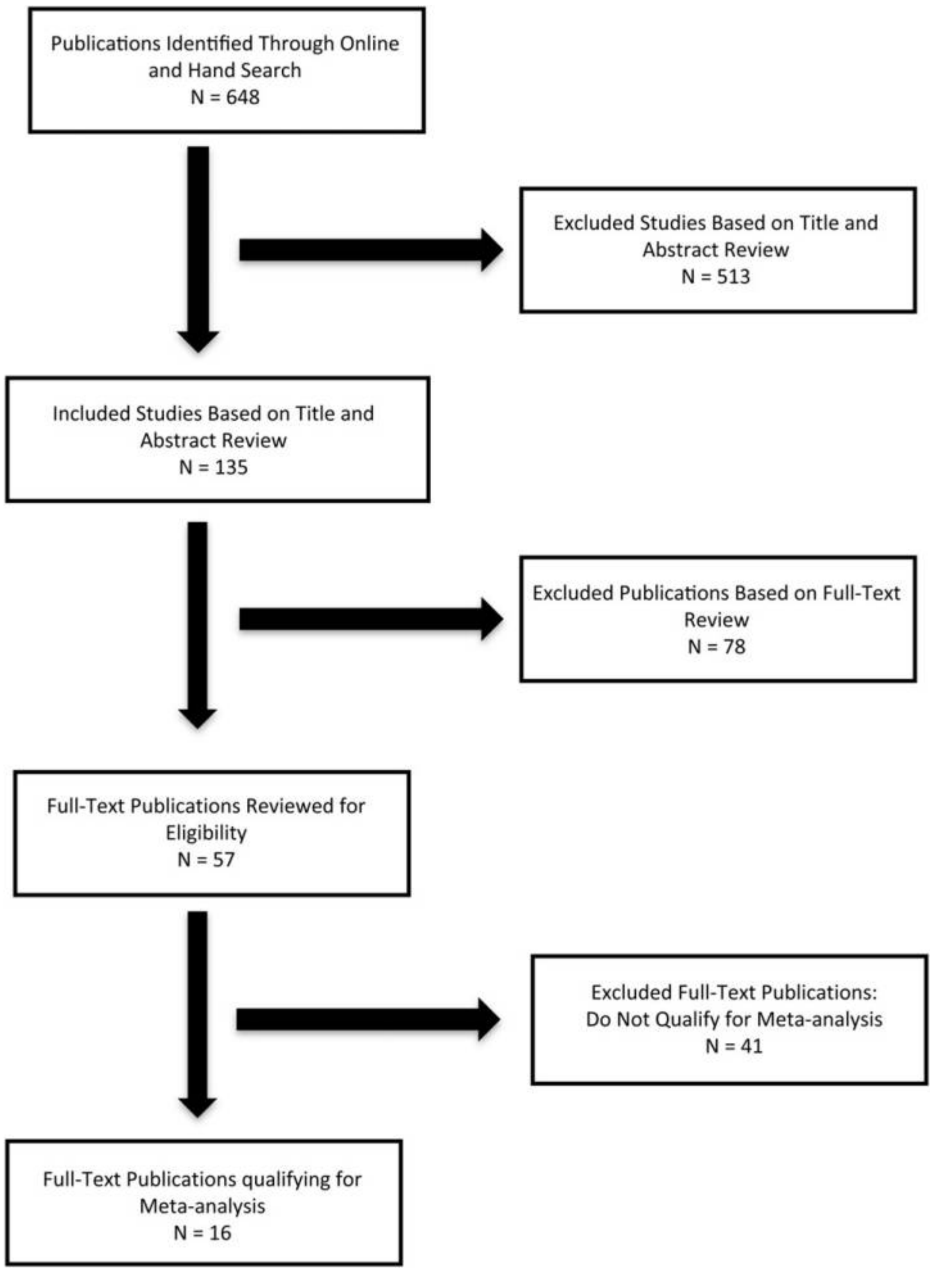

Figure 1.
Flowchart for identification of publications according to PRISMA[30] principles for systematic reviews.

studies[42,43,46-50] reported CBL data at the 12-month follow-up period. A total of 268 were IIP, and 384 were placed in healed/native bone. There was a significant mean difference in CBL changes of –0.242 mm (95% CI, –0.403 to –0.080; $P = 0.003$) in favor of IIP. However, high heterogeneity was observed ($I^2 = 86.10\%$), indicating lack of consistency among studies. Interestingly, when implants were followed for up to 60 months,[33,42,43,46-50] the significance in mean CBL differences between IIP and healed/native bone disappeared (mean = –0.075 mm; 95% CI, –0.223 to 0.089; $I^2 = 77.85\%$) (Fig. 2).

IIP using PS versus IIP using NPS. Three studies[38,41,45] reported CBL changes with follow-up periods of 12 to 27 months comparing IIP with or without PS. One study[41] reported CBL data at 12 months and two[38,45] up to 27 months. There were a total of 60 and 64 implants in the PS and NPS groups, respectively. A significant mean difference in CBL changes of –0.770 mm (95% CI, –1.153 to –0.387; $P < 0.001$) was noted in favor of IIP using PS (Fig. 3).

IIP using one-stage versus two-stage protocol. Five studies[23,39,40,44,51] compared CBL changes in one- versus two-stage IIP from 12 to 60 months. Two studies[39,40] evaluated CBL at 12 months, two up to 24 months,[23,44] and one up to 60 months.[51] Four studies reported CBL at 12 months and included 126 and 128 implants in the one- and two-stage groups, respectively.[23,39,40,51] Mean difference in CBL change (–0.024 mm; 95% CI, –0.278 to 0.229; $P > 0.852$) favored one-stage IIP but was not significant. Five studies[23,39,40,44,51] followed individuals up to 60 months and included 146 and 148 implants in the one- and two-stage groups, respectively. The difference in CBL favored one-stage IIP (–0.017 mm; 95% CI, –0.249 to 0.216; $P = 0.852$) but was not statistically significant (Fig. 4).

IIP using immediate versus delayed loading. Four studies[23,40,44,51] compared CBL around IIP with immediate loading versus IIP with delayed loading. One study[40] evaluated CBL at 12 months, two up to 24 months,[23,44] and one up to 60 months.[51] The immediate loading group had initial primary stability of ≥25 Ncm and ≥60 implant stability quotient (ISQ) in one study[44] and ≥35 Ncm in two studies;[23,40] implant stability values were not reported in the fourth study.[51] Time of definitive restoration placement was 3 months,[51] 4 months,[23] and 6 months.[40,44] Three studies evaluated CBL changes at 12 months with a total of 110 IIP with immediate

Table 1.

Characteristics of the 16 Studies Included in Meta-Analyses

Reference and Treatment Group	Study Design	Patients (n)	Age (years), Mean or Range	Implants (n)	Implant Location	Implant Position Into Extraction Socket	Number of Implants Failed (time of failure)	Implant Insertion Torque (Ncm) and/or ISQ Value	Flap or Flapless IIP	Remaining Socket Walls (n)	Augmentation Procedure	PS or NPS	Healing Protocol	Type of Definitive Restoration (time delivered in months)	Occlusal Protocol: Immediate Loading or Delayed Loading	Implant Success Rate (%)	Implant Survival Rate (%)	Observation Period After Loading (months)	Allocation Concealment Grade	Jadad Score
Cooper et al., 2010[43]	PCT																		C	2
IIP in extraction socket		55	45.1	55	Maxillary anteriors and premolars	Palatal and crestal	3 (NC/NA)	Up to 50 Ncm	40 flapless and 15 flap	3 and 4	NC/NA	NPS	One-stage	Single tooth restoration (3)	Immediate provisional NC/NA	NC/NA	94.50	12		
Implants in native/healed bone		58	42.1	58	Maxillary anteriors and premolars	NC/NA	1 (NC/NA)	Up to 50 Ncm	Flapless	NC/NA	None	NPS	One-stage	Single tooth restoration (3)	NC/NA	NC/NA	98.30	12		
Deng et al., 2010[46]	PCT																		D	1
IIP in extraction socket		12	60	32	Full arch maxilla and mandible	NC/NA	4 (6 months)	>30 Ncm	Flap	NC/NA	Autograft	NPS	One-stage	Fixed partial denture (6)	Immediate provisional NC/NA	NC/NA	87.50	12		
Implants in native/healed bone		12	60	52	Full arch maxilla and mandible	NC/NA	0 (NA)	>30 Ncm	Flap	NC/NA	None	NPS	One-stage	Fixed partial denture (6)	Immediate provisional NC/NA	NC/NA	100	12		
Palattella et al., 2008[33]	RCT																		A	5
IIP in extraction socket		8	35	9	Maxillary anteriors and premolars	Palatal	0 (NA)	35 Ncm, 65 ISQ	Flap	4	NC/NA	NPS	One-stage	Single tooth restoration (NC/NA)	Immediate provisional no loading	NC/NA	100	24		
Implants in native/healed bone		8	35	9	Maxillary anteriors and premolars	Palatal	0 (NA)	35 Ncm, 74 ISQ	Flap	4	None	NPS	One-stage	Single tooth restoration (NC/NA)	Delayed loading	NC/NA	100	24		
Kan et al., 2007[48]	PCT																		D	1
IIP in extraction socket		19	45.1	23	Maxillary anteriors and premolars	NC/NA	0 (NA)	NC/NA	NC/NA	4	Autograft + xenograft	NPS	One-stage	Single tooth restoration (5)	Immediate provisional NC/NA	100	100	12		
Implants in native/healed bone		12	45.1	15	Maxillary anteriors and premolars	NC/NA	0 (NA)	NC/NA	NC/NA	NA	None	NPS	One-stage	Single tooth restoration (5)	Immediate provisional NC/NA	100	100	12		
Lindeboom et al., 2006[49]	PCT																		A	4
IIP in extraction socket		25	39.9	25	Maxillary anteriors and premolars	NC/NA	2 (6 months)	≥25 Ncm, 64.5 ISQ	Flap	3	Autograft + RM	NPS	Two-stage	Single tooth restoration (6)	Delayed loading	92.00	NC/NA	12		
Implants in native/healed bone		25	39.5	25	Maxillary anteriors and premolars	NC/NA	0 (NC/NA)	≥25 Ncm, 64.5 ISQ	Flap	None	None	NPS	Two-stage	Single tooth restoration (6)	Delayed loading	100	100	12		

Table 1. (continued)

Characteristics of the 16 Studies Included in Meta-Analyses

Reference and Treatment Group	Study Design	Patients (n)	Age (years), Mean or Range	Implants (n)	Implant Location	Implant Position Into Extraction Socket	Number of Implants Failed (time of failure)	Implant Insertion Torque (Ncm) and/or ISQ Value	Flap or Flapless IIP	Remaining Socket Walls (n)	Augmentation Procedure	PS or NPS	Healing Protocol	Type of Definitive Restoration (time delivered in months)	Occlusal Protocol: Immediate Loading or Delayed Loading	Implant Success Rate (%)	Implant Survival Rate (%)	Observation Period After Loading (months)	Allocation Concealment Grade	Jadad Score
Paolantonio et al., 2001[42]	CCT																		D	2
IIP in extraction socket		48	41	32	Maxilla and mandible	Crestal	0 (NA)	NC/NA	Flap	4	None	NPS	Two-stage	Single tooth restoration (6)	Delayed loading	NC/NA	100	12		
Implants in native/healed bone		48	41	52	Maxilla and mandible	Crestal	0 (NA)	NC/NA	Flap	None	None	NPS	Two-stage	Single tooth restoration (6)	Delayed loading	NC/NA	100	12		
Jaffin et al., 2007[47]	PCT	17	57 to 82																D	1
IIP in extraction socket				42	Maxilla and mandible	NC/NA	NC/NA	NC/NA	Flap	Bony defect (NC/NA walls)	NC/NA	NPS	One-stage	Fixed partial denture (3 to 6)	Immediate provisional no loading	NC/NA	NC/NA	54		
Implants in native/healed bone				97	Maxilla and mandible	NC/NA	NC/NA	NC/NA	Flap	None	None	NPS	One-stage	Fixed partial denture (3 to 6)	Immediate provisional no loading	NC/NA	NC/NA	54		
Pieri et al., 2009[50]	PCT																		D	1
IIP in extraction socket immediate loading		23	61.9	59	Maxilla and mandible	Subcrestal	1 (NC/NA)	≥30 Ncm, 61.3 ISQ	Flap	4	Autograft + RM or xenograft + RM	PS	One-stage	Fixed partial denture (4 to 5)	Immediate loading	98.30	NC/NA	12		
Implants in native/healed bone immediate loading		23	61.9	85	Maxilla and mandible	Subcrestal	1 (NC/NA)	≥30 Ncm, 62.2 ISQ	Flap	None	None	PS	One-stage	Fixed partial denture (4 to 5)	Immediate loading	98.80	NC/NA	12		
Canullo et al., 2009[38]	RCT																		A	5
IIP PS		11	50	11	Maxillary anteriors and premolars	Middle/premolars palatal/anteriors	NC/NA	32 to 45 Ncm	Flapless	4	Xenograft	PS	One-stage	Single tooth restoration (2)	Immediate provisional no loading	NC/NA	NC/NA	24 to 27		
IIP NPS		11	50	11	Maxillary anteriors and premolars	Middle/premolars palatal/anteriors	NC/NA	32 to 45 Ncm	Flapless	4	Xenograft	NPS	One-stage	Single tooth restoration (2)	Immediate provisional no loading	NC/NA	NC/NA	24 to 27		
Crespi et al., 2009[45]	PCT	45	48.7																B	3
IIP PS				30	Maxillary and mandibular anteriors and premolars	Palatal and subcrestal	0 (NA)	≥35 Ncm	Flapless	4	None	PS	One-stage	Single tooth restoration and fixed partial denture (6)	Immediate provisional immediate loading	NC/NA	100	24		
IIP NPS				34	Maxillary and mandibular anteriors and premolars	Palatal and subcrestal	0 (NA)	≥35 Ncm	Flapless	4	None	NPS	One-stage	Single tooth restoration and fixed partial denture (6)	Immediate provisional immediate loading	NC/NA	100	24		

Table 1. (continued)

Characteristics of the 16 Studies Included in Meta-Analyses

Reference and Treatment Group	Study Design	Patients (n)	Age (years), Mean or Range	Implants (n)	Implant Location	Implant Position Into Extraction Socket	Number of Implants Failed (time of failure)	Implant Insertion Torque (Ncm) and/or ISQ Value	Flap or Flapless IIP	Remaining Socket Walls (n)	Augmentation Procedure	PS or NPS	Healing Protocol	Type of Definitive Restoration (time delivered in months)	Occlusal Protocol: Immediate Loading or Delayed Loading	Implant Success Rate (%)	Implant Survival Rate (%)	Observation Period After Loading (months)	Allocation Concealment Grade	Jadad Score
Pieri et al., 2011[41]	RCT																		A	5
IIP PS		20	45.8	19	Maxillary premolars	Supracrestal	1 (3 weeks)	≥40 Ncm	Flapless	4	Autograft + xenograft	PS	One-stage	Single tooth restoration (4)	Immediate provisional no loading	94.70	NC/NA	12		
IIP NPS		20	46.6	19	Maxillary premolars	Supracrestal	0 (NA)	≥40 Ncm	Flapless	4	Autograft + xenograft	NPS	One-stage	Single tooth restoration (4)	Immediate provisional no loading	100	NC/NA	12		
Crespi et al., 2008[44]	PCT																		D	2
IIP immediate loading		20	45.6	20	Maxillary anteriors and premolars	Palatal and crestal	0 (NA)	≥25 Ncm, ≥60 ISQ	Flapless	4	NC/NA	NPS	One-stage	Single tooth restoration (6)	Immediate provisional immediate loading	NC/NA	100	24		
IIP delayed loading		20	48.8	20	Maxillary anteriors and premolars	Palatal and crestal	0 (NA)	≥25 Ncm, ≥60 ISQ	Flapless	4	NC/NA	NPS	Two-stage	Single tooth restoration (6)	Delayed loading	NC/NA	100	24		
De Rouck et al., 2009[40]	RCT																		A	5
IIP immediate loading		24	55	24	Maxillary anteriors and premolars	NC/NA	1 (1 month)	≥35 Ncm	Flap	4	Xenograft	NPS	One-stage	Single tooth restoration (6)	Immediate provisional immediate loading	NC/NA	96.00	12		
IIP delayed loading		25	52	25	Maxillary anteriors and premolars	NC/NA	2 (3 months)	≥35 Ncm	Flap	4	Xenograft + RM	NPS	Two-stage	Single tooth restoration (6)	Delayed loading	NC/NA	92.00	12		
Prosper et al., 2010[51]	PCT	71	58.3																C	2
IIP immediate loading				60	Mandibular molars	Middle and crestal	2 (4 weeks)	NC/NA	Flap	4	RM	NPS	One-stage	Single tooth restoration (3)	Immediate provisional immediate loading	NC/NA	96.70	60		
IIP delayed loading				60	Mandibular molars	Middle and crestal	2 (2 weeks)	NC/NA	Flap	4	RM	NPS	Two-stage	Single tooth restoration (3)	Delayed loading	NC/NA	96.70	60		
Shibly et al., 2010[23]	RCT																		A	5
IIP immediate loading		26	25 to 94	26	Maxilla	Crestal	1 (3 months)	≥35 Ncm	Flap	3	Allograft + RM	NPS	One-stage	Single tooth restoration (4)	Immediate provisional immediate loading	NC/NA	96.70	24		
IIP delayed loading		29	25 to 94	29	Maxilla	Crestal	2 (2 to 12 weeks)	≥35 Ncm	Flap	3	Allograft + RM	NPS	Two-stage	Single tooth restoration (4)	Delayed loading	NC/NA	93.30	24		
Cordaro et al., 2009[39]	RCT																		A	5
IIP (one-stage)		16	18 to 70	16	Maxilla and mandible	NC/NA	1 (≤6 months)	NC/NA	Flap	4	NC/NA	NPS	One-stage	Single tooth restoration (6)	Delayed loading	NC/NA	93.80	18		
IIP (two-stage)		14	18 to 70	14	Maxilla and mandible	NC/NA	0 (NA)	NC/NA	Flap	4	NC/NA	NPS	Two-stage	Single tooth restoration (6)	Delayed loading	NC/NA	100	18		

ISQ = implant stability quotient; NC/NA = not clear or not available; RM = resorbable membrane; NRM = non-resorbable membrane.

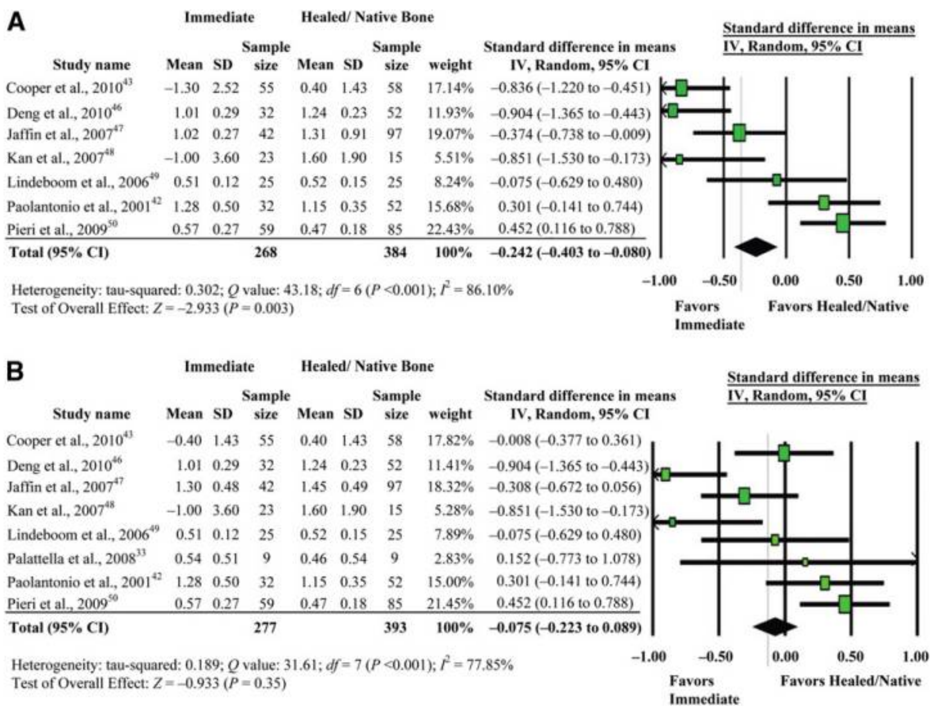

Figure 2.
*Comparison of CBL changes: IIP versus implants placed in healed/native bone at **A)** 12 months and **B)** ≤60 months of follow-up.*

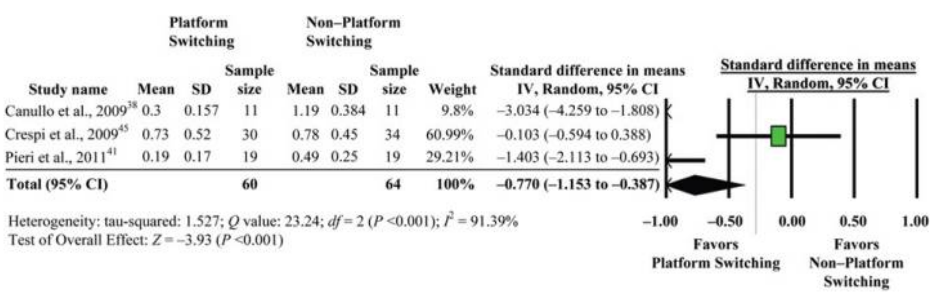

Figure 3.
Comparison of CBL changes: IIP using PS versus IIP using NPS at up to 27 months' follow-up.

loading and 114 with delayed loading.[23,40,51] Mean CBL change (0.002 mm; 95% CI, –0.269 to 0.272; P = 0.991) favored immediate loading, but the difference was not statistically significant. Four studies[23,40,44,51] reported CBL changes from 12 to 60 months and included 130 and 134 implants in the immediate-loading and delayed-loading IIP groups, respectively. The mean difference (0.005 mm; 95% CI, –0.241 to 0.251; P >0.001) favored immediate loading, but was not statistically significant (Fig. 5).

DISCUSSION

The objective of the current meta-analyses was to analyze CBL changes around immediately placed dental implants. Various surgical protocols such as PS, one- or two-stage placement, and time of implant loading can affect the CBL changes around IIP. Therefore, the aforementioned factors were analyzed in four meta-analyses.

IIP in Extraction Sockets Versus Implants Placed in Healed/Native Bone

Traditional reporting on implant survival does not include important information on hard or soft tissue changes. Few studies report specific data on CBL differences over time between IIP and delayed placement.[44,52] In the current meta-analysis, seven studies[42,43,46-50] evaluated CBL changes at 12 months and eight studies[33,42,43,46-50] up to 60 months. The results showed a significant mean CBL difference in favor of IIP compared with implants in healed sites at 12 months. Corresponding mean differences at 60 months were also in favor of IIP, but the differences were not significant. Actually, two[43,48] of five[43,46-48,53] studies showed bone gain in the IIP group compared with bone loss among healed bone individuals. The remaining three[46,47,49] studies showed less bone loss in the IIP compared with more bone loss in the healed/native group. These findings disagree with other studies showing greater risk for bone loss and midfacial recession with IIP.[13,14] In fact, the recent International Team for Implantology consensus[54] showed that IIP alone does not preserve the buccal plate, and bone loss is a natural occurrence in extraction sockets. This is an interesting finding, since bone gain was noted mainly in studies that used augmentation procedures with IIP.[46,48-50] Graft materials included autograft,[46] autograft and xenograft,[48] autograft and resorbable membrane,[49] and autograft or xenograft with resorbable membrane.[50] Further, the majority of studies placed implants in intact 4-wall sockets, and IIP was negated when buccal dehiscence was present.[43] Hence, socket integrity coupled with augmentation procedures might explain the favorable CBL results for IIP. Indeed, several reviews reported that the addition of bone grafts might enhance the bone remodeling process around IIP and increase survival rates.[28,55] The fact that augmentation reduces the magnitude of facial bone loss[54] could explain the favorable CBL findings in the current meta-analysis.

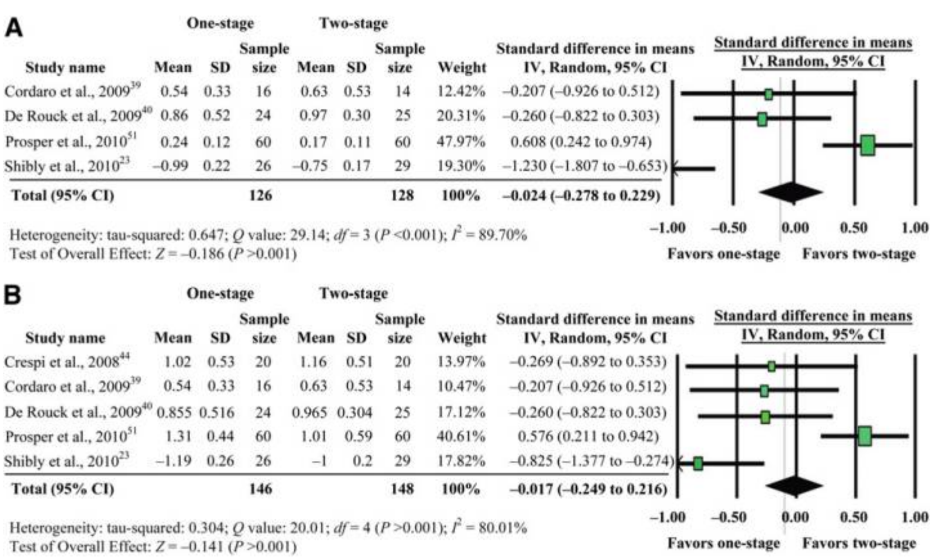

Figure 4.
*Comparison of CBL changes: IIP using one-stage versus IIP using two-stage protocol at **A)** 12 months and **B)** ≤60 months of follow-up.*

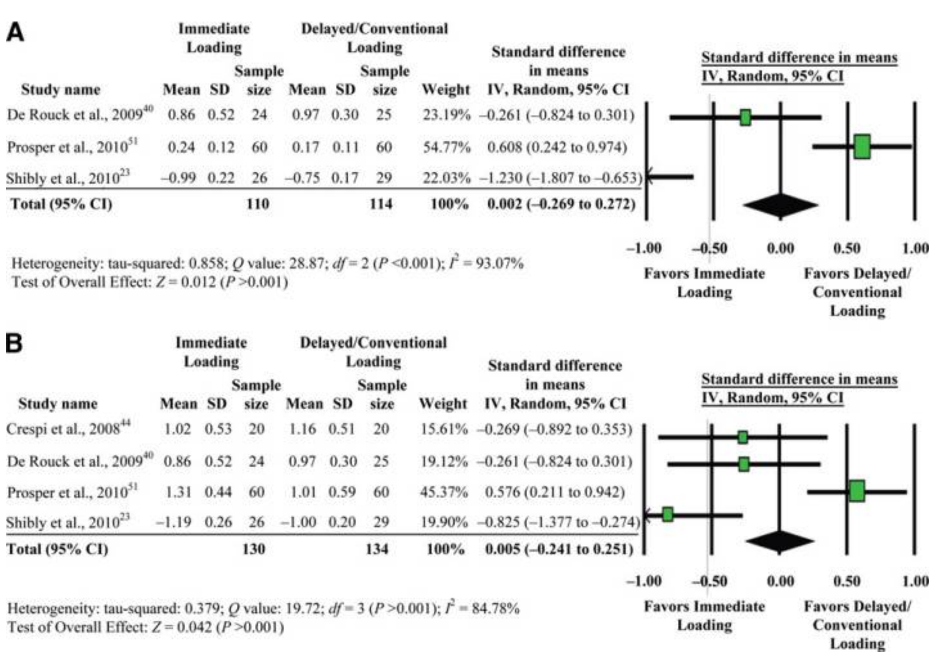

Figure 5.
*Comparison of CBL changes: IIP with immediate loading versus IIP with delayed/conventional loading protocol at **A)** 12 months and **B)** ≤60 months of follow-up.*

IIP Using PS Versus IIP Using NPS

Recent findings in the literature suggest that PS reduces crestal bone loss around dental implants.[56] A recent meta-analysis compared PS effect on CBL in 10 studies (1,239 implants) and found significantly less bone loss in the PS group (0.055 to 0.99 mm) compared with the NPS group (0.19 to 1.67 mm).[56] However, the study by Atieh et al.[56] compared PS to NPS without regard for timing of implant placement as immediate or immediate delayed. The current meta-analysis expands on previous systematic reviews by evaluating CBL changes specifically around IIP based on whether the implant was PS or not. Due to the strict inclusion criteria, only three studies[38,41,45] qualified for meta-analysis. The analysis showed greater bone preservation up to 24 months in the IIP group using PS compared with the NPS group and is in agreement with Atieh et al.[56]

IIP Using One-Stage Versus Two-Stage Protocol

The decision to use one-stage versus two-stage IIP is often a choice for practitioners. For example, soft tissue manipulation for esthetics may dictate the need for a one-stage or two-stage approach. There is little doubt today that both protocols result in successful implant osseointegration.[22] However, the question posed by this meta-analysis is whether there is a difference in CBL with either protocol. The results of the present analysis indicated no significant difference in CBL with either protocol, despite a slight, but non-significant, advantage for the one-stage approach. The difference remained non-significant when the 24-month follow-up study by Crespi et al.[44] was separated from the analysis. Because heterogeneity among studies was high, the results must be interpreted with caution. Thus, based on the evidence, there appears to be too little evidence to conclude that the one- or two-stage approach is superior to the other in minimizing CBL.

IIP Using Immediate Versus Delayed Loading

Few clinical trials meeting the inclusion criteria evaluated the effects of immediate versus delayed loading on CBL around IIP. Four studies[23,40,44,51] evaluated CBL up to 60 months, with three of them reporting CBL at 12 months.[23,44,51] An analysis of the four studies showed a slight, but non-significant, advantage for CBL in favor of delayed loading protocols. The results were essentially unchanged when analyzed at 12 months' follow-up. Although these results suggest that there is no difference between loading protocols for IIP, it must be remembered that there was significant heterogeneity among studies; therefore, the results must be interpreted with caution.

CONCLUSIONS

The results of this meta-analysis showed the following. 1) Significantly less crestal bone is lost around IIP compared with implants placed in healed/native bone. 2) Significantly less crestal bone was lost around PS IIP compared with NPS IIP. 3) There was no difference in mean CBL changes with either a one- or two-stage IIP protocol at ≥12 months of functional loading. 4) Timing of loading of IIP had no significant effect on CBL changes at ≥12 months. 5) There was high heterogeneity among studies for all meta-analyses; hence, the results should be interpreted with caution. This finding indicates that more uniform criteria are needed for methodologic designs of randomized clinical trials to improve homogeneity among studies and confidence in the results.

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