Review

Soft Tissue Changes Around Immediately Placed Implants: A Systematic Review and Meta-Analyses With at Least 12 Months of Follow-Up After Functional Loading

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Background: Immediate implant placement (IIP) is predictable but can lead to esthetic challenges, including midfacial recession (MFR) and papillary height (PH) loss. The aim of this systematic review is to examine the effect of IIP on MFR and PH after at least 12 months of functional loading.

Methods: Literature review of the Cochrane and MEDLINE electronic databases and hand search up to January 2016 identified eligible studies. Four reviewers independently assessed data quality and methodology.

Results: A total of 106 articles satisfied the inclusion criteria. Twelve studies qualified for three meta-analyses. MFR was slightly less in conventional implant placement (CIP) than in IIP, but the result was not statistically significant (mean difference [MD] –0.064 mm; $P = 0.687$). Similarly, there was better PH maintenance in CIPs, with statistical significance for distal PH (DPH) only (cumulative PH: MD –0.396, $P = 0.010$; DPH: MD –0.765, $P < 0.001$; mesial PH [MPH]: MD –0.285, $P = 0.256$). MFR was slightly less in IIP with thick versus thin biotypes, but not statistically significantly different (MD –0.373, $P = 0.243$). Pooled data showed statistically significantly less MFR and better PH maintenance in IIP with thick biotype (MFR: MD –0.478, $P < 0.001$; cumulative PH: MD –0.287, $P < 0.001$; MPH: MD –0.288, $P < 0.001$; DPH: MD –0.310, $P < 0.001$). Non-significantly less MFR (MD 0.253, $P = 0.384$) and significantly better PH maintenance were found in IIP with immediate provisionalization versus conventional restoration (MD –0.519, $P = 0.028$).

Conclusions: IIP in thick biotype and with immediate provisionalization had less MFR and better PH than IIP in thin biotype or with delayed restoration. However, these findings should be interpreted with caution due to high heterogeneity, which was calculated using comprehensive meta-analysis statistical software that took into account sample size and different treatment groups, and limited qualified studies. *J Periodontol 2017;88:876-886.*

KEY WORDS

Dental implants; esthetics; gingival recession; meta-analysis; review.

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Timing of dental implant placement has varied, with early protocols recommending healing for 3 months after extraction and before implant placement followed by an additional 6 months for implant osseointegration before final restoration.[1,2] Immediate implant placement (IIP) can reduce healing time from placement to final restoration with a high success rate (95.6%) that is comparable to conventional implant placement (CIP) (99.4%).[3] Advantages of IIP include fewer surgical interventions, reduced treatment time, and increased patient satisfaction.[4]

Despite the advantages of IIP, midfacial recession (MFR), papillary height (PH) loss, crestal bone loss, and a display of a gray hue of the underlying implant are complicating factors.[5-7] IIP is a technique-sensitive procedure in which primary stability is a determining factor for success. A number of surgical factors may impact the final position of crestal bone and soft tissue levels around IIP, affecting the final esthetic results.[6] Factors affecting esthetic outcomes may include variability of loading protocol,[8,9] presence of thick or thin biotype,[10] implant placement in one or two stages,[11] and use of the platform switching concept.[6,12] Although reviews attempted to evaluate IIP soft tissue changes, no specific data were reported for MFR or PH.[4,13] This is primarily

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due to lack of appropriate studies addressing soft tissue changes around immediate implants. The main objective of these previous analyses was to evaluate survival and success of IIP.[4,13] Other studies evaluated soft tissue response according to immediate restoration rather than surgical variables.[14] Hence, the specific objectives of this systematic review and meta-analyses are to analyze overall soft tissue changes around IIP and evaluate effects of different surgical factors on soft tissue levels.

This systematic review examines the effect of IIP on MFR and changes after at least 12 months of functional loading based on the following: 1) IIP versus CIP (in native/healed bone); 2) IIP in thick versus thin biotype; and 3) IIP with immediate provisionalization/loading versus IIP with delayed 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[15] and Cochrane Collaboration recommendations.[16] Electronic search of two electronic databases (National Center for Biotechnology Information [PubMed and MEDLINE] and Cochrane Collaboration Library) was performed at the University of Detroit Mercy, Detroit, Michigan. Publications in English through January 2016 were selected. In addition to the online search, a hand search of bibliographies of reviews and clinical trials related to the topic of IIP was conducted.

Study Selection and Interventions

To be eligible for inclusion, publications had to be: 1) conducted on human participants; 2) published in English; 3) concerning rough-surface implants with functional loading for minimum 12 months; 4) randomized, controlled, or prospective clinical trials (RCTs, CCTs, or PCTs, respectively); and 5) reporting MFR or PH changes.

Publications were excluded if they: 1) did not match inclusion criteria; 2) reported data on one-piece or machine-surfaced implants; or 3) had missing data relevant to the systematic review.

The following terminology was used to perform the searches 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 (“gingiva”) OR (“gingival recession” OR “recession”) OR (“papilla” OR “interdental papilla”).

Data Extraction and Collection

A data-extraction form was developed and used by two reviewers (BMK and MS) to collect the following study information: 1) author and year of publication; 2) study type and randomization method; 3) treatment groups; 4) patient and implant sample size; 5) midfacial gingival level or interdental PH changes; 6) periodontal biotype; 7) initial implant stability; 8) platform switching and non-platform switching IIP; 9) occlusal protocol, definitive restoration type, and time of IIP loading; 10) augmentation procedure and material types when used; 11) extraction socket morphology, IIP site, and position; 12) healing protocol for one- and two-stage IIP, 13) implant survival and success rates; and 14) follow-up period.

All data were screened and assessed independently by four reviewers (BMK, FA, KH, and ML). All disagreements were resolved by discussion. Corresponding authors were contacted to supply missing relevant study data for complete ascertainment.

Statistical Analyses

Mean MFR-level changes and interdental mesial PH (MPH) and distal PH (DPH) measurements were the basis for data analyses. When studies reported MPH and DPH separately, means were calculated using statistical software.§ Mean differences (MDs) were compared using Hedges g statistic for meta-analysis and 95% confidence intervals (CI) were calculated. Statistically significant differences were reported when $P < 0.05$. Meta-analyses were carried out using comprehensive meta-analysis statistical software.‖ Random-effects models were used to correct for heterogeneity among studies. I^2 values ranged from 0 to 100, with larger values (≥75%) suggesting high heterogeneity, which was calculated using the same comprehensive meta-analysis statistical software that took into account sample size and different treatment groups, because of moderate insensitivity of the Q statistic.[17]

Quality Assessment

The methodologic quality assessment was based on the Cochrane assessment of allocation concealment[18] and the Jadad score calculation.[19] The Cochrane assessment of allocation concealment evaluated validity and randomization of the studies by assigning grades ranging from A to D. Grade A indicated no risk for bias, grade B was unclear risk for bias, and studies with grades C and D had high risk for bias. The Jadad scale was used to assign a score ranging from 0 to 5 points, with a score of 3 to 5 indicating higher study quality.

RESULTS

The electronic search identified 782 possible publications. An additional 90 articles were retrieved

§ JavaScript E-labs, University of Baltimore, Baltimore, MD.
‖ Comprehensive meta-analysis v.3, Biostat, Englewood, NJ.

through hand search of bibliographies of reviews and clinical trials, adding up to a total of 872 relevant publications. After review of titles and abstracts, 219 pertinent studies were selected for full-text review (Fig. 1). Of the 219 studies, 113 were excluded because they failed to meet the inclusion criteria. The remaining 106 studies reported data that satisfied the initial inclusion criteria for systematic review. Of these 106 publications, 12 exhibited a test and control arm allowing a series of meta-analyses to be performed (Fig. 1). Interobserver agreement among reviewers was calculated using κ statistic (κ = 0.80). Characteristics of the 12 studies[5,20-30] are summarized in Table 1.

Description of Studies and Methodologic Quality

Of the 12 included studies, there were four RCTs,[20-22] six PCTs,[5,23-28] and two clinical case studies.[29,30] The studies were assessed according to the Cochrane assessment of allocation concealment[18] and the Jadad score calculation.[19] Only RCTs[20-22] scored high (grade A and score of 5), whereas the remaining studies scored low (grade C to D and score of 1 to 2) according to the two assessment methods.[18,19] The 12 studies included a total of 625 patients (aged 18 to 75 years) and 639 implants with a follow-up period of 12 to 60 months (mean follow-up of 37 months). Of the 639 implants, 396 (62%) were placed immediately in extraction sockets and 243 (38%) were conventionally placed.

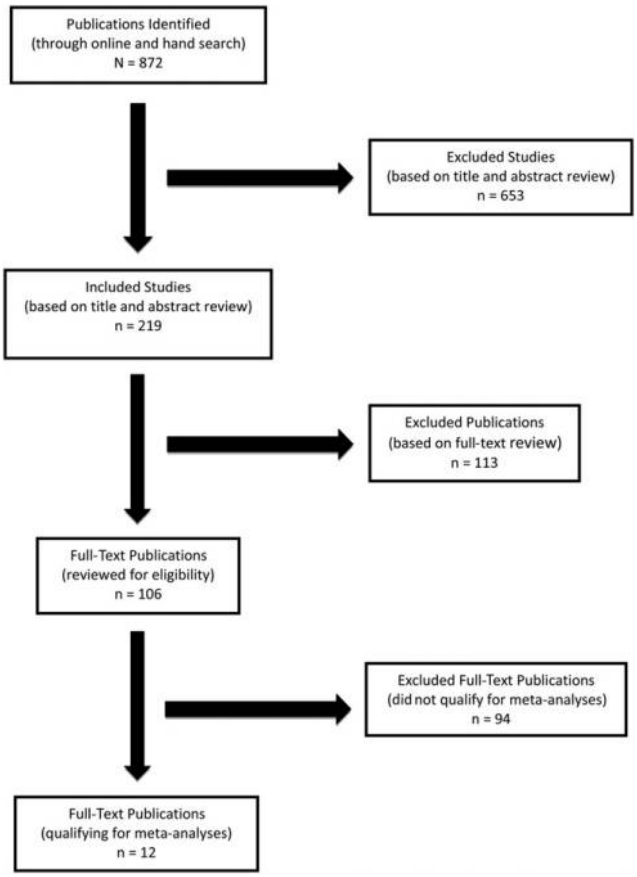


Figure 1.
Flowchart for identification of publications according to PRISMA principles for systematic reviews.[15]

Meta-Analyses 1

Effect of IIP versus CIP on MFR in extraction sockets. Six studies[22,24-26,28,30] evaluated the effect of IIP versus CIP on MFR. MFR was reported in millimeters, and the studies were analyzed using a random-effects model. Effect size was raw difference in means. All IIP occurred at the time of extraction, whereas CIP ranged between 2 and 5 months after extraction in three studies[22,25,30] and after an unspecified healing period in two studies.[24,26]

The studies included a total of 180 IIPs and 206 CIPs with 12 to 60 months of follow-up. MD of –0.064 mm (SD = 0.160, 95% CI: –0.377 to 0.249; $P = 0.687$) indicated slightly less recession; however, the difference was not statistically significant. Also, note that there was moderate heterogeneity ($I^2 = 64.62\%$) (Fig. 2A).

Effect of IIP versus CIP on PH in extraction sockets. Three studies[24,26,30] evaluated the effect of IIP versus CIP on PH in millimeters. PH was evaluated using a random-effects model and effect size was raw differences in mean. MD was –0.396 (SD = 0.155, 95% CI: –0.699 to –0.093; $P < 0.001$), indicating significantly less cumulative PH loss with CIP versus IIP (Fig. 2B). Further subanalysis compared the effect of IIP versus CIP on MPH and DPH in two studies.[24,30] MD was –0.285 mm (SD = 0.251, 95% CI: –0.777 to 0.207; $P = 0.256$) for MPH and –0.765 mm (SD = 0.219, 95% CI: –1.194 to –0.336; $P < 0.001$) for DPH showing better PH preservation in the CIP group. No measurable heterogeneity was noted among studies ($I^2 = 0\%$) (Figs. 2C and 2D).

Meta-Analyses 2

Effect of IIP on MFR in thick versus thin biotype. Three studies[5,27,29] had test and control arms allowing meta-analyses. The studies had follow-up periods ranging from 18.9 to 48 months (mean = 30.3 months). There were 50 IIPs in thin and 47 in thick biotype groups. MD was –0.373 mm (SD = 0.320, 95% CI: –1.000 to 0.253; $P = 0.243$). There was less recession in IIP with thick versus thin biotype, but the difference was not significant. High heterogeneity was identified among studies ($I^2 = 79.62\%$) (Fig. 3A). A subanalysis of 11 studies[5,21,27,29-36] evaluated the effect of IIP on MFR in thick versus thin biotype using the pooled-estimates method. MD was –0.478 mm (SD = 0.083, 95% CI: –0.641 to –0.315; $P < 0.001$). Results were significant, but heterogeneity was high ($I^2 = 85.26\%$) (Fig. 3B).

Table 1.

Characteristics of 12 Studies Included in Meta-Analyses

Author/Year	Study Design	Treatment Groups	Implant Location	Periodontal Biotype (thick/thin)	Presence of Periodontal/ Peri-apical Infection	Number of Patients	Number of Implants Placed	Mean Age (years [range])	Measurement Technique	Implant Diameter (mm) × Length (mm)
Palattella et al. 2008[22]	RCT	IIP with IP CIP at 8 weeks	Maxillary esthetic	NS NS	No	8 8	9 9	35 (21 to 49) 35 (21 to 49)	Clinically	4.1 to 4.8 × 10 to 12 4.1 to 4.8 × 10 to 12
Cooper et al. 2010[25]	PCT	IIP CIP at 4 to 5 months after GBR	Maxillary esthetic	NS NS	No	55 58	55 58	45.1 42.1	Clinically	NS NS
Raes et al. 2011[30]	Clinical study	IIP with IP	Maxillary esthetic	Thick: periodontal probe tip not visible through labial sulcus	NS	16	16	45 (22 to 68)	Digital photographs and standardized digital slides	4.0 to 5.0 × 13 to 17
		CIP with provisionalization		Thick and thin		23	23	40 (19 to 75)		3.5 to 4.5 × 11 to 17
De Bruyn et al. 2013[26]	PCT	IIP CIP	Maxillary esthetic	NS NS	NS	48 55	48 55	45 42	Clinically	3.5 to 5 × 11 to 19 3.5 to 5 × 11 to 19
Cooper et al. 2014[24]	PCT	IIP with IP CIP with provisionalization	Maxillary anterior	NS NS	NS	45 49	45 49	45 42	Clinically	3.5 to 5.0 × 11 to 17 3.5 to 5.0 × 11 to 17
Cordaro et al. 2009[20]	RCT	IIP (submerged)	Maxillary/mandibular esthetic	Thick and thin (unspecified)	NS	14	14	18 to 70	Clinically	NS
		IIP (non-submerged)		Thick and thin (unspecified)		16	16	18 to 70		NS
De Rouck et al. 2009[21]	RCT	IIP with IP	Maxillary esthetic	Thick (flat gingival biotype, relatively short wide teeth, low contact points, short papillae)	No	24	24	55	Clinically with acrylic stent	4.3 × 16
		CIP		Thick		25	25	52		4.3 × 16
Barone et al. 2014[23]	PCT	IIP with IP loading IIP (submerged) with delayed loading	Maxillary/mandibular (not tooth specific)	NS NS	No	15 15	15 15	43 ± 17.5 51 ± 19.5	Clinically	NS NS
Evans and Chen 2008[5]	PCT	IIP with thin periodontal biotype	Maxillary/mandibular esthetic	Thin: periodontal probe tip visible through labial sulcus	No	24	24	47.9 ± 12.8	Study casts and digital photographs	4.1 to 4.8
		IIP with thick periodontal biotype		Thick: periodontal probe tip not visible through labial sulcus		18	18	47.9 ± 12.8		4.1 to 4.8
Kan et al. 2009[29]	Clinical study	IIP with IP + CTG (thin biotype)	Maxillary anterior	Thin: periodontal probe tip visible through labial sulcus	No	12	12	52.3	Study casts with jig	>3.5 × 13
		IIP with IP + CTG (thick biotype)		Thick: periodontal probe tip not visible through l abial sulcus		8	8	52.3		>3.5 × 13
Kan et al. 2011[27]	PCT	IIP with IP	Maxillary esthetic	Thick and thin	NS	35	35	36.8 (18 to 65)	Study casts with jig	NS
		IIP with IP		Thick: periodontal probe tip not visible through labial sulcus		21	21	36.8 (18 to 65)		NS
		IIP with IP		Thin: periodontal probe tip visible through labial sulcus		14	14	36.8 (18 to 65)		NS
Miyamoto and Obama 2011[28]	PCT	Delayed two-stage technique, GBR NRM with BPBM and FDBA	Maxillary anterior	NS	NS	10	16	51.69 (36 to 69)	Digital photographs	NS
		Delayed two-stage technique using BM and BPBM and FDBA		NS		3	8	57.5 (45 to 66)		NS
		IIP with autogenous bone graft with IP		NS		6	7	37.86 (24 to 48)		NS

Table 1. (continued)

Characteristics of 12 Studies Included in Meta-Analyses

Author/Year	Stability: Starting Torque in Ncm (ISQ values)	Flap (Fp) or Flapless (Fs)	Bone Graft/ Membrane Type	Jumping Distance (peri-implant facial gap) (mm)	Implant Survival Rates (%)	Tissue Level Versus Bone Level Stage Implant Placement	One-Stage Versus Two-Stage Implant Placement	PS Versus NPS	Type of Prostheses (insertion time in months)	Immediate Provisionalization	Immediate Loading	Final Evaluation After Loading (in months)	Cochrane Assessment of Allocation Concealment	Jadad Score
Palattella et al. 2008[22]	35 (65) 35 (74)	Fp Fp	NS NS	NS NS	100 100	Tissue Tissue	One stage One stage	NPS NPS	ST (NS) ST (NS)	Yes Yes	No No	24 24	Grade A	5
Cooper et al. 2010[25]	<50 <50	Fs Fp	NS NS	NS NS	92.7 98.3	Bone Bone	One stage One stage	NPS NPS	ST (3) ST (3)	Yes Yes	NS NS	12 12	Grade C	2
Raes et al. 2011[30]	>25 >25	Fs Fp	NS NS	Yes NS	93.8 100	Bone Bone	One stage One stage	NPS NPS	ST (3 to 4) ST (3 to 4)	Yes Yes	No No	12 12	Grade D	2
De Bruyn et al. 2013[26]	NS NS	NS NS	NS NS	NS NS	94.6 98.3	NS NS	One stage One stage	NS NS	ST (3) ST (3)	Yes Yes	No No	36 36	Grade D	2
Cooper et al. 2014[24]	NS (99) NS (99)	Fs Fs	NS NS	NS NS	95 98	NS NS	NS NS	NS NS	ST (3) ST (3)	Yes Yes	NS NS	60 60	Grade C	2
Cordaro et al. 2009[20]	NS NS	Fp Fp	NS NS	<2 <2	100 93.8	Tissue Tissue	Two stage One stage	NPS NPS	ST (6) ST (6)	No Yes	No Yes	12 12	Grade A	5
De Rouck et al. 2009[21]	>35 >35	Fp Fp	Xenograft Xenograft with BM	NS NS	96 92	Bone Bone	One stage Two stage	NPS NPS	ST (6) ST (6)	Yes No	Yes No	12 12	Grade A	5
Barone et al. 2014[23]	>45 <45	Fs Fs	Xenograft with BM Xenograft with BM	Yes Yes	100 100	Bone Bone	One stage Two stage	NPS NPS	ST (NS) ST (4)	Yes NS	Yes NS	24 24	Grade D	2
Evans and Chen 2008[5]	NS NS	NS NS	NS NS	NS NS	100 100	Bone and tissue Bone and tissue	Two stage Two stage	NS NS	ST (3 to 4) ST (3 to 4)	No No	No No	18.9 18.9	Grade C	2
Kan et al. 2009[29]	> 35 > 35	NS NS	NS NS	NS NS	100 100	Bone Bone	One stage One stage	NS NS	ST (5) ST (5)	Yes Yes	No No	24 24	Grade D	I
Kan et al. 2011[27]	NS NS NS	NS NS NS	NS NS NS	NS NS NS	100 100 100	Bone Bone Bone	One stage One stage One stage	NPS NPS NPS	ST (5) ST (5) ST (5)	Yes Yes Yes	No No No	48 48 48	Grade D	I
Miyamoto and Obama 2011[28]	NS NS NS	NS NS NS	NRM + xenograft + allograft BM + xenograft + allograft Autogenous bone graft	2 2 2	NS NS NS	Bone Bone Bone	Two stage Two stage One stage	NPS NPS NPS	ST (2 to 4) ST (2 to 4) ST (3 to 6)	No No Yes	No No No	27.12 14 47	Grade D	I

ISQ = implant stability quotient; PS = platform switching; NPS = non-platform switching; NS = not specified; ST = single tooth; BM = bioabsorbable membrane; NRM = non-resorbable membrane; BPBM = bovine porous bone mineral; FDBA = freeze-dried bone allograft; IP = immediate provisionalization.

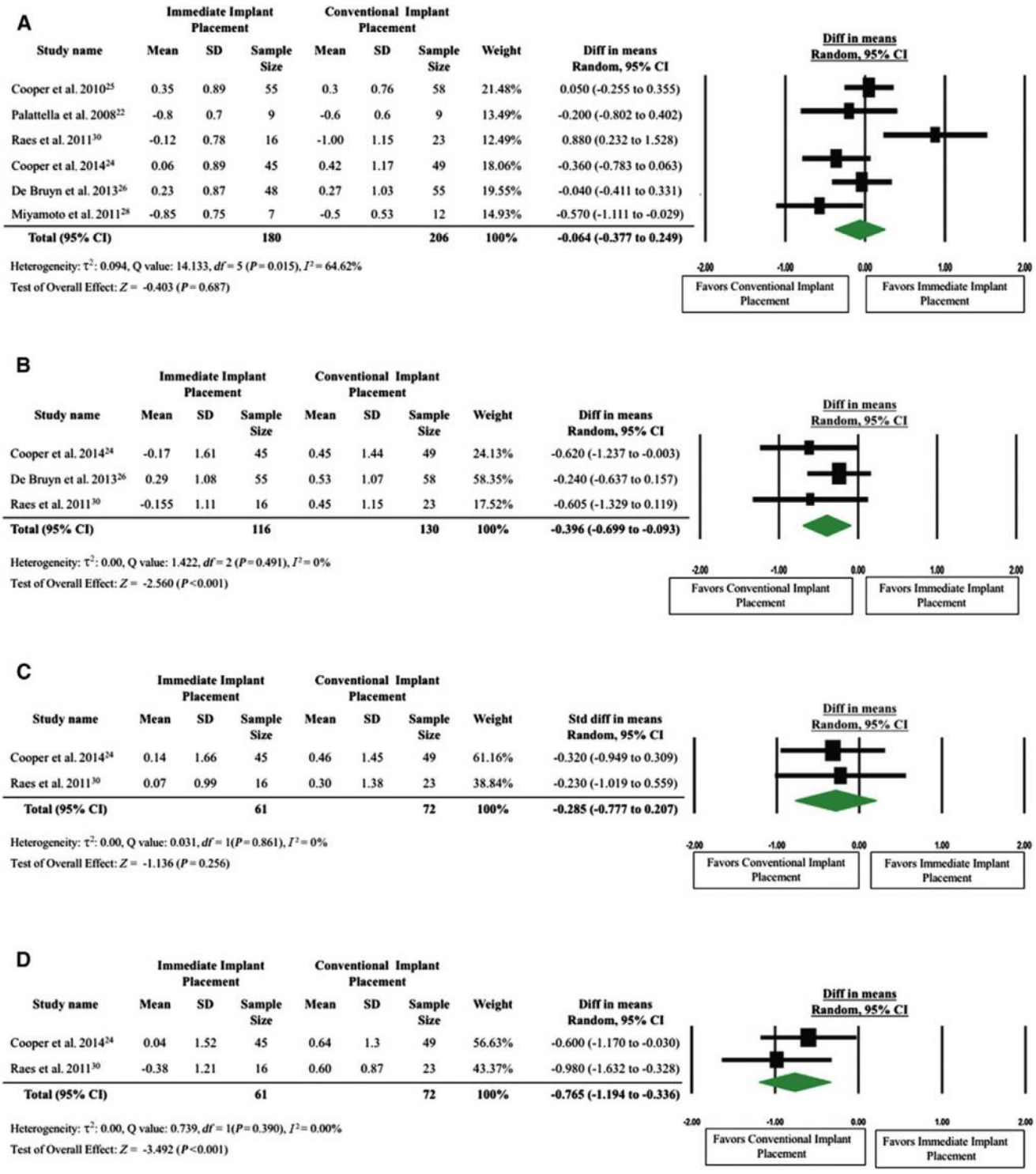
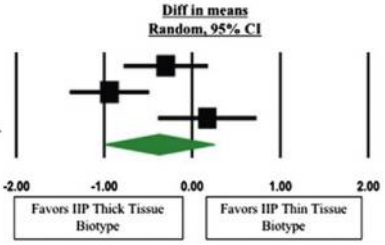


Figure 2.
Comparison of soft tissue changes: IIP versus CIP up to 60 months of follow-up. ***A)*** *MFR.* ***B)*** *Cumulative PH.* ***C)*** *MPH.* ***D)*** *DPH.* df = *degrees of freedom; Diff = difference.*

A

Study name	IIP Thin Tissue Biotype Mean	SD	Sample Size	IIP Thick Tissue Biotype Mean	SD	Sample Size	Weight	Diff in means Random, 95% CI
Evans et al. 2008[5]	-1.00	0.9	24	-0.7	0.57	18	33.81%	-0.300 (-0.775 to 0.175)
Kan et al. 2011[27]	-1.5	0.88	14	-0.56	0.46	21	34.63%	-0.940 (-1.385 to -0.495)
Kan et al. 2009[29]	0.06	0.45	12	0.23	0.82	8	31.56%	0.170 (-0.385 to 0.725)
Total (95% CI)			**50**			**47**	**100%**	**-0.373 (-1.000 to 0.253)**

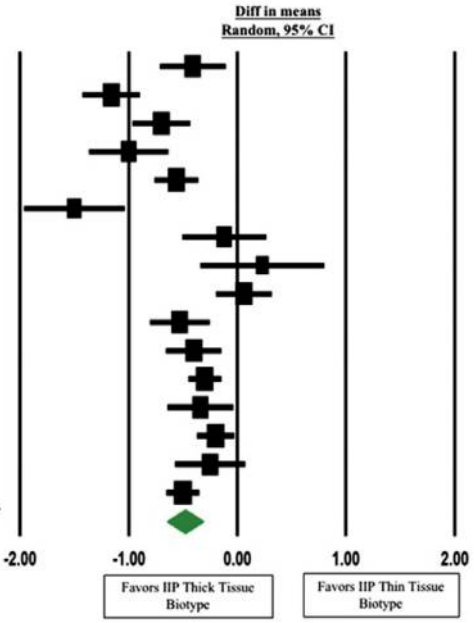
Heterogeneity: τ^2: 0.244, Q value: 9.815, $df = 2$ ($P = 0.007$), $I^2 = 79.623\%$
Test of Overall Effect: $Z = -1.168$ ($P = 0.243$)



B

Study name	Tissue Biotype	Mean	SD	Sample size	Weight	Diff in means Random, 95% CI
De Rouck et al. 2009[21]	Thick	-0.41	0.75	24	6.19%	-0.410 (-0.710 to -0.110)
De Rouck et al. 2009[21]	Thick	-1.16	0.66	25	6.54%	-1.160 (-1.419 to -0.901)
Evans et al. 2008[5]	Thick	-0.90	0.83	18	6.50%	-0.700 (-0.963 to -0.437)
Evans et al. 2008[5]	Thin	-0.90	0.77	24	5.66%	-1.000 (-1.360 to -0.640)
Kan et al. 2011[27]	Thick	-0.56	0.46	21	7.03%	-0.560 (-0.757 to -0.363)
Kan et al. 2011[27]	Thin	-1.50	0.88	14	4.81%	-1.500 (-1.961 to -1.039)
Raes et al. 2011[30]	Thick	-0.12	0.78	16	5.47%	-0.120 (-0.502 to 0.262)
Kan et al. 2009[29]	Thick	0.23	0.82	8	4.01%	0.230 (-0.338 to 0.798)
Kan et al. 2009[29]	Thin	0.06	0.45	12	6.57%	0.060 (-0.195 to 0.315)
De Rouck et al. 2008[31]	Thick	-0.53	0.76	30	6.43%	-0.530 (-0.802 to -0.258)
Spinato et al. 2012[35]	Thick (GBR)	-0.40	0.60	22	6.60%	-0.400 (-0.651 to -0.149)
Spinato et al. 2012[35]	Thick	-0.30	0.36	23	7.36%	-0.300 (-0.447 to -0.153)
Cosyn et al. 2011[33]	Thick	-0.34	0.80	28	6.22%	-0.340 (-0.636 to -0.044)
Cosyn et al. 2013[32]	Thick	-0.20	0.40	22	7.23%	-0.200 (-0.367 to -0.033)
Spinato et al. 2014[36]	Thin	-0.25	0.46	8	6.02%	-0.250 (-0.569 to 0.069)
Malchiodi et al. 2013[34]	Thick	-0.50	0.60	64	7.36%	-0.500 (-0.647 to -0.353)
Total (95% CI)					**100%**	**-0.478 (-0.641 to -0.315)**

Heterogeneity: τ^2: 0.088, Q value: 101.777, $df = 15$ ($P = 0.000$), $I^2 = 85.262\%$
Test of Overall Effect: $Z = -5.749$ ($P < 0.001$)



C

Study name	Tissue Biotype	Mean	SD	Sample size	Weight	Diff in means Random, 95% CI
Cosyn et al. 2011[33]	Thick	-0.065	1.06	28	1.58%	-0.262 (-0.587 to 0.064)
Cosyn et al. 2013[32]	Thick	-0.35	0.50	22	3.83%	-0.350 (-0.559 to -0.141)
De Rouck et al. 2008[31]	Thick	-0.36	0.77	30	2.19%	-0.360 (-0.636 to -0.084)
De Rouck et al. 2009[21]	Thick	-0.38	0.79	19	18.6%	-0.030 (-0.425 to -0.235)
De Rouck et al. 2009[21] (conventional)	Thick	-0.48	0.49	19	20.64%	-0.260 (-0.350 to -0.170)
Kan et al. 2011[27]	Thick	-0.215	0.38	21	9.52%	-0.240 (-0.373 to -0.107)
Kan et al. 2011[27]	Thin	-0.24	0.31	14	3.81%	-0.195 (-0.405 to 0.015)
Pieri et al. 2011 (NPS)[37]	Thin	-0.33	0.21	19	18.60%	-0.330 (-0.425 to -0.235)
Pieri et al. 2011 (PS)[37]	Thin	-0.26	0.20	19	20.64%	-0.260 (-0.350 to -0.170)
Raes et al. 2011[30]	Thick	-0.155	1.11	16	0.57%	-0.155 (-0.697 to 0.387)
Total (95% CI)				**207**	**100%**	**-0.287 (-0.328 to -0.246)**

Heterogeneity: τ^2: 0.088 , Q value: 101.777, $df = 1$ ($P = 0.000$), $I^2 = 85.262\%$
Test of Overall Effect: $Z = -5.749$ ($P < 0.001$)

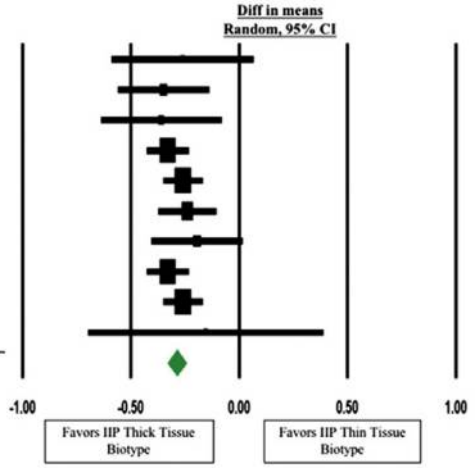


Figure 3.
Comparison of soft tissue changes: IIP in thick biotype versus thin biotype up to 48 months of follow-up. ***A)*** *Meta-analysis of MFR.* ***B)*** *Pooled estimates for MFR.* ***C)*** *Pooled estimates for cumulative PH.* df = *degrees of freedom; Diff = difference; PS = platform switching; NPS = non-platform switching.*

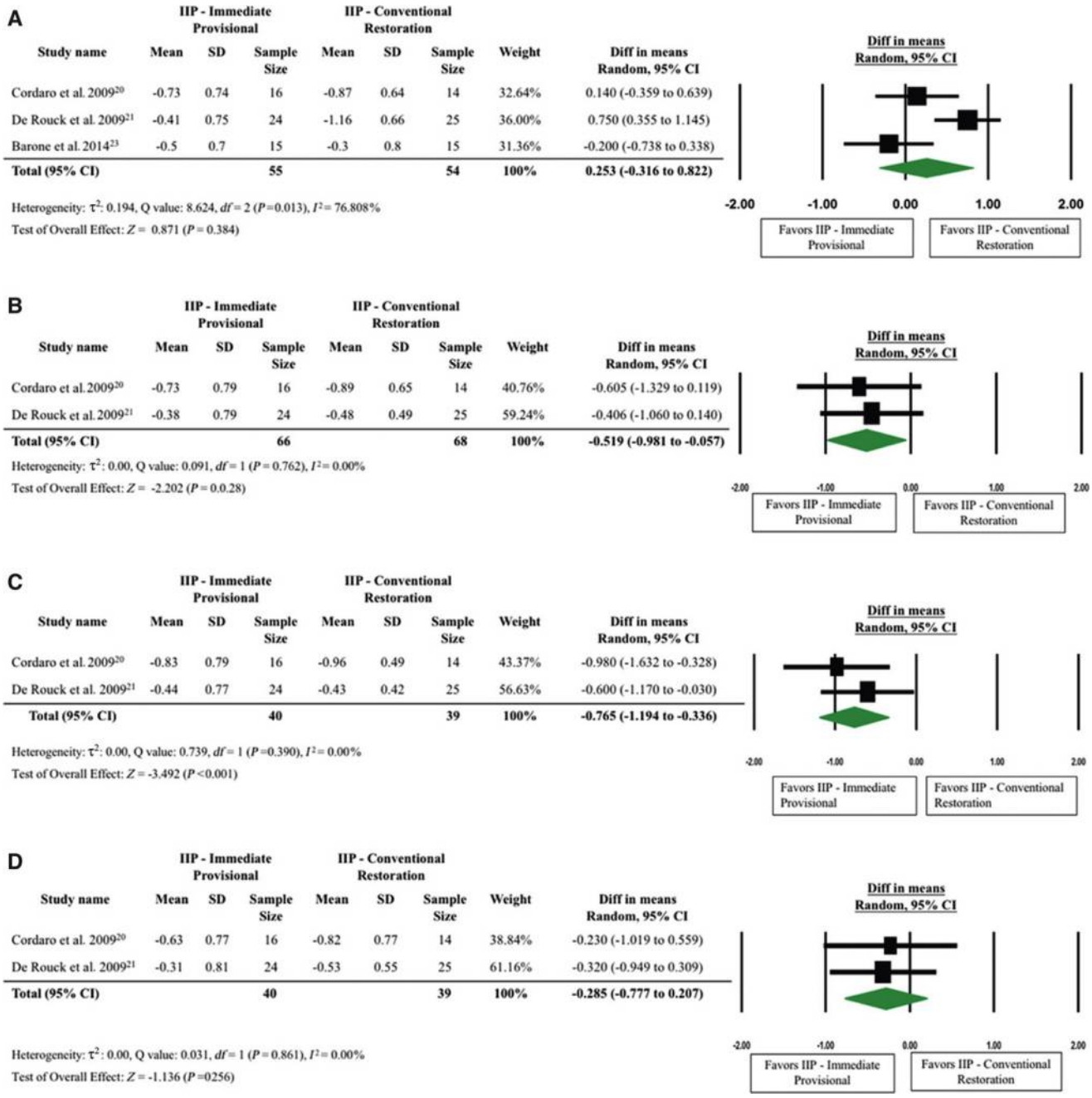


Figure 4.
Comparison of soft tissue changes: IIP using immediate provisionalization versus IIP using conventional restoration at 12 months of follow-up. ***A)*** *MFR.* ***B)*** *Cumulative PH.* ***C)*** *MPH.* ***D)*** *DPH.* df = *degrees of freedom; Diff = difference.*

Effect of IIP on PH in thick versus thin biotype. Seven studies[21,27,30-33,37] qualified for inclusion in the meta-analyses. MD was –0.287 mm (SD = 0.021, 95% CI: –0.328 to –0.246; *P* <0.001) in favor of thick biotype. The difference was significant, but with high heterogeneity (I^2 = 85.62%) (Fig. 3C). Six studies[21,30-33,37] evaluated the effect of IIP on MPH and DPH (in millimeters) in thick versus thin biotype. MD was –0.288 mm in MPH (SD = 0.025, 95% CI: –0.338 to –0.239; *P* <0.001) and –0.310 mm in DPH (SD = 0.023, 95% CI: –0.354 to –0.266; *P* <0.001). There was significantly less PH loss in IIP with thick biotype.

Meta-Analyses 3

Effect of IIP on MFR with immediate provisionalization versus IIP with conventional restoration. Three studies[20,21,23] had test and control groups and qualified for meta-analyses. MD was 0.253 mm (SD = 0.290,

95% CI: –0.316 to 0.822; $P = 0.38$), showing minimal coronal gain in midfacial marginal gingiva favoring the IIP immediate provisionalization group. However, the difference was not significant and had high heterogeneity among studies ($I^2 = 76.81\%$) (Fig. 4A).

Effect of IIP on PH with immediate provisionalization versus IIP with delayed/conventional restoration. Meta-analyses were based on two studies.[20,21] Mean study follow-up time was 12 months. MD for cumulative PH (MPH and DPH) was –0.519 mm (SD = 0.236, 95% CI: –0.981 to –0.057; $P = 0.03$) with better maintenance of cumulative PH for IIP with immediate provisionalization versus IIP with conventional restoration. The difference among groups was statistically significant with no measurable heterogeneity ($I^2 = 0\%$) (Fig. 4B).

Separate meta-analyses were conducted on MPH and DPH in two studies.[20,21] MD for MPH was –0.765 mm (SD = 0.219, 95% CI: –1.194 to –0.336; $P < 0.001$) and for DPH it was –0.285 mm (SD = 0.251, 95% CI: –0.777 to 0.207; $P = 0.26$). There was no measureable heterogeneity among studies ($I^2 = 0.0\%$) (Figs. 4C and 4D).

DISCUSSION

The current study analyzes changes in MFR and PH around immediately placed dental implants. Nine meta-analyses and two pooled-estimates analyses were conducted to evaluate MFR and PH.

IIP Versus CIP

IIP is a predictable procedure with high success rates. Although a previous systematic review described recession and PH loss around IIP,[38] to the best of the authors' knowledge no study has used meta-analyses to compare soft tissue response to IIP and CIP.

IIP Versus CIP Effect on MFR

In the current meta-analyses, findings indicate that MFR is greater in IIP than in CIP in native bone. The literature evaluating IIP indicates that MFR is a potential risk factor. However, mean MFR in the current analyses showed less loss than that reported in a recent systematic review (–0.54 ± 0.39 mm).[39] The current results show that IIP had slightly more MFR (–0.064 ± 0.16 mm) than CIP. Gain in midfacial height was found in two (0.061 mm, 95% CI: –0.31 to 0.43; 0.866 mm, 95% CI: 0.199 to 1.532)[25,30] of the six studies,[22,24-26,28,30] both of which had 12 months of follow-up. Lower reported MFR could be due to the midfacial tissue gain shown in the two studies.[25,30] A systematic review of IIP with simultaneous connective tissue graft (CTG) placement by Lee et al.[40] showed gain in midfacial gingival level (0.07 mm, 95% CI: –0.44 to 0.59; $P = 0.12$); however, follow-up time was shorter (up to 2 years).[40] The current study expands on previous systematic reviews by including investigations with longer follow-up time (up to 5 years). All six studies[22,24-26,28,30] represented implants placed in the maxillary esthetic zone. These results should be interpreted with caution because heterogeneity among the six studies[22,24-26,28,30] was moderate ($I^2 = 64.62\%$).

IIP Versus CIP Effect on PH

Meta-analyses of three studies[25,26,30] were completed for cumulative PH. Implants placed into native bone showed better PH maintenance compared with IIP. Results for PH were similar to MFR with a difference of –0.396 mm in favor of CIPs ($P = 0.01$). Subanalyses looking at IIP showed better PH in MPH than in DPH. This may be due to the wider interproximal contact point on the mesial aspect of single-tooth implant restoration with smaller interdental space.[41]

IIP in Thick Versus Thin Biotype

Gingival recession (MFR) is a common concern for IIP, with periodontal biotype being an important factor affecting MFR incidence and severity around immediate implants.[5] The literature cites conflicting results for MFR around IIP, with some reporting similar recession for thick and thin biotypes[5] whereas others show significant recession for thin biotype.[27] Although a recent systematic review found non-significant difference in recession regardless of biotype after IIP, results were based on pooled estimates only.[14] This review expands on previous studies[13,14] by analyzing data in a meta-analysis format. Three studies[5,27,29] qualified for inclusion in the meta-analyses comparing thin and thick biotype with MD of –0.373 mm (95% CI: –1.000 to 0.253; $P = 0.243$) in favor of thick biotype. Pooled estimates from seven studies[21,27,30-33,37] also showed less recession with thick biotype (–0.478 mm, 95% CI: –0.641 to –0.315; $P < 0.001$). A recent systematic review by Lee et al.[40] showed improvement in midfacial gingival levels using CTG with simultaneous implant placement during 6 to 25.8 months (gain of 0.07 mm, 95% CI: –0.44 to 0.59; $P = 0.12$). In the present review, only one study[29] showed increase in gingival height using CTG in thin and thick biotype IIPs. Lack of difference with CTG addition may have resulted from a small sample size. Data showed better soft tissue response for thick biotype around IIPs. Despite favorable soft tissue response to IIP in thick biotypes, results should be interpreted cautiously because of high study heterogeneity and potential bias from use of both single- and double-armed studies in the pooled estimates.

IIP in Thick Versus Thin Biotype Effect on PH

Seven studies[21,27,30-33,37] compared PH based on a pooled-estimates analysis. Data showed more PH loss with thin biotype IIP ($P < 0.001$). Further subanalysis compared MPH and DPH separately showing similar results ($P < 0.001$). A previous study[42] reported

on the advantage of using flapless IIP to improve PH maintenance. However, the current study showed similar PH for flap and flapless IIP.

Effect of IIP With Immediate Provisionalization Versus IIP With Conventional Restoration on MFR

The peri-implant emergence profile can be developed using provisional or conventional restorations to maximize soft tissues reducing MFR incidence. This meta-analyses used three studies[20,21,23] to evaluate levels of MFR with immediate provisionalization compared with conventional restoration at 12 and 24 months. There was a MD of 0.253 mm with IIP and immediate provisionalization, showing less recession than IIP with conventional restoration after a second-stage surgery (P = 0.38). A separate analysis was performed to elucidate the effect of immediate provisionalization on PH maintenance. The two studies included[20,21] showed a MD of –0.519 mm where IIP with immediate provisionalization showed better cumulative PH preservation compared with conventional restoration (P = 0.03). Immediate provisionalization of IIP may show better PH preservation due to a decrease in tissue trauma from second-stage surgical procedures with conventional restorations. These findings are in agreement with the results of De Rouck et al.,[21] which proposed that IIP with immediate provisionalization may provide better soft tissue support and thus lead to a decrease in amount of MFR and PH loss.

Although the findings of this study are important, they must be viewed with caution because the number of qualified studies was limited by disparate methodologies of design that led to high heterogeneity in the analyses. Hence, this study is limited by the quality of data that currently exists. It is recommended that future studies adopt a similar format for methodology and data collection.

CONCLUSIONS

Results of the present meta-analyses and pooled estimates show the following: 1) MFR and PH loss were slightly less in CIP than in IIP, but results were not statistically significant; 2) MFR was less in IIP with thick versus thin biotype, but statistically significant for the pooled estimates only; 3) slight, although non-statistically significant, gain in midfacial gingival margin and better PH maintenance in IIP with immediate provisionalization compared with conventional restoration, but the result was not statistically significant; and 4) a limited number of studies and high heterogeneity restricts the interpretability of findings and precludes recommendations at this time. Future studies should be more standardized to allow more consistent data collection and robust analysis.

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