Comparative evaluation of crestal bone level by flapless and flap techniques for implant placement: Systematic review and meta-analysis

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Abstract

Aim: To compare the crestal bone level of flapless technique of dental implant placement with the flap technique.

Setting and Design: This Systematic review and Meta-analysis was conducted according to the Preferred Reporting Items For Systematic Review and Meta-Analyses (PRISMA) Guidelines and registered with PROSPERO.

Materials and Methods: Electronic search of Medline and Google scholar databases for articles from 2010 till March 2020 was performed. Studies comparing the crestal bone level with both the techniques were included. After the collection of data, the risk of bias was assessed for each study.

Statistical Analysis Used: Meta-analysis was executed using RevMan 5 software version 5.3.

Results: 23 studies were included. Statistically significant difference in crestal bone level was found between flapless and flap surgery with mean difference of −0.14 (flapless placement versus flap surgery; 95% CI: −0.24 to −0.03; $P = 0.01^*$). The difference in crestal bone level between the 2 groups was not statistically significant with a mean difference of –0.05(Guided flapless placement versus flap surgery; 95% CI: −0.10 to 0.00; P=0.06). Meta-analysis of the freehand flapless surgery with flap surgery generated a mean difference of −0.20 which was found to be statistically significant (Freehand flapless placement versus flap surgery; 95% CI: −0.37 to −0.03; $P=0.02^*$).

Conclusions: Flapless placement of implant can positively influence crestal bone loss in comparison with conventional flap technique.

Keywords: Crestal bone level, dental implant, flapless, guided flapless

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Submitted: 10-May-2021 **Revised:** 08-Sep-2021 **Accepted:** 01-Oct-2021 **Published:** 09-Nov-2021

INTRODUCTION

Dental implants facilitate mastication, phonation, and esthetics and are one of the most common treatment modalities used for the rehabilitation of missing teeth. To provide support for the dental prosthesis, implants form a direct connection with the surrounding bone known as "osseointegration."[1] Enhancing patient comfort and predictability of treatment with precise presurgical

Access this article online	
Quick Response Code:	Website: www.j-ips.org
	DOI: 10.4103/jips.jips_208_21

How to cite this article: Lahoti K, Dandekar S, Gade J, Agrawal M. Comparative evaluation of crestal bone level by flapless and flap techniques for implant placement: Systematic review and meta-analysis. J Indian Prosthodont Soc 2021;21:328-38.

treatment planning have been the goals of evolving implant dentistry.[2]

Branemark has advocated flap elevation technique for implant placement since the 1970s. The protocol by Branemark placed the incision line and sutures away from the implant location, reducing the risk of infection at the surgical site location.[3,4] The current advancements and incorporation of new technologies have led to an approach wherein the implants can be placed with minimal incision either freehand or with the assistance of surgical guide. Sustained efforts to incorporate this minimally invasive flapless technique have been made in the field of implantology. Although the scientific evidence to prove the accuracy is still not considered adequate, many researchers advocate this approach based on their assessment of the literature.[5-7] Chrcanovic *et al*. in 2014[5] in their systematic review stated that flapless approach significantly influenced the implant survival rate compared to conventional surgery. Lin *et al*.[6] and Lemos *et al*.[7] could not establish a significant difference in the survival rate or crestal bone loss between the two techniques. Although freehand implant placement is not considered as accurate as guided flapless surgery as reported by Nickenig *et al*. in 2010,[8] a review by Voulgarakis *et al*. in 2014[9] suggested that the surgical guides did not significantly influence the outcome.

No real conclusion has been reached to date which would clearly state the benefit of one approach over the other. This systematic review was thereby designed to compile the literature and compare the flapless and flap techniques in terms of crestal bone level.

MATERIALS AND METHODS

This systematic review was designed and performed in accordance with PRISMA guidelines laid down in 2015.[10] A specifically formulated protocol was registered with PROSPERO (CRD42020162689) before the start of the review.

Study question

"How is the crestal bone level by flapless technique compared to flap technique for dental implant placement?" which fulfills the PICOS framework [Table 1].

Search strategy

Electronic search of MEDLINE and Google Scholar from 2010 to March 2020 was performed. Subject AND Adjective combinations were used:

Subject: Dental implant OR dental implant placement AND Adjective: flapless technique OR flapless placement OR open flap OR flap elevation OR flapless surgery OR Keywords – combinations of the following keywords: "crestal bone level;" "dental implant;" "surgery;" "flap;" and "flapless;" "Flapless versus Flap surgery;" and "crestal bone loss." Furthermore, a manual search was conducted based on the references of selected studies.

Table 1: PICOS framework

Domain	Description
P	Patients requiring dental implant surgery
I	Flapless technique
C	Flap technique
O	Crestal bone level around implant
S	Prospective clinical trials

Inclusion criteria

a. Studies on patients requiring rehabilitation with dental implant
b. Studies which had data regarding the crestal bone level of both the intervention and comparison groups
c. Prospective clinical studies
d. Full-text access of article
e. Primary language of article: English.

Exclusion criteria

Duplicate studies, *In vitro* studies, case reports, opinions, letters, and reviews.

Data collection

After the studies were scanned for information, relevant data were tabulated which comprised authors of the study, study year, technique of placement, crestal bone changes, and other outcome measures. Any disagreements were resolved by discussion. The data were compiled to perform meta-analysis.

Risk of bias for individual studies

Bias assessment for randomized studies was done based on the fulfillment of criteria of sequence generation, blinding, allocation concealment, and addressed outcome measures. For nonrandomized studies, the Newcastle–Ottawa scale was used.

Statistical analysis

Crestal bone level was the primary outcome measure, which was treated as a continuous data variable. Aggregate analysis using a fixed-effects model and a random-effects model was carried out. Heterogeneity was tested. Forest plot was generated showing standardized mean difference as the effect measure. Funnel plot was drawn to check for publication bias. The analysis was performed by using Review Manager (RevMan) [Computer program]. Version 5.3. Copenhagen: The Nordic Cochrane Centre, The Cochrane Collaboration, 2014.

RESULTS

Study selection

Four thousand four hundred and forty-three records were obtained by the selection process [Figure 1]. After removing duplicate records, 2343 were held back. Fifty-seven records were reached after 2286 were scanned according to eligibility criteria. Thirty-four articles were removed after full-text reading for reasons mentioned in Table 2. In the end, only 23 articles were retained for meta-analysis.

Description of included studies

This review consisted of 23 studies listed in Table 3. Total data from 948 patients rehabilitated with 1407 implants were included. Of the 23 studies, 3 studies had a follow-up time of up to 3 months.[43,56,58] Six had a long follow-up of 3 years or more.[42,46-48,51] In 8 studies, flapless surgery was done with the help of computed tomography (CT)-guided or surgical stent,[56,46-48,54,59,61] while the remaining 15 were performed by the freehand approach. Some studies used a submerged protocol,[41,44,53,56] whereas others used a nonsubmerged protocol,[40,43,45,49,51,52,57,58,60] and two studies involved both the protocols.[46,55] Loading time of the implants was also mentioned in the studies. In five studies, implants were loaded immediately or early for both the groups.[43,50,59-61] Fourteen studies applied a delayed loading protocol,[40-42,44,45,47-49,51-55,57] whereas two studies[46,54] involved both protocols of loading, and in two studies, the implants were not loaded.[56,58]

Among the 23 studies, 694 implants were placed by flapless technique and 713 implants were placed by flap technique. Implant survival ranged from 87.2% to 100% for flapless implant placement and 93.3% to 100% for flap technique. 100% survival was found in 10 studies.[42,45,47,49,53,55-59] Significant results indicating less crestal bone loss with flapless technique were reported by studies.[42,44,49,51,57,58]

Risk of bias assessment of the studies

The Newcastle–Ottawa scale, as shown in Table 4a, showed that all the studies had low bias considering the number of stars. For randomized studies, if studies did not fulfill two or more of the four criteria, the risk of bias was considered high. Among the ten randomized studies, five were low risk,[41,45,57,60,61] two were judged to be at moderate risk,[46,47] and the remaining three were at high risk of bias [Table 4b].[41,44,48]

Meta-analysis of the studies

Twenty-three studies were included with 1407 implants placed in 948 patients. On account of the heterogeneity ($Tau^2 = 0.04$, Chi-square = 126.96, df = 21, $P < 0.00001$; $I^2 = 83\%$), a random-effects model was used. Meta-analysis revealed statistically significant difference in crestal bone level with MD of −0.14 (flapless placement vs. flap surgery; 95% confidence interval [CI]: −0.24–−0.03; $P = 0.01$*), indicating the positive effect of flapless technique on the outcome measure in comparison with flap technique, as shown in Figure 2.

Table 2: List of excluded studies

Reason for exclusion	References
No control group	Nikzad and Azari[11]
	Jeong *et al*.[12]
	Lee *et al*.[13]
	Tee[14]
	Kareem *et al*.[15]
	Oliver *et al*.[16]
	Komiyama *et al*.[17]
	Altinci *et al*.[18]
	Jesch *et al*.[19]
Review articles	Lin *et al*.[6]
	Chrcanovic *et al*.[5]
	Vohra *et al*.[20]
	Romero-Ruiz *et al*.[21]
	Llamas-Monteagudo *et al*.[22]
	Zhuang *et al*.[23]
	Yadav *et al*.[24]
	Cai *et al*.[25]
Data inadequate for crestal bone loss	Arisan *et al*.[26]
	Berdougo *et al*.[27]
	Bashutski *et al*.[28]
	Voulgarakis *et al*.[9]
	Meizi *et al*.[29]
	Yadav *et al*. (2018)[30]
	Gupta *et al*.[31]
Retrospective studies	Nickenig *et al*.[8]
	Rousseau *et al*.[32]
	De Bruyn *et al*.[33]
	Nguyen *et al*.[34]
	Yue *et al*.[35]
Immediate implant placement	Stoupel *et al*.[36]
	Mazzocco *et al*. (2017)[37]
Other outcome comparison studies	Danza and Carinci[38]
	Lindeboom and van Wijk[2]
	Kaur *et al*.[39]

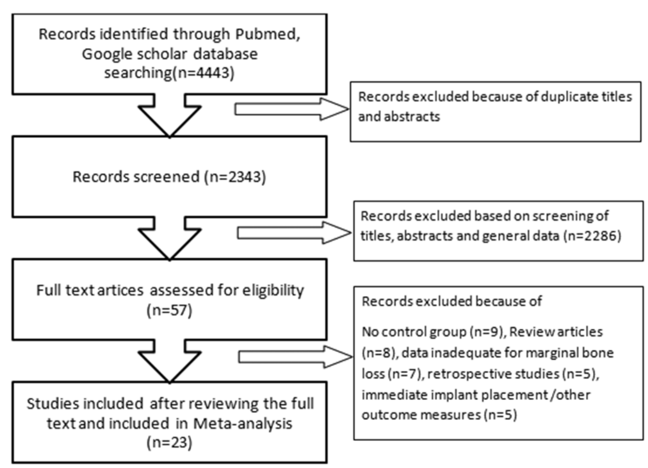

Figure 1: PRISMA flow diagram for study selection process

Table 3: Description of studies

Name	Published time	Study	Patients	Follow-up time	Age range (years)	Failed implants	Survival rate	Loading time
Anumala *et al.*[40]	2019	P	30 patients 30 implants	6 months	25-50	NM	NM	Conventional
Kumar *et al.*[41]	2018	RCT	20 patients 20 implants	1 year	25-60	1/10 (T) 0/10 (C)	NM	Conventional
Naeini *et al.*[42]	2018	P	49 patients 53 implants	6-9 years	28-85	0/26 (T) 0/27 (C)	100% (T) 100% (C)	Conventional
Singla *et al.*[43]	2018	RP	20 patients 20 implants	3 months	30-50	NM	NM	Immediate
Shamsan *et al.*[44]	2018	RCT	12 patients 16 implants	6 months	20-60	0/10 (T) 1/10 (C)	NM	Conventional
Wang *et al.*[45]	2017	RCT	40 patients 40 implants	2 years	19-45 (39±13.2)	0/20 (T) 0/20 (C)	100% (T) 100% (C)	Conventional
Bömicke *et al.*[46]	2017	RCT	38 patients 38 implants	3 years	53 (21-70)	6/19 (T) 5/19 (C)	95% (T) 100% (C)	Immediate (T) Conventional (C)
Froum and Khouly[47]	2017	RCT	60 patients 60 implants	8.6 years	NM	0/30 (T) 0/30 (C)	100% (T) 100% (C)	Conventional
Pisoni *et al.*[48]	2016	RCT	40 patients 69 implants	3 years	61.69±14.23	5/39 (T) 2/30 (C)	87.2% (T) 93.3% (C)	Conventional
Maier[49]	2016	P	80 patients 195 implants	1 year	18-78	0/95 (T) 0/100 (C)	100% (T) 100% (C)	Conventional
Maló *et al.*[50]	2016	P	40 patients 72 implants	3 years	19-79	1/32 (T) 0/40 (C)	96.8% (T) 100%(C)	Immediate nonfunctional
Prati *et al.*[51]	2016	P	60 patients 132 implants	3 years	25-72	2/64 (T) 1/65 (C)	96.9% (T) 98.5% (C)	Conventional
Samad *et al.*[52]	2016	P	60 patients 60 implants	6 months	19-75	1/30 (T) 1/30 (C)	96.6% (T) 96.6% (C)	Conventional
Kanwar *et al.*[53]	2016	P	10 patients 20 implants	6 months	20-60	0/10 (T) 0/10 (C)	100% (T) 100% (C)	Conventional
Pozzi *et al.*[54]	2014	RCT	51 patients 51 implants	1 year	28-84	0/25 (T) 1/26 (C)	100% (T) 96.2% (C)	Immediate and Conventional
Sunitha and Sapthagiri[55]	2013	P	40 patients 40 implants	2 years	25-62	0/20 (T) 0/20 (C)	100% (T) 100% (C)	Conventional
Katsoulis *et al.*[56]	2012	P	40 patients 195 implants	3 months	20-79 (61±9)	0/85 (T) 0/110 (C)	100% (T) 100% (C)	Not loaded
Tsoukaki *et al.*[57]	2013	RCT	20 patients 30 implants	12 weeks	47.47±9.72 (T) 46.40±9.52 (C)	0/15 (T) 0/15 (C)	100% (T) 100% (C)	Conventional
Al-Juboori *et al.*[58]	2013	P	9 patients 22 implants	12 weeks	27-62 (50)	0/11 (T) 0/11 (C)	100% (T) 100% (C)	Implants not loaded
Froum *et al.*[59]	2011	P	52 patients 52 implants	12 months	NM	0/27 (T) 0/25 (C)	100% (T) 100% (C)	Early Loading
Cannizzaro *et al.*[60]	2011	RCT	40 patients 143 implants	1 year	22-65	2/76 (T) 2/67 (C)	97.3% (T) 97% (C)	Immediate
Marcelis *et al.*[54]	2012	P	20 patients 20 implants	1 year	48.7±16.4	0/16 (T) 1/18 (C)	100% (T) 94.4% (C)	Conventional
Van de Velde *et al.*[61]	2010	RCT	13 patients 70 implants	18 months	39-75 (55.7)	1/36 (T) 0/34 (C)	97.2% (T) 100% (C)	Immediate

Name	Crestal bone loss	CT guided template	Implant surface modification (brand)	Healing strategy	Observations
Anumala *et al.*[40]	0.083±0.782 (T) -0.493±1.8125 (C)	No	Single-stage, single-piece threaded titanium implants (ADIN Dental Implant Systems Ltd, Alon Tavor, Afula, Israel)	Nonsubmerged	Lesser loss of bone was found with flapless surgery as also better soft-tissue changes were seen
Kumar *et al.*[41]	0.6495±0.17 (T) 0.9575±0.29 (C)	No	MIS SEVEN implants (MIS implants Technologies Limited)	Submerged	Statistically significant less PD, bone loss, and pain were seen with flapless technique
Naeini *et al.*[42]	−0.89±0.96 (T) 0.49±1.12 (C)	No	Branemark TiUnite external hex	NM	Flapless implants showed comparable results to conventional flap procedure
Singla *et al.*[43]	2.355±0.61 (T) 2.13±0.955 (C)	No	Single-piece Adin implants	Nonsubmerged	Crestal bone loss and pain were less with flapless implant placement
Shamsan *et al.*[44]	0.45±0.22 (T) 0.82±0.09 (C)	No	Dentium Superline Implant System (Seoul, Korea)	Submerged	Flapless surgery reduces crestal bone loss, soft-tissue inflammation, pain, edema, bleeding, and soft-tissue recession

Contd...

Table 3: Contd...

Name	Crestal bone loss	CT guided template	Implant surface modification (brand)	Healing strategy	Observations
Wang *et al*.[45]	0.5±0.2 (T) 0.4±0.3 (C)	No	ITI dental implant (Institut Straumann AG, Waldenburg, Switzerland)	Nonsubmerged	Flapless approach improved patient comfort and decreased soft-tissue reaction. Comparable MBL and success rates were observed
Bömicke *et al*.[46]	1.34±1.19 (T) 0.67±0.57 (C)	Yes	One-piece (NobleDirect Groovy, Nobel Biocare) and two-piece (NobleDirect Groovy, Nobel Biocare)	Nonsubmerged (T) Submerged (C)	Comparable results between the groups with regard to participants with implant failure, prosthesis failure, any complication, or changes of PPD, PI, or GI were found
Froum and Khouly[47]	0.36±0.63 (T) 0.23±0.95 (C)	Yes	Anodically oxidized surface one-piece (NobleDirect, Noble Biocare)	NM	Long-term survival rates, stable bone, and soft-tissue levels were observed with both techniques
Pisoni *et al*.[48]	0.198±0.763 (T) 0.174±0.94 (C)	Yes	Two-piece (SLA Standard, Straumann)	NM	Type of approach does not influence peri-implant bone
Maier[49]	−0.09±0.49 (T) 0.55±0.57 (C)	No	Two-piece self-locking conical connection abutment system	Nonsubmerged	Flapless surgery caused less crestal bone loss
Maló *et al*.[50]	1.6±1.22 (T) 1.44±0.49 (C)	No	(NobelSpeedy Groovy) with oxidized surfaces (TiUnite; Nobel Biocare AB)	NM	More MBL reported with freehand flapless technique
Prati *et al*.[51]	1.22±0.87 (T) 1.23±0.88 (C)	No	Cylindrical titanium implant with rough surface obtained with calcium phosphate grit blasting and acid-free roughening process (PrimaConnex, Keystone Dental)	Nonsubmerged	Both techniques demonstrated comparable results for MBL
Samad *et al*.[52]	0.196±0.204 (T) 0.164±0.13 (C)	No	NM	Nonsubmerged	The flapless surgery has advantages over the conventional technique and helps to increase the patient acceptance
Kanwar *et al*.[53]	1.09±0.37 (T) 1.21±0.205 (C)	No	NM	Submerged	Flapless technique exhibits comparable results to implants placed with flap procedure
Pozzi *et al*.[54]	0.71±0.25 (T) 0.80±0.29 (C)	Yes	NobelSpeedy Groovy (Nobel Biocare) threaded titanium parallel-walled implants with external connection and an oxidized surface (TiUnite)	Submerged for implants inserted with torque less than 35 Ncm	Computer-guided and freehand surgeries showed comparable result More postoperative pain and swelling were found at sites with flap surgery
Sunitha and Sapthagiri[55]	0.09±0.02 (T) 0.47±0.4 (C)	No	Root form implant with internal hex abutment connection system	Nonsubmerged (T) Submerged (C)	Flapless surgery caused less crestal bone loss and also led to better papillary fill
Katsoulis *et al*.[56]	1.32±0.25 (T) 1.37±0.2 (C)	Yes	Oxidized (Noble Replace Select Tapered, Nobel Biocare, Goteborg, Sweden)	Submerged	Both approaches showed favorable results
Tsoukaki *et al*.[57]	0.00±0.00 (T) 0.29±0.06 (C)	No	Sandblasted+fluoride (OsseoSpeed, Astra Tech, Sweden)	Nonsubmerged	Decreased peri-implant sulcus depth values, milder inflammation, and no bone resorption was seen with flapless surgery
Al-Juboori *et al*.[58]	0.9±0.3 (T) 1.15±0.85 (C)	No	Sandblasted and acid etched (SLA, Straumann, Basel, Switzerland)	Nonsubmerged	The bone level in the flap approach was more positively correlated with the implant level at implant placement than in the flapless
Froum *et al*.[59]	0.25±1.02 (T) 0.73±1.03 (C)	Yes	Oxidized (Noble Replace Select Tapered, Nobel Biocare, Goteborg, Sweden)	NM	High survival rates, stable marginal bone, and probing depth were found with both techniques
Cannizzaro *et al*.[60]	0.38±0.42 (T) 0.43±0.4 (C)	No	Sandblasted and acid-NP etched (SwissPlus, Zimmer Dental, Carlsbad, USA)	Nonsubmerged	Both the approaches were comparable with no significant difference
Marcelis *et al*.[54]	0.06±0.12 (T) 0.1±0.1 (C)	Yes	Sandblasted+fluoride (OsseoSpeed, Astra Tech, Sweden)	NM	Flapless implants lose slightly more bone than implants placed with flap elevation
Van de Velde *et al*.[61]	1.95±0.7 (T) 1.93±0.42 (C)	Yes	Sandblasted and acid-etched (SLA, Straumann, Basel, Switzerland)	Nonsubmerged	Implants could successfully integrate using a flapless approach compared to conventional technique

P: Prospective study, RCT: Randomized controlled trial, RP: Radiographic prospective, T: Test group (Flapless surgery), C: Control group (flap surgery), MBL: Marginal bone loss, NM: Not mentioned, CT: Computed tomography, PPD: Probing pocket depth, PI: Plaque index, GI: Gingival Index

Table 4a: Quality assessment of nonrandomized controlled trials by the Newcastle-Ottawa scale

Study	Selection				Comparability		Outcome			Total (9/9)
	Representativeness of the exposed Cohort	Selection of the nonexposed Cohort	Ascertainment of exposure	Demonstration that the outcome of interest was not present at the start of study	Comparability of Cohorts on the basis of the design or analysis: Main factor	Comparability of Cohorts on the basis of the design or analysis: Additional factor	Assessment of outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow-up of Cohorts	
Anumala *et al*.[40]	*	*	*	*	*	0	*	0	*	7/9
Naeini *et al*.[42]	*	*	*	*	*	0	*	*	*	8/9
Singla *et al*.[43]	*	*	*	*	*	0	*	0	*	7/9
Maier[49]	*	*	*	*	*	0	*	*	*	8/9
Maló *et al*.[50]	*	*	*	*	*	0	*	*	*	8/9
Prati *et al*.[51]	*	*	*	*	*	0	*	*	*	8/9
Samad *et al*.[52]	*	*	*	*	*	0	*	0	*	7/9
Kanwar *et al*.[53]	*	*	*	*	*	0	*	0	*	7/9
Sunitha and Sapthagiri[55]	*	*	*	*	*	0	*	*	*	8/9
Katsoulis *et al*.[56]	*	*	*	*	*	0	*	0	*	7/9
Al-Juboori *et al*.[58]	*	*	*	*	*	0	*	0	*	7/9
Froum *et al*.[59]	*	*	*	*	*	0	*	*	*	8/9
Marcelis *et al*.[54]	*	*	*	*	*	0	*	*	*	8/9

At least 1-year follow-up was considered adequate for the outcome. *-Present, 0-Absent

For subgroup analysis, meta-analysis of eight studies was performed. Low heterogeneity (Chi-square = 7.77, df = 7, P = 0.35; I^2 = 10%) led to the fixed-effects model. The results indicated that the difference in crestal bone level between these guided flapless and flap technique groups was not statistically significant with a mean difference of −0.05 (guided flapless placement vs. flap surgery; 95% CI: −0.10–0.00; P = 0.06) [Figure 3]. Subgroup analysis of the freehand flapless surgery with flap surgery generated a random-effects model due to the high heterogeneity (Tau^2 = 0.07, Chi-square = 110.60, df = 13, $P < 0.00001$; I^2 = 88%) with MD of −0.20, which was found to be statistically significant (freehand flapless placement vs. flap surgery; 95% CI: −0.37–−0.03; P = 0.02*) [Figure 4].

Publication bias

Funnel plot indicated the absence of publication bias, as shown in Figures 5-7.

DISCUSSION

Implant placement with flap reflection is a traditional well-accepted approach, while flapless placement has been an experimental evolving technique which still requires a backup of substantial evidence. It is much of a controversy with versatile opinions, and no specific conclusion has still been reached. Thus, this review was aimed to compare the available literature to reach a more specific conclusion with evidentiary support from meta-analysis.

Narrowing the inclusion criteria to only randomized trials could have enhanced the homogeneity, but it was noticed that it could exclude several studies with significant data.

The latest meta-analysis concerning the outcome was published in 2020 by Cai *et al*.[25] They included only six studies with high heterogeneity (I^2 = 78%) in the meta-analysis and failed to state a statistical difference in long-term crestal bone loss. Results of the analysis performed by Cai *et al*.[25] should be interpreted with caution because of the limited number of studies included. Furthermore, they included only the long-term studies which excluded all the literature published after 2017.

In this meta-analysis, 23 studies were included. The result showed that the flapless placement significantly reduced the crestal bone loss with the mean difference of −0.14. This reduced bone loss could be explained by intact periosteum and blood supply which is a known advantage of flapless technique.[62] In flap technique, the branches of supraperiosteal vessels get compromised, affecting

Table 4b: Quality assessment of randomized controlled trials

Name	Published time	Sequence generation	Allocation concealment	Incomplete outcome data addressed	Blinding	Estimated potential risk of bias
Kumar *et al*.[41]	2018	Yes	Unclear	Yes	Unclear	High
Shamsan *et al*.[24]	2018	No	Inadequate	No	No	High
Wang *et al*.[44]	2017	Yes	Adequate	Yes	Yes	Low
Pisoni *et al*.[48]	2017	Yes	Unclear	Yes	No	High
Froum and Khouly[47]	2017	Yes	Unclear	Unclear	Yes	Moderate
Bömicke *et al*.[46]	2017	Yes	Adequate	Yes	No	Moderate
Pozzi *et al*.[54]	2014	Yes	Adequate	Yes	Yes	Low
Tsoukaki *et al*.[57]	2012	Yes	Adequate	Yes	Yes	Low
Cannizzaro *et al*.[60]	2011	Yes	Adequate	Yes	Yes	Low
Van de Velde *et al*.[61]	2010	Yes	Adequate	Yes	Yes	Low

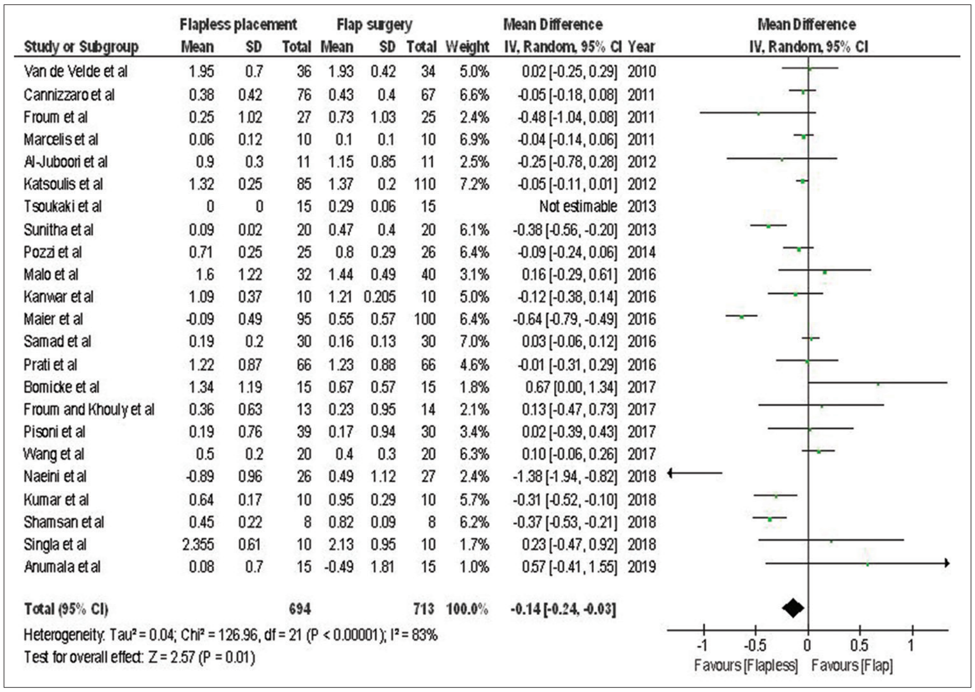

Figure 2: Forest plot of meta-analysis results comparing crestal bone level of flapless and flap surgery groups

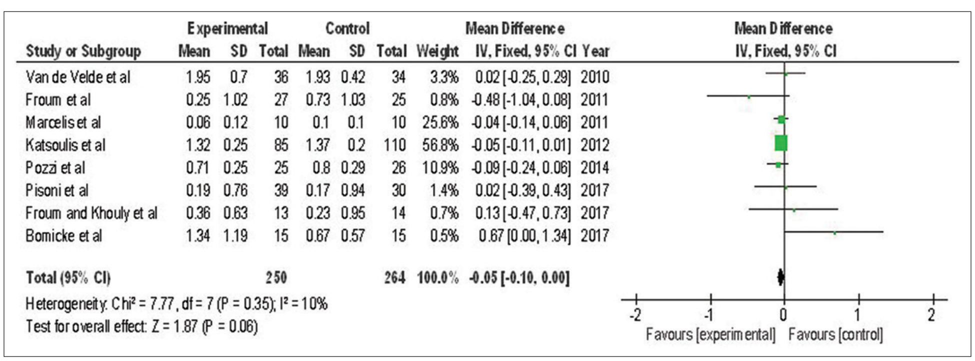

Figure 3: Forest plot of meta-analysis results comparing crestal bone level of guided flapless and flap surgeries

the blood supply.[63] Kim *et al*. in 2009[64] in their study on dogs stated that flapless implant placement presented a much richer vascularization. Al Juboori *et al*.[58] and Kim *et al*.[64] attributed lesser bone with flapless technique to the excellent defense to bacterial invasion because of the intact bloody supply. Jeong *et al*. in 2007[65] showed that sites with flapless technique had a greater bone–implant contact and less bone loss. Similar findings of reduced bone loss with flapless technique were noted by You *et al*.,[66] Mazzocco *et al*.,[37] Kumar *et al*.,[41] Shamsan *et al*.,[44] Maier,[49] and Sunitha and Sapthagiri.[55] The flapless technique ensures a favorable healing environment for the soft-tissue

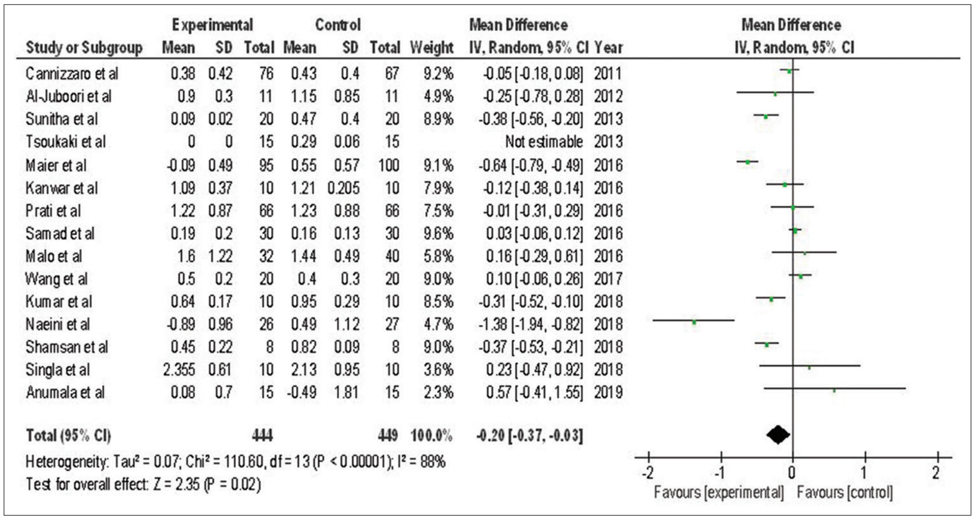

Figure 4: Forest plot of meta-analysis results comparing crestal bone level of freehand flapless and flap surgery groups

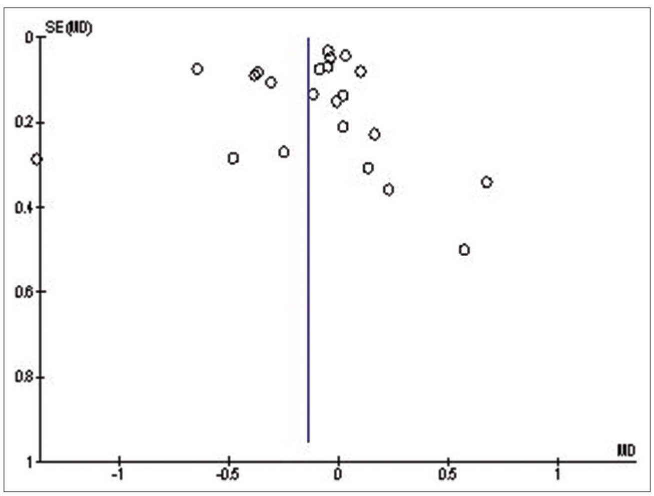

Figure 5: Funnel plot for studies reporting outcome of crestal bone levels of freehand flapless and flap surgeries

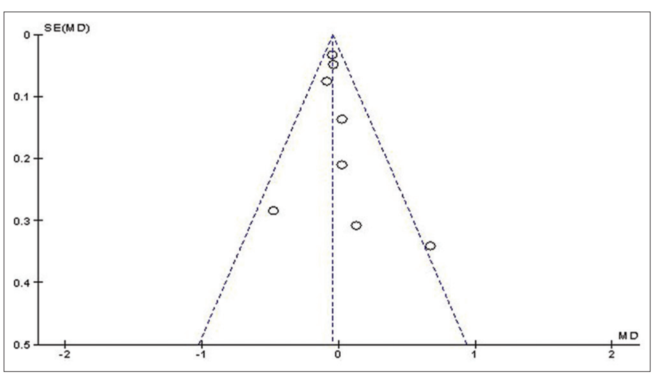

Figure 6: Funnel plot for studies reporting outcome of crestal bone levels of guided flapless and flap surgeries

architecture as well as hard-tissue volume with reduced time for stable remodeling.[67]

Studies[50,61] with the view that flapless surgery leads to more crestal bone loss than conventional flap failed to prove a significant difference. One of the reasons for more bone loss associated with flapless technique could be because of the contamination of the surgical site with the epithelial and connective tissue cells from the oral mucosa.[68]

Interestingly, several studies[45,48,51,53,56,59] and reviews[5,20] showed comparable outcome with both the surgical techniques. The flapless surgery can thus be considered as an acceptable treatment option based on the evidence obtained from the literature. The use of CT scans, advanced planning software, surgical guides, and dynamic navigation systems can help to improve the predictability and precision.

Subgroup analysis comparing the guided flapless approach with the conventional surgery did not yield a significant result. This could be attributed to the limited data available and the variability of the guided approach used. Furthermore, there remain concerns with the deviations in the inclination and positioning of implants by flapless surgery from the ideally planned position, which could affect the outcome.[5]

Comparison of the freehand flapless placement with conventional surgery showed a significant difference, indicating that flapless surgery can affect the crestal bone loss even without the use of a guided approach.

Based on the results of this study, the choice of surgical technique significantly affects crestal bone level which is in agreement with a previous systematic review by Zhuang *et al.* in 2018.[23] However, the studies included have high heterogeneity, and the authors in cases of doubt have opted for direct visualization of the surgical field. Presurgical

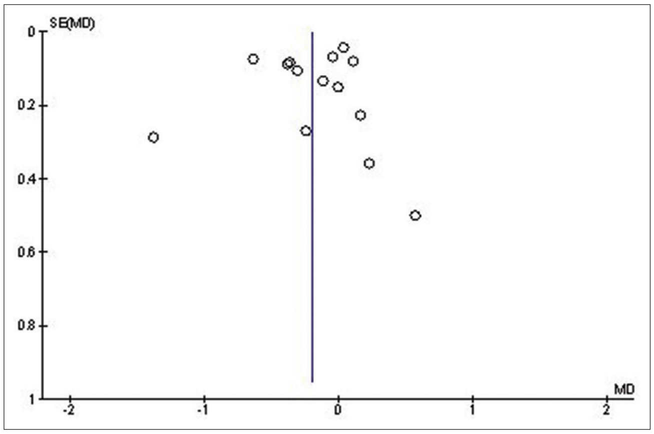

Figure 7: Funnel plot for studies reporting outcome of crestal bone levels of freehand flapless and flap surgeries

planning is a must to reduce the possible complications. The fear of such complications should not stop the clinicians to acknowledge the benefits that the flapless technique can provide. With the upcoming digital trends in implantology, flapless surgeries have the capacity to evolve with a greater safety margin.

The results of this review should be interpreted with caution because of its limitations. Confounding factors may have affected the outcomes. Further, less emphasis was given on local or systemic condition of patients. Furthermore, heterogeneity of the included studies was high. Double-blinded randomized controlled trials with broader pool of patients to determine the effect of flapless implant surgery on patient outcome variables are required to reach definitive conclusions.

CONCLUSIONS

1. Flapless technique of dental implant placement has significantly less crestal bone loss compared to the flap technique. Therefore, flapless implant surgery can be considered as a promising alternative to conventional flap
2. The use of a guided or freehand approach of flapless surgery both showed less crestal bone loss compared to flap surgery; however, significant results could not be obtained.

Acknowledgment

The authors acknowledge Swargiya Dadasaheb Kalmegh Smruti Dental College and Hospital, Nagpur, and all the concerned authorities for the opportunity to work on this project.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Brånemark PI, Adell R, Breine U, Hansson BO, Lindström J, Ohlsson A. Intra-osseous anchorage of dental prostheses. I. Experimental studies. Scand J Plast Reconstr Surg 1969;3:81-100.
2. Lindeboom JA, van Wijk AJ. A comparison of two implant techniques on patient-based outcome measures: A report of flapless vs. conventional flapped implant placement. Clin Oral Implants Res 2010;21:366-70.
3. Albrektsson T, Zarb G, Worthington P, Eriksson AR. The long-term efficacy of currently used dental implants: A review and proposed criteria of success. Int J Oral Maxillofac Implants 1986;1:11-25.
4. Brånemark PI, Hansson BO, Adell R, Breine U, Lindström J, Hallén O, *et al.* Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. Scand J Plast Reconstr Surg Suppl 1977;16:1-132.
5. Chrcanovic BR, Albrektsson T, Wennerberg A. Flapless versus conventional flapped dental implant surgery: A meta-analysis. PLoS One 2014;9:e100624.
6. Lin GH, Chan HL, Bashutski JD, Oh TJ, Wang HL. The effect of flapless surgery on implant survival and marginal bone level: A systematic review and meta-analysis. J Periodontol 2014;85:e91-103.
7. Lemos CA, Verri FR, Cruz RS, Gomes JM, Dos Santos DM, Goiato MC, *et al.* Comparison between flapless and open-flap implant placement: A systematic review and meta-analysis. Int J Oral Maxillofac Surg 2020;49:1220-31.
8. Nickenig HJ, Wichmann M, Schlegel KA, Nkenke E, Eitner S. Radiographic evaluation of marginal bone levels during healing period, adjacent to parallel-screw cylinder implants inserted in the posterior zone of the jaws, placed with flapless surgery. Clin Oral Implants Res 2010;21:1386-93.
9. Voulgarakis A, Strub JR, Att W. Outcomes of implants placed with three different flapless surgical procedures: A systematic review. Int J Oral Maxillofac Surg 2014;43:476-86.
10. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. J Clin Epidemiol 2009;62:1006-12.
11. Nikzad S, Azari A. Custom-made radiographic template, computed tomography, and computer-assisted flapless surgery for treatment planning in partial edentulous patients: A prospective 12-month study. J Oral Maxillofac Surg 2010;68:1353-9.
12. Jeong SM, Choi BH, Kim J, Xuan F, Lee DH, Mo DY, *et al.* A 1-year prospective clinical study of soft tissue conditions and marginal bone changes around dental implants after flapless implant surgery. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2011;111:41-6.
13. Lee DH, Choi BH, Jeong SM, Xuan F, Kim HR. Effects of flapless implant surgery on soft tissue profiles: A prospective clinical study. Clin Implant Dent Relat Res 2011;13:324-9.
14. Tee YL. Minimally invasive surgical placements of nonsubmerged dental implants: A case series report, evaluation of the surgical technique and complications. J Oral Implantol 2011;37:579-87.
15. Kareem JJ, Al Garrawi HA, Badeia R. A clinical assessment of peri-implant marginal bone loss and soft tissue status in dental implant placed by flapless implant surgery. Mustansiria Dent J 2012;9:70-82.
16. Oliver R. Flapless dental implant surgery may improve hard and soft tissue outcomes. J Evid Based Dent Pract 2012;12:87-8.
17. Komiyama A, Hultin M, Näsström K, Benchimol D, Klinge B. Soft tissue conditions and marginal bone changes around immediately loaded implants inserted in edentate jaws following computer guided treatment planning and flapless surgery: A ≥1-year clinical follow-up study. Clin Implant Dent Relat Res 2012;14:157-69.
18. Altinci P, Can G, Gunes O, Ozturk C, Eren H. Stability and marginal

bone level changes of SLActive titanium-zirconium implants placed with flapless surgery: A prospective pilot study. Clin Implant Dent Relat Res 2016;18:1193-9.
19. Jesch P, Jesch W, Bruckmoser E, Krebs M, Kladek T, Seemann R. An up to 17-year follow-up retrospective analysis of a minimally invasive, flapless approach: 18 945 implants in 7783 patients. Clin Implant Dent Relat Res 2018;20:393-402.
20. Vohra F, Al-Kheraif AA, Almas K, Javed F. Comparison of crestal bone loss around dental implants placed in healed sites using flapped and flapless techniques: A systematic review. J Periodontol 2015;86:185-91.
21. Romero-Ruiz MM, Mosquera-Perez R, Gutierrez-Perez JL, Torres-Lagares D. Flapless implant surgery: A review of the literature and 3 case reports. J Clin Exp Dent 2015;7:e146-52.
22. Llamas-Monteagudo O, Girbés-Ballester P, Viña-Almunia J, Peñarrocha-Oltra D, Peñarrocha-Diago M. Clinical parameters of implants placed in healed sites using flapped and flapless techniques: A systematic review. Med Oral Patol Oral Cir Bucal 2017;22:e572-81.
23. Zhuang J, Zhao D, Wu Y, Xu C. Evaluation of outcomes of dental implants inserted by flapless or flapped procedure: A meta-analysis. Implant Dent 2018;27:588-98.
24. Yadav MK, Verma UP, Parikh H, Dixit M. Minimally invasive transgingival implant therapy: A literature review. Natl J Maxillofac Surg 2018;9:117-22.
25. Cai H, Liang X, Sun DY, Chen JY. Long-term clinical performance of flapless implant surgery compared to the conventional approach with flap elevation: A systematic review and meta-analysis. World J Clin Cases 2020;8:1087-103.
26. Arisan V, Karabuda CZ, Ozdemir T. Implant surgery using bone- and mucosa-supported stereolithographic guides in totally edentulous jaws: Surgical and post-operative outcomes of computer-aided vs. standard techniques. Clin Oral Implants Res 2010;21:980-8.
27. Berdougo M, Fortin T, Blanchet E, Isidori M, Bosson JL, Chrcanovic BR, *et al.* Flapless implant surgery using an image-guided system. A 1- to 4-year retrospective multicenter comparative clinical study. PLoS One 2010;9:980-8.
28. Bashutski JD, Wang HL, Rudek I, Moreno I, Koticha T, Oh TJ. Effect of flapless surgery on single-tooth implants in the esthetic zone: A randomized clinical trial. J Periodontol 2013;84:1747-54.
29. Meizi E, Meir M, Laster Z. New-design dental implants: A 1-year prospective clinical study of 344 consecutively placed implants comparing immediate loading versus delayed loading and flapless versus full-thickness flap. Int J Oral Maxillofac Implants 2014;29:e14-21.
30. Yadav R, Agrawal KK, Rao J, Anwar M, Alvi HA, Singh K, *et al.* Crestal bone loss under delayed loading of full thickness versus flapless surgically placed dental implants in controlled type 2 diabetic patients: A parallel group randomized clinical trial. J Prosthodont 2018;27:611-7.
31. Gupta R, Luthra RP, Kukreja S. To compare and evaluate the difference in crestal bone loss after implant placement by conventional flap and flapless technique followed by early loading of implants : An *in vivo* study. Int J Appl Dent Sci 2018;4:213-8.
32. Rousseau P, Stoupel J, Lee CT, Glick J, Sanz-Miralles E, Chiuzan C, *et al.* The clinical and radiographic outcome of implants placed in the posterior maxilla with a guided flapless approach and immediately restored with a provisional rehabilitation: A randomized clinical trial. Clin Oral Implants Res 2010;21:1171-9.
33. De Bruyn H, Atashkadeh M, Cosyn J, van de Velde T. Clinical outcome and bone preservation of single TiUnite™ implants installed with flapless or flap surgery. Clin Implant Dent Relat Res 2011;13:175-83.
34. Nguyen M, Doan N, Du Z, Reher P, Xiao Y. A measure of clinical outcomes in dental implant surgery flapless surgery versus flap technique in posterior maxilla of post menopause women. IFMBE Proc 2015;46:133-4.
35. Yue Q, Hu XL, Lin Y. Study on clinical effectiveness between flap and flapless immediate implant placement in maxillary esthetic zone. Chin J Pr Stomatol 2015;8:410-4.
36. Stoupel J, Lee CT, Glick J, Sanz-Miralles E, Chiuzan C, Papapanou PN. Immediate implant placement and provisionalization in the aesthetic zone using a flapless or a flap-involving approach: A randomized controlled trial. J Clin Periodontol 2016;43:1171-9.
37. Mazzocco F, Jimenez D, Barallat L, Paniz G, Del Fabbro M, Nart J. Bone volume changes after immediate implant placement with or without flap elevation. Clin Oral Implants Res 2017;28:495-501.
38. Danza M, Carinci F. Flapless surgery and immediately loaded implants: A retrospective comparison between implantation with and without computer-assisted planned surgical stent. Stomatologija 2010;12:35-41.
39. Kaur T, Kumar S, Jain S, Aggarwal R, Choudhary S, Reddy NK. A radiographic evaluation of peri-implant bone level in immediate and conventionally loaded implants using flap and flapless techniques. J Contemp Dent Pract 2019;20:707-15.
40. Anumala D, Haritha M, Sailaja S, Prasuna E, Sravanthi G, Ravindra N. Effect of flap and flapless implant surgical techniques on soft and hard tissue profile in single-stage dental implants. J Orofac Sci 2019;9:22-7.
41. Kumar D, Sivaram G, Shivakumar B, Kumar T. Comparative evaluation of soft and hard tissue changes following endosseous implant placement using flap and flapless techniques in the posterior edentulous areas of the mandible – A randomized controlled trial. Oral Maxillofac Surg 2018;22:215-23.
42. Naeini EN, Dierens M, Atashkadeh M, De Bruyn H. Long-term clinical outcome of single implants inserted flaplessly or conventionally. Clin Implant Dent Relat Res 2018;20:829-37.
43. Singla N, Kumar S, Jain S, Choudhary S, Dandiwal N, Nandalur KR. Crestal bone changes around immediately loaded single-piece implants using flap and flapless technique: A radiographic study. J Contemp Dent Pract 2018;19:949-54.
44. Shamsan YA, Eldibany RM, El Halawani GN, Rania A. Flapless versus conventional flap approach for dental implant placement in the maxillary esthetic zone. Alexandria Dent J 2018;43:80-5.
45. Wang F, Huang W, Zhang Z, Wang H, Monje A, Wu Y. Minimally invasive flapless vs. flapped approach for single implant placement: A 2-year randomized controlled clinical trial. Clin Oral Implants Res 2017;28:757-64.
46. Bömicke W, Gabbert O, Koob A, Krisam J, Peter R. Comparison of immediately loaded flaplessplaced one-piece implants and flapped-placed conventionally loaded two-piece implants, both fitted with all-ceramic single crowns, in the posterior mandible: 3-year results from a randomised controlled pilot trial. Int J Oral Implant 2017;10:179-95.
47. Froum SJ, Khouly I. Survival rates and bone and soft tissue level changes around one-piece dental implants placed with a flapless or flap protocol: 8.5-year results. Int J Periodontics Restorative Dent 2017;37:327-37.
48. Pisoni L, Ordesi P, Siervo P, Bianchi AE, Persia M, Siervo S. Flapless versus traditional dental implant surgery: Long-term evaluation of crestal bone resorption. J Oral Maxillofac Surg 2016;74:1354-9.
49. Maier FM. Initial crestal bone loss after implant placement with flapped or flapless surgery – A prospective cohort study. Int J Oral Maxillofac Implants 2016;31:876-83.
50. Maló P, de Araújo Nobre M, Lopes A. Three-year outcome of fixed partial rehabilitations supported by implants inserted with flap or flapless surgical techniques. J Prosthodont 2016;25:357-63.
51. Prati C, Zamparini F, Scialabba VS, Gatto MR, Piattelli A, Montebugnoli L, *et al.* A 3-year prospective cohort study on 132 calcium phosphate-blasted implants: Flap vs. flapless technique. Int J Oral Maxillofac Implants 2016;31:413-23.
52. Samad A, Haider A, Shihab O. Comparison between flapless and flap dental implant surgery: A clinical and radiographic study. Zanco J Med Sci 2016;20:1267-71.
53. Kanwar K, Madan R, Kanwar S, Singh GP. Comparative evaluation of peri-implant vertical crestal bone changes following implant placement with 'flapless 'and 'with-flap' techniques – *In vivo* study. Asian J Oral Health Allied Sci 2016;6:3-8.
54. Marcelis K, Vercruyssen M, Naert I, Teugh- els W, Quirynen M. Model-

based guided implant insertion for solitary tooth replace-ment: a pilot study. Clin Oral Implants Res 2012;23:999-1003.
55. Sunitha RV, Sapthagiri E. Flapless implant surgery: A 2-year follow-up study of 40 implants. Oral Surg Oral Med Oral Pathol Oral Radiol 2013;116:e237-43.
56. Katsoulis J, Avrampou M, Spycher C, Stipic M, Enkling N, Mericske-Stern R. Comparison of implant stability by means of resonance frequency analysis for flapless and conventionally inserted implants. Clin Implant Dent Relat Res 2012;14:915-23.
57. Tsoukaki M, Kalpidis CD, Sakellari D, Tsalikis L, Mikrogiorgis G, Konstantinidis A. Clinical, radiographic, microbiological, and immunological outcomes of flapped vs. flapless dental implants: A prospective randomized controlled clinical trial. Clin Oral Implants Res 2013;24:969-76.
58. Al-Juboori MJ, Ab Rahman S, Hassan A, Bin Ismail IH, Tawfiq OF. What is the effect of initial implant position on the crestal bone level in flap and flapless technique during healing period? J Periodontal Implant Sci 2013;43:153-9.
59. Froum SJ, Cho SC, Elian N, Romanos G, Jalbout Z, Natour M, *et al*. Survival rate of one-piece dental implants placed with a flapless or flap protocol – A randomized, controlled study: 12-month results. Int J Periodontics Restorative Dent 2011;31:591-601.
60. Cannizzaro G, Felice P, Leone M, Checchi V, Esposito M. Flapless versus open flap implant surgery in partially edentulous patients subjected to immediate loading: 1-year results from a split-mouth randomised controlled trial. Eur J Oral Implantol 2011;4:177-88.
61. Van de Velde T, Sennerby L, De Bruyn H. The clinical and radiographic outcome of implants placed in the posterior maxilla with a guided flapless approach and immediately restored with a provisional rehabilitation: A randomized clinical trial. Clin Oral Implants Res 2010;21:1223-33.
62. Campelo LD, Camara JR. Flapless implant surgery: A 10-year clinical retrospective analysis. Int J Oral Maxillofac Implants 2002;17:271-6.
63. Belser UC, Schmid B, Higginbottom F, Buser D. Outcome analysis of implant restorations located in the anterior maxilla: A review of the recent literature. Int J Oral Maxillofac Implants 2004;19 Suppl:30-42.
64. Kim JI, Choi BH, Li J, Xuan F, Jeong SM. Blood vessels of the peri-implant mucosa: A comparison between flap and flapless procedures. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;107:508-12.
65. Jeong SM, Choi BH, Li J, Kim HS, Ko CY, Jung JH, *et al*. Flapless implant surgery: An experimental study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;104:24-8.
66. You TM, Choi BH, Li J, Xuan F, Jeong SM, Jang SO. Morphogenesis of the peri-implant mucosa: A comparison between flap and flapless procedures in the canine mandible. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;107:66-70.
67. Sclar AG. Guidelines for flapless surgery. J Oral Maxillofac Surg 2007;65:20-32.
68. Berdougo M, Fortin T, Blanchet E, Isidori M, Bosson JL. Flapless implant surgery using an image-guided system. A 1- to 4-year retrospective multicenter comparative clinical study. Clin Implant Dent Relat Res 2010;12:142-52.