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Influence of crown-to-implant ratio and different prosthetic designs on the clinical conditions of short implants in posterior regions: A 4-year retrospective clinical and radiographic study

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Abstract

Background: Short implants (intra-bony length ≤ 8 mm) are generally considered as an alternative to bone augmentation in challenging situations; however, clinical evidence from large-scale studies with long follow-up regarding the application of short implants remains deficient.

Purpose: The present study aimed to assess the mid-term clinical outcomes of short implants supporting fixed prostheses in the posterior region, and to investigate the effects of the crown-to-implant ratio (C/I), and other patient-, implant-, prosthesis-relevant factors on the clinical conditions around short implants.

Materials and methods: 180 Thommen short implants in 130 partially edentulous patients were enrolled in the study after 3 to 7 (mean 4.2) years of follow-up. Potential risk factors (patient sex and age, implant diameter and location, splinted vs single-tooth restorations, retention mode, anatomical and clinical C/I ratios) were evaluated according to the following outcomes: Implant survival, marginal bone loss (MBL), and mechanical and biological complications.

Results: In total, four implants in four patients failed as a result of peri-implantitis. The cumulative survival rate was 97.8% for implant-based analysis. The peri-implant MBL around 180 short implants was 0.90 ± 0.78 mm. The mean clinical C/I ratio was 1.16 ± 0.36. Correlation analysis revealed that the influence of the clinical C/I ratio and patient age were significant for MBL ($P < .05$), whereas other potential risk factors showed no significant association with the outcome. Among 180 short implants, 24 cases (13.3%) had biological complications and 32 cases (17.8%) had mechanical complications, respectively. Peri-implant MBL and complication rates around splinted and non-splinted implants were not statistically different.

Conclusion: Within the limitations of this study, short implants supporting fixed prostheses in the posterior region achieved predictable clinical outcomes over a 3 to 7 year period. Within the range of 0.47 to 3.01, the higher the C/I ratio, the less the peri-implant MBL.

KEYWORDS
crown-to-implant ratio, marginal bone loss, short implant, splint

1 | INTRODUCTION

During past decades, implant-supported restoration has become a successful therapy for the rehabilitation of aesthetic and masticatory functions in various clinical scenarios. However, severely absorbed residual alveolar ridges with poor bone quality and quantity pose challenges to implant treatment. Several surgical procedures have been developed to vertically augment the bone, including onlay bone graft, guided bone regeneration (GBR), and maxillary sinus floor lifting.[1,2] Although widely used, these techniques lead to prolonged treatment periods, and higher extra expenses, still remaining as technically sensitive procedures associated with a high incidence of complications.[3]

To overcome these drawbacks in patients with low alveolar ridges, the application of short implants offers a viable therapeutic option to both clinicians and patients, which reduces the treatment time, cost, and morbidity, and greatly promotes patient satisfaction.[4] At the first European Association for Osseointegration (EAO) consensus conference, implants with an intrabony length of 8 mm or less were considered as short implants.[5] Recent clinical studies have proven high survival rates of short implants that were comparable to the survival rates of standard implants.[6,7] Our previous study demonstrated that the 2-year performance of 6.5-mm short implants placed using osteotome sinus floor elevation procedures, exhibited similar clinical outcomes to long implants placed using lateral sinus floor elevation in severely atrophic posterior maxillae.[8] However, there is limited evidence for short implants from studies with larger sample sizes and longer follow-up.

The crown-to-implant (C/I) ratio is often increased in short implants compared with conventional length implants. From a biomechanical point of view, unfavorable loading conditions, including non-axial force and overload, could be amplified in implant-supported prostheses showing high C/I ratios. This might transfer stress to the peri-implant crestal bone and consequently lead to either marginal bone loss (MBL) or biological and mechanical complications. Nevertheless, there are some controversies regarding the effects of the C/I ratio on MBL and long-term stability of short implants. Hingsammer et al.[9] reported that short implants with C/I ratios of 1.6 or greater tended to increase the risk of marginal bone resorption. Conversely, several publications found no significant correlation between the C/I ratio and MBL.[10-12] Moreover, previous studies rarely investigated the C/I ratio of short implants together with other potential risk factors of MBL, such as implant diameter, implant location, and patient-related factors.

Selection of the appropriate prosthetic treatment modality for short implants is another critical factor to maintain the long-term stability of implants. Splints, cantilever extensions, and different styles of prosthesis retention are all alternatives in clinical implant restoration. A series of studies demonstrated that the use of splints in short implants could reduce the stress around the bone-to-implant interface, resulting in fewer prosthesis-related complications, such as screw loosening and veneer fracture.[13,14] However, the use of single-tooth replacement has proven that marginal bone levels can be optimally maintained, regardless of higher forces in posterior areas.[15] To date, few longitudinal comparative studies have provided clinical evidence to clarify the pros and cons of splinted and non-splinted prostheses around short implants.

Therefore, the purposes of the present study were: (a) to evaluate the cumulative survival rate of Thommen short implants placed in the posterior region, (b) to investigate the influence of the C/I ratio and other parameters on MBL around short implants, and (c) to evaluate the influence of different prosthetic treatment modalities (splinted vs single implant restorations) on MBL and the complication rate of short implants.

2 | MATERIALS AND METHODS

2.1 | Study design and ethical approval

The study was designed as a retrospective cohort study, and conducted according to the fundamental principles of the Helsinki Declaration. The study was approved by the Ethics Committee of Peking University Hospital of Stomatology (PKUSSIRB-201631115).

2.2 | Inclusion and exclusion criteria

The records of all patients who had received implant surgery between February 2012 and May 2016 at the fourth Dental Department, Peking University School and Hospital of Stomatology were checked and filtered.

The inclusion criteria were as follows: (a) Volunteered for the study; (b) age ≥ 18 years; (c) received one or more short implants (6.5 or 8 mm) (Thommen Medical AG, Grenchen, Switzerland) placement in the premolar-molar region; (d) a follow-up of at least 3 years after loading; and (e) systemic and local conditions appropriate for implant placement.

Patients were excluded under these conditions: (a) Uncontrolled systemic illness; (b) untreated periodontal diseases or other oral diseases; (c) a history of bisphosphonate therapy; (d) a history of radiotherapy; (e) complete edentulism; (f) psychiatric problems or unrealistic expectations; and (g) heavy smokers (>10 cigarettes per day).

2.3 | Treatment procedures

The implant surgery was performed according to the manufacturer's specification by the same experienced oral surgeon. The implant platform was placed at or slightly below the level of the alveolar crest. Oral panoramic radiograph was taken immediately after surgery. The second surgery was conducted 3 to 4 months after the implant insertion, and healing abutment was placed. After 2 to 4 weeks of healing, an impression at implant level was taken. Thereafter, implant-supported fixed prosthesis was manufactured and delivered. Patients were called back to join the clinical examination and oral hygiene instruction every 6 to 12 months.

2.4 | Outcome measures

At the latest follow-up, data including general conditions, smoking history, and self-reported complications were recorded using a questionnaire survey. The clinical and radiographic indices were investigated as follows.

2.4.1 | Implant survival

Implant survival was assessed based on the criteria proposed by Buser et al.,[16] comprising the absence of mobility, the absence of subjective complaints such as pain or paresthesia, the absence of peri-implant infection, and the absence of continuous radiolucency around the implant.

2.4.2 | Radiographic examination and evaluation

Standardized panoramic radiographs were obtained using an X-ray device (Planmeca ProMax Dimax3 Ceph, Planmeca, Helsinki, Finland) under the same conditions: An X-ray voltage of 60 to 62 kV, a current of 8 to 12 mA, and an exposure time of 16 seconds, as described in our previous studies.[8,17] As shown in Figure 1, the peri-implant marginal bone level was evaluated as the distance from the implant platform to the coronal point of bone-implant contact on panoramic radiographs using the Image J 1.52a software (National Institutes of Health, Bethesda, MD). The measurement was calibrated with the known distance of the thread pitch to avoid radiographic distortion. The peri-implant MBL was calculated by comparing the marginal bone level at the follow-up visit with that at implant insertion.

As shown in Figure 2, two types of C/I ratios were calculated: The anatomical C/I ratio and the clinical C/I ratio.[18] The clinical C/I ratio referred to the distance from the highest cuspid of the crown to the most coronal bone-implant contact divided by the distance from the implant tip to the most coronal bone-implant contact. As to the anatomical C/I ratio, the fulcrum was positioned at the crown-abutment interface.

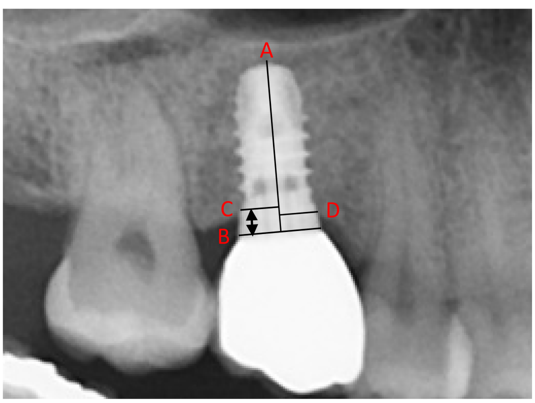

FIGURE 1 Peri-implant marginal bone level measured on radiographs. A, Implant axis; B, implant platform line; C, a line perpendicular to (A), and right cross the coronal point of the distal bone-implant contact; D, a line perpendicular to (A), and right cross the coronal point of the mesial bone-implant contact. The marginal bone level is the perpendicular distance between (B) and (C), or (B) and (D), respectively. All measurements were adjusted using the known length of the thread pitch to avoid radiographic distortion

2.4.3 | Peri-implant soft tissue parameters

To investigate the parameters of the peri-implant soft tissues, the modified sulcus bleeding index (mSBI)[19] and probing depth (PD) were evaluated at six sites around each implant.

2.4.4 | Mechanical and biological complications

Mechanical complications included implant fracture; abutment fracture; slippery thread; screw loosening or fracture; porcelain fracture; framework fracture; and loss of retention. Biological complications referred to functional problems caused by biological factors, including loss of proximal contact, fistula formation, mucosal recession, peri-implant mucositis, and peri-implantitis. Peri-implantitis was diagnosed by soft tissue inflammation, increased probing depth (≥5 mm), and radiographic bone resorption >3 mm.[20]

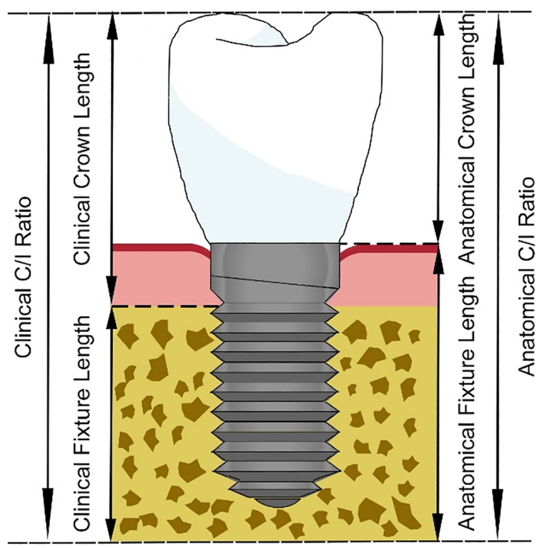

FIGURE 2 Diagram defining the measurements of clinical crown/implant ratio (C/I) (left) and anatomical C/I ratio (right), adapted from Blanes et al. The anatomical crown length was measured from the highest cuspid of the crowns to the crown-abutment interface, along a perpendicular line. The clinical crown length was measured from the highest cuspid of the crowns to the coronal point of the bone-implant contact

2.5 | Statistical analysis

Statistical calculations were conducted using SPSS Statistics 20.0 software (IBM Corp., Armonk, NY). Quantitative data were presented as the mean ± SD. Categorical data were described as frequencies and percentages. The Shapiro-Wilk test served to test the normal distribution of the variables. Implant survival rates were calculated using Kaplan-Meier survival analysis. Differences between two groups were analyzed by Student's *t* test, while differences between multiple groups were analyzed by one-way analysis of variance (ANOVA) and a least significant difference (LSD). The differences between rates were tested using Fisher's exact test. Pearson's correlation analysis was used for normal distributed values with a linear coherence. For non-normally distributed, non-linear values, the nonparametric Spearman correlation analysis was performed to calculate the correlation coefficient (*r*) and the *P* value. A multiple linear regression model was used to evaluate the independent predictors of MBL among clinical C/I and the above-mentioned clinically relevant parameters. The socio-demographic characteristics and other possible factors that might influence the outcomes between drop-out group and the retained group were compared using Mann-Whitney *U* test for non-normally distributed quantitative variables, and chi-square test for categorical variables. The *P* values were considered statistically significant if less than .05.

3 | RESULTS

A total of 175 patients who received 245 short implants in the premolar-molar region met the inclusion criteria. Among them, 45 patients with 65 implants were lost to follow-up during subsequent years because of migration (14/45), travel (13/45), death (1/45), serious illness (7/45), or refusal to participate in the observation (10/45). The comparison between patients lost to follow-up and the retained patients showed no significant differences for the social-demographic variables age (P = .145, Mann-Whitney U), gender (P = .287, chi-square), systemic condition (P = .748, chi-square), nor for the variables periodontal disease (P = .908, chi-square), implant diameter (P = .870, chi-square) or antagonist type (P = .624, chi-square). These patients were considered as dropout and therefore excluded in the final analysis.

Therefore, the analysis included 180 short implants from 130 patients (57 males and 73 females). Patients were between 29 and 78 (mean 50.5) years old at the time of surgery. The mean observation period was 51 ± 12 months (range: 31 to 82 months). Table 1 describes the size and location of the short implants.

3.1 | Clinical and radiographic parameters

Four short implants were exposed to peri-implantitis, manifested by mucosal inflammation and progressive loss of supporting marginal bone, resulting a cumulative survival rate of 97.8% (implant-based). Figure 3 shows the cumulative implant survival curve. Clinical examination of the 180 implants displayed an average mSBI of 0.59 ± 0.71 and an average PD value of 2.99 ± 1.08 mm (Table 2). Compared with the value at implant insertion (baseline), the average of MBL in mesial and distal sites were 1.08 ± 1.00 mm and 0.79 ± 0.90 mm,

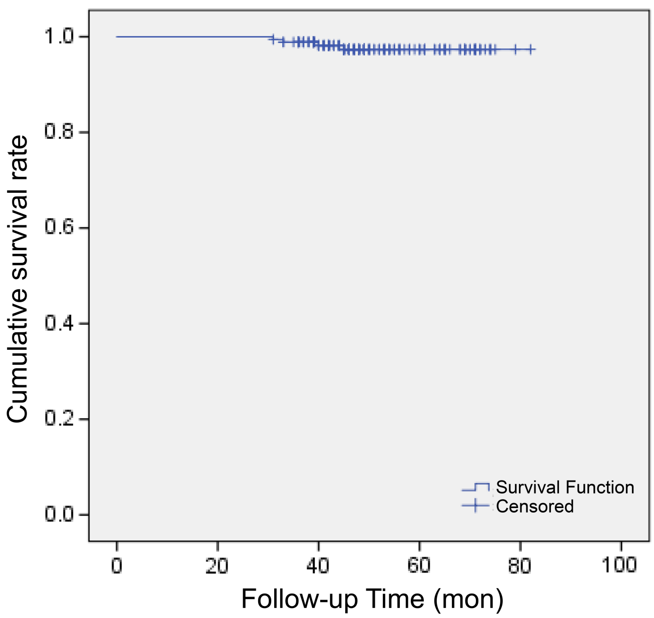

FIGURE 3 Graph of the Kaplan-Meier cumulative implant survival rate during the entire follow-up period

TABLE 1 Implant lengths, diameters, and positions for 180 implants placed in the study

Implant size (*w* × *l*) (mm)	Maxillary premolars	Maxillary molars	Mandibular premolars	Mandibular molars	Total
4.0 × 8.0	7	3	1	5	16
4.5 × 8.0	11	27	2	22	62
5.0 × 8.0	5	39	1	36	81
6.0 × 8.0	-	1	-	-	1
4.0 × 6.5	2	1	1	2	6
4.5 × 6.5	1	5	-	2	8
5.0 × 6.5	-	3	-	3	6
Total	26	79	5	70	180

respectively. The radiographic images show a relatively stable marginal bone level around short implants supporting single or splinted crowns during the 5-year follow-up period (Figure 4).

3.2 | Effect of the C/I ratio and other risk factors on peri-implant MBL

The mean clinical C/I ratio at the loading time was 1.16 ± 0.36. The majority of the implant prostheses (70%) showed a clinical C/I ratio ≥ 1. As shown in Figure 5 and Table 3, the MBL of implant-supported crowns with lower C/I ratios was significantly greater (1.14 ± 0.75 mm) than those with higher C/I ratios (0.81 ± 0.77 and 0.45 ± 0.47 mm, respectively).

The univariate analysis showed no significant discrepancies in MBL based on patient's gender, periodontal condition, implant location, implant diameter, implant length, prosthesis type, fixation type, cantilever, antagonist type, or anatomical C/I ratio (Table 4). By contrast, Spearman's correlation analysis indicated that the clinical C/I ratio was negatively related to MBL (r = −.247, P = .001) while the patient's age was positively related to MBL (r = .220, P = .003). Thereafter, these factors (P < .2 in the univariate analysis) were included into a further analysis by multiple linear regression method, which exhibited a similar outcome.

TABLE 2 Clinical and radiologic parameters at the 3 to 7 year follow-up

Parameter	Min	Max	Mean	SD
mSBI	0	3	0.59	0.71
PD (in mm)	1	7	2.99	1.08
Mesial MBL (in mm)	−1.25	4.20	1.08	1.00
Distal MBL (in mm)	−1.64	4.40	0.79	0.88

Abbreviations: MBL, marginal bone loss; mSBI, modified sulcus bleeding index; PD, probing depth.

3.3 | Biological and technical complications

Biological complications were found in 24 implants (13.3%), including 4 with peri-implantitis, and 20 with peri-implant mucositis. Mechanical complications occurred in 32 implants (17.8%), including 1 screw loosening, 14 porcelain fracture, and 17 loss of retention. No abutment or implant fractures were discovered. There was no significant difference in the complication rates between splinted and non-splinted implants (Table 5).

4 | DISCUSSION

This study was aimed to investigate the mid-term outcomes of short implants in the posterior region. The results demonstrated high survival rates of both implants and prostheses, with minimal marginal bone loss and a low rate of complications after 3 to 7 years. Among a number of previous retrospective studies, few studies have evaluated the effects of the C/I ratio and different prosthesis types on both the MBL and complication rate. Our study, with a relatively large sample size and long observation period, has provided new evidence from a novel perspective for the utility of short implants in the posterior region.

The exact definition of short implants remains controversial. The intrabony length, below which the implants are considered as short implants, has been varying from ≤10 mm,[21,22] ≤8.5 mm,[23] ≤8 mm,[24] and ≤ 6 mm.[25,26] The change in classification is also a reflection of technical evolution and predictable performance of short implants. A series of prospective and retrospective studies have adopted the

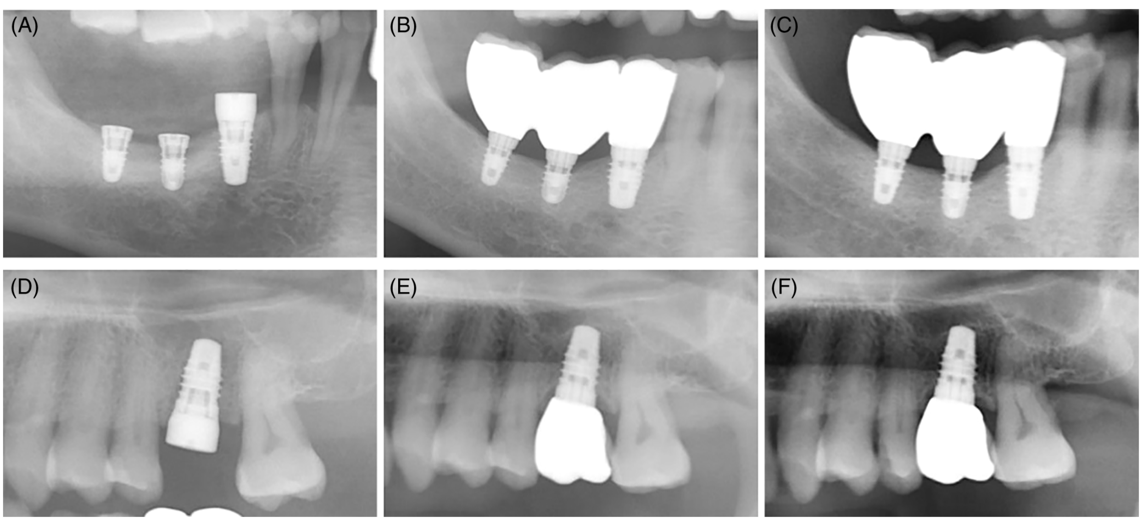

FIGURE 4 Representative radiographs of short implants supporting splinted crowns (A-C) or a single crown (d-f). A,D: Radiograph obtained immediately after implant installation; B,E: Radiograph obtained 1 year after loading; C,F: Radiograph obtained 5 years after loading. Note the stability of the crestal bone levels

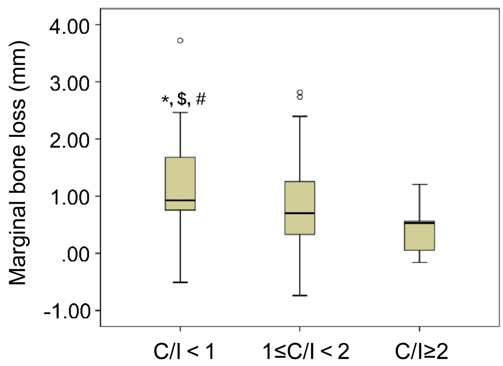

FIGURE 5 Detailed data of marginal bone loss (MBL) by clinical C/I ratio. Groups were divided according to different clinical C/I ratios, group a: C/I < 1, group b: 1 ≤ C/I < 2, group c: C/I ≥ 2. *One way ANOVA test for overall comparison *P* = .01. $Marginal bone loss in group a > group b, LSD Post-Hoc test; *P* = .007. #Marginal bone loss in group a > group c, LSD Post-Hoc test; *P* = .035

TABLE 3 Detailed data of marginal bone loss (MBL) by clinical C/I ratio

Clinical C/I ratios	Mean and SD (mm)	Median	*P*
Group a: 0-0.99	1.14 ± 0.75	0.73-1.69	<.05[a,b,c]
Group b: 1-1.99	0.81 ± 0.77	0.33-1.29	
Group c: ≥2	0.45 ± 0.47	0.01-0.72	

Note: Groups were divided according to different clinical C/I ratios.
[a]One way ANOVA test for overall comparison *P* = .01.
[b]Marginal bone loss in group a > group b. LSD Post-Hoc test; *P* = .007.
[c]Marginal bone loss in group a > group c. LSD Post-Hoc test; *P* = .035.

relatively practical classification of intrabony length ≤ 8 mm as short implants.[27,28] Therefore, implants with lengths of 8 and 6.5 mm were both considered as short implants in the present study.

Our results revealed a high cumulative survival rate of 97.8% around short implants after a follow-up of 3 to 7 years, which was consistent with previous studies.[6] The incidence of peri-implant mucositis and peri-implantitis in this study was 11.1% and 2.2%, respectively, which was slightly lower than that of implants showed in previous research.[29,30] The predictable performance of short implants might be attributed to the following factors. First, the advancement in implant surface modification guarantees superior bone-to-implant contact and secure osseointegration. It could be presumed that the macro design and surface modification technology might play more critical roles in the primary and secondary stability of implants than the implant length. Moreover, these implants all have a machined collar, which is an essential safety mechanism to help connective tissue adhesion and build biological width,[31] thus preventing bacterial infiltration into the microgap and reducing subsequent bone remodeling.[32]

The amount of peri-implant MBL was 0.90 ± 0.78 mm during follow-up for 3 to 7 years. To ensure standardization and avoid possible radiographic distortion of the panoramic radiographs, internal calibration was performed with the known distance of the thread pitch (1.00 mm). This would make the measurement fairly precise and accurate for clinical use, which has been validated by Persson et al,[33] Langlois Cde et al,[34] and Schulze et al.[35] The amount of MBL was a little higher than that of short implants reported by Lai et al[36] and Rossi et al.[37] The discrepancy might be explained due to the different baselines used in the different studies, some of which used the loading time, while the present study defined the insertion time as the baseline. Some studies showed that increased C/I ratios might be a risk factor for peri-implant crestal bone loss.[9,38] Conversely, other researchers failed to find significant relation between MBL and various factors, such as crown height space, C/I ratio, implant location, and neck design.[39] Nevertheless, these previous studies had certain limitations, such as using different measurements of the C/I ratio, different types of surface configurations, and loading procedures, resulting in marked heterogeneity of the results.

The present results demonstrated an inverse correlation between the clinical C/I ratio and the MBL ($r = -.247$, $P = .001$). This trend was consistent with the results of a 10-year prospective study by Blanes et al, who revealed that the MBL of implant-supported crowns with higher C/I ratios was significantly lower than those with lower C/I ratios.[18] On the one hand, our findings might be explained by the "stress-shielding" effect of the bone. Several studies have demonstrated that the stress concentration at the alveolar crest caused by the occlusal forces might stimulate bone formation, whereas diminished stress (such as low C/I ratios, splinted implants) might lead to disuse atrophy and eventual crestal bone resorption.[40,41] On the other, this could be attributed to the reason that aforementioned characteristics of the implant provided benefits for the preservation of the supporting bone (eg, hydrophilic surface, machined collar, and unique implant-abutment connection), which may offset the influence of unfavorable loads on the short implants.

In spite of the wide variety of prosthesis modalities, clinician's decision making for implant prostheses is still largely built on empiricism and illation of rules from traditional prosthodontics around natural teeth, rather than evidence-based data. Finite element studies have shown that splinted prostheses could reduce the stress of alveolar bone around short implants and prevent bone resorption.[13] There are also clinical studies reporting that the incidence of mechanical complications, such as screw loosening in non-splinted crowns, was higher than that of splinted crowns.[42] The results of our study indicated that there was no significant difference in the MBL and complication rate between splinted and non-splinted crowns. The discrepancy of the results mainly comes from the different selection of indications.[43] The majority of non-splinted crowns (35/55, 64%) in this study were used for 8 mm-length and 5 mm-diameter implants. Besides, the number of non-splinted crowns used in second molar regions, where the implant/prosthesis assembly bears the maximal occlusal force in the arch, was small. Under the premise of strictly controlling the indication, single crowns also achieved a similarly high survival rate and low complication rate to the splinted ones.

One of the drawbacks of our study is the limited sample size (n = 20) of 6.5-mm implants, which should be enlarged in future

TABLE 4 Univariate analysis of correlations between marginal bone loss (MBL) and patient, implant and prosthetic factors

Factors		No.	Mean and SD (mm)	*r*	*P*
Gender	Male	97	0.78 ± 0.74	.138	.064
	Female	83	1.03 ± 0.80		
Age	≤50	85	0.82 ± 0.81	.220	.003[a]
	>50	95	0.97 ± 0.74		
Periodontal disease	Yes	54	0.88 ± 0.77	.005	.947
	No	126	0.90 ± 0.78		
Location	Maxilla	105	0.84 ± 0.70	.057	.445
	Mandible	75	0.97 ± 0.87		
Implant diameter	4.0 mm	22	0.98 ± 0.97	.012	.873
	4.5 mm	70	0.88 ± 0.72		
	5.0 mm	87	0.90 ± 0.77		
	6.0 mm	1	-		
Implant length	6.5 mm	20	1.11 ± 0.73	.104	.163
	8 mm	160	0.87 ± 0.78		
Fixation type	Screwed	159	0.91 ± 0.78	−.068	.367
	Cemented	21	0.80 ± 0.75		
Clinical C/I	0-0.99	54	1.14 ± 0.75	−.247	.001[a]
	1-2	120	0.81 ± 0.77		
	≥2	6	0.45 ± 0.47		
Anatomical C/I	0-0.99	86	0.79 ± 0.68	.122	.103
	1-2	94	0.99 ± 0.85		
Prosthesis type	Single	55	0.75 ± 0.71	.096	.201
	Splinted	125	0.96 ± 0.80		
Cantilever	Yes	9	1.25 ± 0.82	.100	.180
	No	171	0.88 ± 0.77		
Antagonist type	Natural tooth	128	0.95 ± 0.76	−.080	.284
	Tooth-retained crown	18	0.79 ± 0.70		
	Implant-retained crown	34	0.77 ± 0.86		

[a]Indicating statistical significance ($P \le .05$).

TABLE 5 Complications with regard to different implant prosthetic treatment modalities

	All implants (n = 180)	Groups (%) Single restorations (n = 55)	Splinted restorations (n = 125)	*P*
Biological complications				
Peri-implant mucositis	20/180	3/55 (5.5)	17/125 (13.6)	0.109
Peri-implantitis	4/180	0/55 (0.0)	4/125 (3.2)	0.428
Mechanical complications				
Screw loosening or fracture	1/180	0/55 (0.0)	1//125 (0.8)	1.000
Veneer chipping	14/180	4/55 (7.3)	10/125 (8.0)	1.000
Loss of retention	17/180	3/55 (5.5)	14/125 (11.2)	0.225
Abutment fracture	-	-	-	-
Implant fracture	-	-	-	-

studies. In addition, during a long follow-up observation period, 45 patients were lost to follow-up because of migration, travel, or refusing to continue to participate in the observation, which may result in a potential selection bias to this retrospective study. However, we compared the socio-demographic characteristics and the distribution of other possible factors that might influence the outcomes between the lost follow-up group and the retained group, and found no significant differences. Therefore, we considered that the relatively high drop-out rate had little effect on the results. In addition, we tried to obtain the data of the lost visitors by telephone follow-up. During telephone inquiries, we learned that all the lost visitors had no symptoms of implant-supported crowns loosening or falling out, no occlusal discomfort or any other discomfort, which provided supplemental information representing, albeit non-verifiable, support for our conclusions. To summarize, further prospective randomized-controlled trials should be conducted to support the present findings.

5 | CONCLUSIONS

Within the limitations of the present study, short implants supporting fixed prostheses achieved predictable clinical outcomes over a 3 to 7 year period, which serves as a viable therapeutic option for insufficient vertical bone height in the posterior region. Within the range of 0.47 to 3.01, the higher the C/I ratio, the less the peri-implant MBL.

CONFLICT OF INTEREST

The authors declare that no conflict of interest exists in relation to this project.

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