

Influence of crown-to-implant ratio on periimplant marginal bone loss in the posterior region: a five-year retrospective study

Kyung-Jin Lee, Yong-Gun Kim, Jin-Woo Park, Jae-Mok Lee, Jo-Young Suh*

Department of Periodontology, Kyungpook National University School of Dentistry, Daegu, Korea

Purpose: The aim of this study was to evaluate the influence of the crown-to-implant (C/I) ratio on the change in marginal bone level around the implant and to determine the site-related factors influencing the relationship between the C/I ratio and periimplant marginal bone loss.

Methods: A total of 259 implants from 175 patients were evaluated at a mean follow-up of five years. Implants were divided into two groups according to their C/I ratios: ≤ 1 , and > 1 . Site-related factors having an influence on the relationship between C/I ratio and periimplant marginal bone loss were analyzed according to the implant location, implant diameter, implant manufacturer, prosthesis type, and guided bone regeneration (GBR) procedure.

Results: It was found that 1) implants with a C/I ratio below 1 exhibited greater periimplant marginal bone loss than implants with a C/I ratio more than 1, 2) site-related factors had an effect on periimplant marginal bone loss, except for the implant system used, 3) the C/I ratio was the factor having more dominant influence on periimplant marginal bone loss, compared with implant diameter, prosthesis type, implant location, and GBR procedure, 4) implants with a C/I ratio below 1 showed greater periimplant marginal bone loss than implants with a C/I ratio greater than 1 in the maxilla, but not in the mandible, 5) and periimplant marginal bone loss was more affected by the implant system than the C/I ratio.

Conclusions: Within the limitations of this study, implants with a higher C/I ratio exhibited less marginal bone loss than implants with a lower C/I ratio in the posterior regions. The C/I ratio was a more dominant factor affecting periimplant marginal bone loss in the maxilla than the mandible. Meanwhile, the implant system was a more dominant factor influencing periimplant marginal bone loss than the C/I ratio.

Keywords: Alveolar bone loss, Dental implants, Follow-up studies.

INTRODUCTION

Dental implants have been a widely accepted option for replacement of missing teeth. Clinicians may use guidelines associated with natural teeth and apply them to potential implant sites or existing implant-supported restorations. One of these guidelines is the crown-to-root (C/R) ratio, which is used as a parameter for deciding on the suitability of teeth

employed as abutments in dental prostheses. The C/R ratio is calculated from a radiograph with respect to length of the tooth not within bone divided by the portion of the tooth in alveolar bone [1]. With regard to discussion of the C/R ratio in the literature, various ratios have been reported. Dykema [2] reported that a C/R ratio of 1:1.5 was desirable. Shillingburg [3] suggested a ratio of 1:1.5 as most favorable for an abutment, and a C/R ratio of 1:1 as a minimum for a tooth abutment.

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***Correspondence:** Jo-Young Suh

Department of Periodontology, Kyungpook National University School of Dentistry, 2175 Dalgubeol-daero, Jung-gu, Daegu 700-705, Korea

E-mail: jysuh@knu.ac.kr, Tel: +82-53-600-7501, Fax: +82-53-427-3263

However, these guidelines were based on empiricism rather than scientific data. Several studies have demonstrated that teeth with an unfavorable C/R ratio can function successfully as abutment teeth [4-6]. Grossmann and Sadan [1] concluded that no definitive recommendations for an optimal C/R ratio could be established.

A similar clinical condition regarding an unfavorable C/R ratio is often encountered in edentulous areas restored with an implant-supported prosthesis. In particular, the posterior region of the mouth offers a challenging clinical scenario for rehabilitation with dental implants. Resorption of the alveolar ridge, the presence of the inferior alveolar nerve, pneumatization of the sinus, and occlusal forces create a clinical environment that may jeopardize the long-term biomechanical success of the implant restoration. Therefore, crown height of the implant often becomes relatively longer, compared with the length of implant embedded in bone. The longer the crown height is, the greater the effect of the moment of force or lever arm with any lateral force on the implant becomes. These moment loads would induce a stress concentration at the crest of the alveolar ridge at the implant-to-tissue interface, and lead to periimplant marginal bone loss [7].

An early longitudinal study demonstrated that crown-to-implant (C/I) ratio was a more sensitive indicator of potential implant failure than the residual bone height [8]. Accordingly, a C/I ratio between 0.5 and 1 was proposed for prevention of periimplant bone stress, marginal bone loss, and eventual implant failure [9-11]. This recommendation was also based on prosthodontic and periodontal principles extrapolated from tooth-supported reconstructions [3]. Conversely, Schulte et al. [12] reported that the C/I ratio of 889 plateau-design single tooth implants was 1.3 on average, with an average survival rate of 98.2% over 2.3 years. Schulte et al. [12] concluded that the C/I ratio of functioning implants was similar to that of failed implants.

The basis of successful long-term results of implants depends primarily on preservation of bone support. Therefore, maintenance of osseointegration and a steady state of the marginal bone level are imperative features. The radiographic image is the most important source of information for determining the amount of marginal bone loss around implants [13]. However, radiographic information on the change in marginal bone level around implants with different C/I ratios is limited. In addition, more information is needed in order to investigate factors having an influence on the relationship between the C/I ratio and periimplant marginal bone loss.

The current study had two objectives: 1) to determine the effect of the C/I ratio on change in periimplant marginal bone level, and 2) to determine the site-related factors that influence the relationship between the C/I ratio and periimplant

marginal bone loss.

MATERIALS AND METHODS

This retrospective study included patients referred to the Department of Periodontology, Kyungpook National University Dental Hospital for treatment of implant therapy between January 2000 and January 2008 who fulfilled the following criteria: 1) partially edentulous patients requiring implant restoration in the posterior maxilla or mandible; 2) at least three years between completion of implant prosthesis and follow-up; 3) no systemic diseases that would contraindicate oral surgical treatment; and 4) nonsmoking. In addition, all patients were given a periodic recall check. The study protocol was reviewed and accepted by the Research Ethics Committee, Kyungpook National University Hospital (Ethics Reference No. KNUH 2012-08-021).

Three different implant systems were used: The system I implant was anodized commercially pure titanium. The system II implant had a resorbable blasting media (RBM) treated surface in a solution containing Ca₃PO₄. The system III implant had a hybrid surface, so that the coronal part of the implant has a smooth surface, whereas from the third thread to the apex, the surface of the implant was acid-etched with HCl/H₂SO₄. All of the implants had external hexagon connections. Placement of all implants was performed using a standard two-stage surgical protocol. A healing period of 3 to 6 months was allowed before prosthetic loading. In all cases, gold-machined UCLA-type abutments with a noble alloy for casting were screwed onto the top of implants using a torque wrench calibrated at 30 Ncm.

During the follow-up examination, the following site-related factors were collected for each implant: implant diameter, implant location, implant system, prosthesis type, and guided bone regeneration (GBR) procedure.

Radiographic evaluation

For evaluation of the C/I ratio and change in marginal bone level, periapical radiographs were taken using a long-cone paralleling technique [14]. The images were digitized for measurement using specialized software (ImageTool, Ver. 1.28, University of Texas Health Science Center at San Antonio, San Antonio, TX, USA). A computer-assisted calibration was performed for each radiograph by evaluation of the previous known values (e.g., fixture length). Unclear radiographs or implant sites were excluded. The following linear measurements between landmarks were taken [15]: 1) crown height (CH) was measured from the top of the restoration to the first bone-to-implant contact (FBIC) on both mesial and distal sides; 2) implant length (IL) was measured from the apex to

Table 1. Mean periimplant marginal bone loss according to crown-to-implant (C/I) ratio and site-related factors (n = 259).

Implant factor	No. (%)	MBL (mm), mean ± SD
C/I ratio		
< 1	116 (44.8)	1.18 ± 0.18 ^{a)}
≥ 1	143 (55.2)	0.73 ± 0.13
Implant diameter		
Regular	124 (47.9)	0.99 ± 0.15
Wide	135 (52.1)	0.88 ± 0.22
Implant location		
Maxilla	126 (48.6)	0.96 ± 0.11
Mandible	133 (51.4)	0.91 ± 0.14
Prosthesis type		
Splinted	186 (47.1)	0.97 ± 0.13
Single	73 (52.9)	0.90 ± 0.21
GBR procedure		
With	78 (30.1)	0.87 ± 0.21
Without	181 (69.9)	0.96 ± 0.13
Implanted system		
System I	125 (48.3)	0.81 ± 0.15 ^{b)}
System II	76 (29.3)	0.65 ± 0.12 ^{b)}
System III	58 (22.4)	1.57 ± 0.25

MBL: mean periimplant marginal bone loss, SD: standard deviation, GBR: guided bone regeneration.

^{a)}Statistically significant difference compared to C/I ratio ≥ 1 (Student's *t*-test; *P* < 0.05).

^{b)}Statistically significant difference compared to system III (analysis of variance/Tukey's test; *P* < 0.001).

the FBIC on both mesial and distal sides. To obtain the mesial C/I ratio, the mesial CH was divided by the mesial IL. The distal C/I ratio was also determined, and mean mesiodistal C/I ratio was then obtained for each implant (Fig. 1). The periimplant marginal bone level was measured from the reference point to the FBIC. The reference point was the fixture-abutment interface. The mesial and distal values of the marginal bone loss were averaged to one value. The mean marginal bone loss was calculated as the difference between the initial marginal bone level and the marginal bone level at the follow-up examination. All radiographic measurements were recorded to the nearest 0.1 mm and assessed three times by one examiner.

Statistical analysis

Descriptive statistics were performed, the absolute and relative frequency distribution were calculated for qualitative variables, and the mean ± standard deviation was calculated for quantitative variables. Comparative statistics were performed, mean marginal bone loss was analyzed for different C/I ratios (divided into two categories: < 1 and ≥ 1), implant diameter (divided into two categories: 3.75 to 4 as regular and

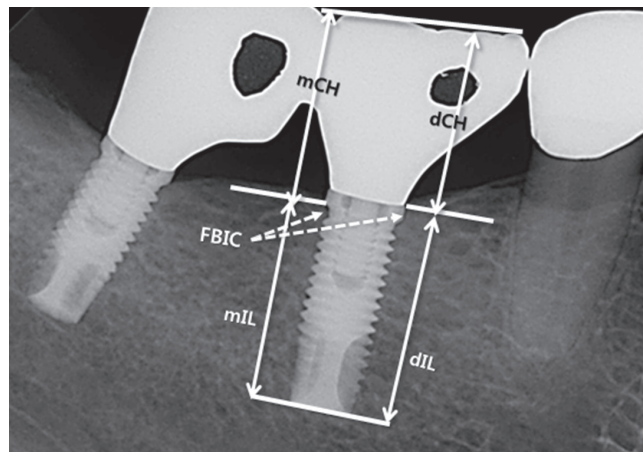


Figure 1. Formula for calculation of crown-to-implant (C/I) ratio. mCH/mIL: mesial C/I ratio, dCH/dIL: distal C/I ratio. An average mesiodistal C/I ratio was obtained per implant restoration. mCH: mesial clinical crown height, mIL: mesial implant length, dCH: distal clinical crown height, dIL: distal implant length, FBIC: the first bone-to-implant contact.

5 mm as wide), implant location (maxilla and mandible), implant system (divided into three categories: system I, system II, and system III), prosthesis type (divided into two categories: single and splinted), and GBR procedure (divided into two categories depending on the use or not of GBR). The Student's *t*-test was used for comparison of the means of the two groups. However, for comparison of the means of three or more groups, the one-way parametric analysis of variance test was applied and *post hoc* examination of group mean differences was performed using Tukey's test. The Kruskal-Wallis test was used for three or more groups when required. Pearson's correlation was applied for determination of associations between the C/I ratio and periimplant marginal bone loss. A *P*-value of less than 0.05 was considered statistically significant. A statistical software package SPSS ver. 17.0 (SPSS Inc., Chicago, IL, USA) was used in performance of all statistical analyses.

RESULTS

A total of 259 implants from 175 patients were analyzed in this study. The mean follow-up period amounted to 5.7 ± 2.0 years. The study population consisted of 81 men and 94 women with a mean age of 54.2 ± 15.6 years (range, 21 to 76 years).

The frequency of the C/I ratios of implants is shown in Fig. 2. In this study, C/I ratios were sorted into two groups based on 259 measurements: 44.7% of the cases belonged to the < 1 group, and 55.3% to the ≥ 1 group. The mean C/I ratio was 1.06 ± 0.42. The mean periimplant marginal bone loss at the five-year follow-up was 0.93 ± 0.15 mm (range, 0.05 to 1.89 mm).

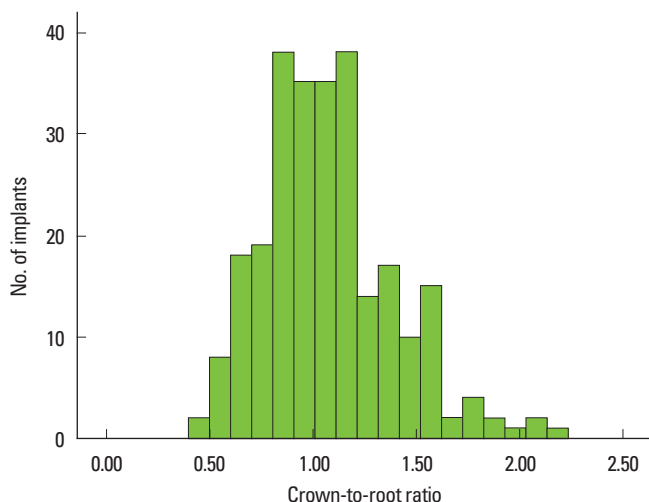


Figure 2. Distribution of the implants according to their crown-to-implant ratio.

The effect of C/I ratio on periimplant marginal bone loss after insertion of definitive restoration was evaluated and is shown in Table 1. Implants with a lower C/I ratio showed a statistically significantly greater periimplant marginal bone loss than implants with a higher C/I ratio ($P < 0.05$). Results of Pearson's correlation analysis revealed a statistically significant inverse relationship between C/I ratio and periimplant marginal bone loss ($r = -0.258$, $P < 0.001$).

Except for the implant system, site-related factors did not have an influence on periimplant marginal bone loss (Table 1). Compared with the system I and system II implants, the system III implant showed statistically significantly greater bone loss ($P < 0.001$). In analysis of the combination effect of the C/I ratio and site-related factors (Table 2), the C/I ratio was the more dominant factor influencing the change in periimplant marginal bone level, compared with implant diameter, prosthesis type, implant location, and GBR procedure. In terms of implant location, implants with a lower C/I ratio had greater periimplant marginal bone loss than implants with a higher C/I ratio in the maxilla ($P < 0.05$), while the C/I ratio had no influence on periimplant marginal bone loss in the mandible ($P > 0.05$). Meanwhile, periimplant marginal bone loss was more affected by the implant system than the C/I ratio in posterior areas.

DISCUSSION

Implant surface, implant location, and surgical procedure as well as loading after prosthetic rehabilitation could affect the change in the periimplant marginal bone level. The C/I ratio has been regarded as one of the geometric loading factors that could increase biomechanical complications [16]. In

Table 2. Mean periimplant marginal bone loss according to combination of crown-to-implant (C/I) ratio and site-related factors ($n = 259$).

Implant factor	C/I ratio < 1		C/I ratio ≥ 1	
	No.	MBL (mm)	No.	MBL (mm)
Implant diameter				
Regular	53	1.29 \pm 0.27 ^{a)}	71	0.77 \pm 0.21
Wide	60	1.20 \pm 0.24 ^{a)}	75	0.63 \pm 0.13
Implant location				
Maxilla	50	1.26 \pm 0.30 ^{a)}	76	0.77 \pm 0.20
Mandible	66	1.05 \pm 0.21	67	0.78 \pm 0.15
Prosthesis type				
Splinted	63	1.27 \pm 0.28 ^{a)}	59	0.70 \pm 0.19
Single	53	1.12 \pm 0.21 ^{a)}	84	0.59 \pm 0.18
GBR procedure				
With	25	1.24 \pm 0.30 ^{a)}	53	0.70 \pm 0.21
Without	91	1.17 \pm 0.21 ^{a)}	90	0.75 \pm 0.20
Implant surface				
System I	56	0.86 \pm 0.27 ^{b)}	69	0.77 \pm 0.21 ^{c)}
System II	21	0.71 \pm 0.14 ^{b)}	55	0.63 \pm 0.20 ^{c)}
System III	39	1.65 \pm 0.33	19	1.41 \pm 0.36

Values are presented as mean \pm standard deviation.

MBL: mean periimplant marginal bone loss, GBR: guided bone regeneration.

^{a)}Statistically significant difference compared to C/I ratio ≥ 1 (Student's *t*-test; $P < 0.05$).

^{b,c)}Statistically significant difference compared to system III (analysis of variance/Tukey's test; $P < 0.001$).

mathematical models, the higher the effect of bending moments, the greater the possibility of occurrence of bone loss around implants with long lever arms, such as those with an unfavorable C/I ratio. Nevertheless, the current study found that implants with a higher C/I ratio showed statistically significantly less periimplant marginal bone loss than implants with a lower C/I ratio. This finding can be explained by the fact that the stress concentration at the bone crest caused by masticatory forces may stimulate bone formation around some implant fixtures. This biologic phenomenon is supported by the 'stress-shielding' effect described in previous studies [17,18]. According to these authors, clinical scenarios in which bone stress is reduced may cause disuse atrophy and eventual marginal bone loss.

Blanes et al. [19] evaluated both the clinical C/I ratio and anatomical C/I ratio of nonsubmerged internal implants. The clinical C/I ratio applied in the current study was measured from the top of the crestal bone in contact with the implant to the top of the crown as the CHI; thus, the length of the implant was measured from the bottom of the fixture to the top of the crestal bone in contact with the implant, whereas, the anatomical C/I ratio was measured from the bottom of the fixture to the implant-abutment connection and then from

that point to the top of the crown. This is an important difference due to the fact that an implant of conventional length may exhibit a high C/I ratio if the marginal bone has remodeled to a level far below the implant-abutment connection. Rokni et al. [18] found no association between the C/I ratio and FBIC levels, but did find an association between decreasing FBIC levels and increasing IL, as well as splinting of restorations. However, Blanes et al. [19] reported that higher clinical C/I ratios showed lower average bone loss when compared with lower C/I ratios. This observation is in agreement with the results of our study. The anatomical C/I ratio offers a more favorable biomechanical scenario, as the lever arm is shorter than that in the clinical C/I ratio. Nevertheless, because the stiffness of components connected to the implant is greater than that of the cortical bone, the clinical C/I ratio measured in our study appears to offer a more realistic clinical scenario for evaluation of the effect of the C/I ratio on complications of implant restoration [20]. Therefore, the most coronal bone-to-implant contact is the location where the applied forces and strains they create are resisted by bone. Ultimately, for determination of change in marginal bone loss related to the C/I ratio, the clinical C/I ratio is a more appropriate parameter than the anatomical C/I ratio.

In this study, the implant location had an influence on peri-implant marginal bone loss related to the C/I ratio. Implants with a lower C/I ratio had more periimplant marginal bone loss than implants with a higher C/I ratio in the maxilla, while the C/I ratio had no influence on periimplant marginal bone loss in the mandible. Bone density is directly related to the elastic modulus of bone [21]. Due to its lower elastic modulus, the cancellous bone exhibited a lower stress concentration and less variation than the cortical bone [22]. The explanation could be that the difference of bone density induces this result. In the maxilla posterior area, the C/I ratio could act as a more dominant loading factor, which may increase the peri-implant marginal bone loss, compared with the bone density.

Interestingly, in our study, a statistically significant difference in periimplant marginal bone loss was observed according to the implant system. It appears that, among the implant systems, differences in surface texture of the implant result in significant differences in the magnitude of the marginal bone resorption. Radiographic evaluation of marginal bone levels around different implant systems showed that implants with a hybrid surface were associated with greater change in crestal bone levels than implants with an anodized or RBM surface ($P < 0.001$). In analysis of the combined effect of the C/I ratio and implant system on periimplant marginal bone loss, the implant system was a more dominant factor influencing the change in periimplant marginal bone level than the C/I ratio. However, our results differ from those of previ-

ous studies evaluating the effects of implant surface characteristics on periimplant marginal bone loss. A recent clinical study found that among TiUnite, Osseotite, and machined dental implants, no statistically significant differences in bone loss were observed at two years postloading [23]. Until now, no specific implant surface characteristic has been found to be superior in marginal bone preservation [24]. As this study included a relatively small sample size, and, other than the configuration of the surface, the implants studied had no other differences that may have influenced the results, conducting further studies on other fixture designs is necessary in order to clarify the mechanism and the relationship between the design and marginal bone loss in dental implants.

Although the results of the current study showed an inverse relationship between the C/I ratio and marginal bone loss, due to the following limitations, our result should be interpreted with caution. A recent study found no correlation between the C/I ratio and periimplant marginal bone loss [25]. The reports established different categories of C/I ratio from ours. The C/I ratio was sorted into six groups based on 234 measurements (<1 , $1-1.2$, $1.21-1.4$, $1.41-1.6$, $1.61-2$, and >2). However, because the number of implant-supported restorations with a C/I ratio greater than 2 was very low, we only classified our cases into two groups based on the C/I ratio of 1. Furthermore, our results came from a retrospective study. Due to issues of bias and confounding factors, this type of study has less validity than a randomized, prospective study.

Within the limitations of this study, it is suggested that the C/I ratio and implant system were factors that should be considered as affecting marginal bone loss around the implant in the posterior region more than implant diameter, prosthesis type, implant location, or GBR procedure, especially in the maxilla.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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REFERENCES

1. Grossmann Y, Sadan A. The prosthodontic concept of crown-to-root ratio: a review of the literature. *J Prosthet Dent* 2005;93:559-62.
2. Dykema RW. Diagnosis and Treatment Planning. In: Johnston JF, Dykema LW, Goodacre CJ, Phillips RW. Johnston's

- modern practice in fixed prosthodontics. 4th ed. Philadelphia: WB Saunders; 1986. p.8-21.
3. Shillingburg HT Jr. Treatment Planning for the Replacement of Missing Teeth. In: Shillingburg HT Jr, Hobo S, Whitsett LD, Jacobi R, Brackett SE. Fundamentals of fixed prosthodontics. 3rd ed. Chicago: Quintessence Publishing; 1997. p.89-90.
 4. Nyman S, Ericsson I. The capacity of reduced periodontal tissues to support fixed bridgework. *J Clin Periodontol* 1982;9:409-14.
 5. Laurell L, Lundgren D, Falk H, Hugoson A. Long-term prognosis of extensive polyunit cantilevered fixed partial dentures. *J Prosthet Dent* 1991;66:545-52.
 6. Yi SW, Ericsson I, Carlsson GE, Wennström JL. Long-term follow-up of cross-arch fixed partial dentures in patients with advanced periodontal destruction. Evaluation of the supporting tissues. *Acta Odontol Scand* 1995;53:242-8.
 7. Bidez MW, Misch CE. Clinical Biomechanics in Implant Dentistry. In: Misch CE. Contemporary implant dentistry. St. Louis: Mosby Elsevier; 2008. p.543-55.
 8. Brose MO, Avers RJ, Rieger MR, Duckworth JE. Submerged alumina dental root implants in humans: five-year evaluation. *J Prosthet Dent* 1989;61:594-601.
 9. Nasr HF, Meffert RM. A proposed radiographic index for assessment of the current status of osseointegration. *Int J Oral Maxillofac Implants* 1993;8:323-8.
 10. Haas R, Mensdorff-Pouilly N, Mailath G, Watzek G. Brånemark single tooth implants: a preliminary report of 76 implants. *J Prosthet Dent* 1995;73:274-9.
 11. Glantz PO, Nilner K. Biomechanical aspects of prosthetic implant-borne reconstructions. *Periodontol* 2000 1998; 17:119-24.
 12. Schulte J, Flores AM, Weed M. Crown-to-implant ratios of single tooth implant-supported restorations. *J Prosthet Dent* 2007;98:1-5.
 13. Verhoeven JW, Cune MS, de Putter C. Reliability of some clinical parameters of evaluation in implant dentistry. *J Oral Rehabil* 2000;27:211-6.
 14. Updegrave WJ. Right-angle dental radiography. *Dent Clin North Am* 1968;12:571-9.
 15. Urdaneta RA, Rodriguez S, McNeil DC, Weed M, Chuang SK. The effect of increased crown-to-implant ratio on single-tooth locking-taper implants. *Int J Oral Maxillofac Implants* 2010;25:729-43.
 16. Rangert BR, Sullivan RM, Jemt TM. Load factor control for implants in the posterior partially edentulous segment. *Int J Oral Maxillofac Implants* 1997;12:360-70.
 17. Pilliar RM, Cameron HU, Binnington AG, Szivek J, Macnab I. Bone ingrowth and stress shielding with a porous surface coated fracture fixation plate. *J Biomed Mater Res* 1979;13:799-810.
 18. Rokni S, Todescan R, Watson P, Pharoah M, Adegbenbo AO, Deporter D. An assessment of crown-to-root ratios with short sintered porous-surfaced implants supporting prostheses in partially edentulous patients. *Int J Oral Maxillofac Implants* 2005;20:69-76.
 19. Blanes RJ, Bernard JP, Blanes ZM, Belser UC. A 10-year prospective study of ITI dental implants placed in the posterior region. II: Influence of the crown-to-implant ratio and different prosthetic treatment modalities on crestal bone loss. *Clin Oral Implants Res* 2007;18:707-14.
 20. Sekine H, Komiyama Y, Hotta H, Yoshida T. Mobility Characteristics and Tactile Sensitivity of Osseointegrated Implant-Supporting Systems. In: Van Steenberghe D. Tissue integration in oral and maxillofacial reconstruction. Amsterdam: Excerpta Medica; 1986. p.326-39.
 21. Misch CE, Qu Z, Bidez MW. Mechanical properties of trabecular bone in the human mandible: implications for dental implant treatment planning and surgical placement. *J Oral Maxillofac Surg* 1999;57:700-6.
 22. Akca K, Cehreli MC. Biomechanical consequences of progressive marginal bone loss around oral implants: a finite element stress analysis. *Med Biol Eng Comput* 2006;44: 527-35.
 23. Aalam AA, Nowzari H. Clinical evaluation of dental implants with surfaces roughened by anodic oxidation, dual acid-etched implants, and machined implants. *Int J Oral Maxillofac Implants* 2005;20:793-8.
 24. Abrahamsson I, Berglundh T. Effects of different implant surfaces and designs on marginal bone-level alterations: a review. *Clin Oral Implants Res* 2009;20 Suppl 4:207-15.
 25. Tawil G, Aboujaoude N, Younan R. Influence of prosthetic parameters on the survival and complication rates of short implants. *Int J Oral Maxillofac Implants* 2006;21:275-82.