

# Marginal Assessment of Crowns by the Aid of Parallel Radiography

Farnaz Fattahi<sup>1</sup>, Rashin Giti<sup>1</sup>, Kianoosh Torabi<sup>1</sup>

<sup>1</sup> Department of Fixed Prosthodontics, School of Dentistry, Shiraz University of Medical Sciences, Shiraz, Iran

*Received 18 September 2014 and Accepted 13 December 2014*

## Abstract

**Introduction:** Marginal adaptation is the most critical item in long-term prognosis of single crowns. This study aimed to assess the marginal quality as well as the discrepancies in marginal integrity of some PFM single crowns of posterior teeth by employing parallel radiography in Shiraz Dental School, Shiraz, Iran. **Methods:** In this descriptive study, parallel radiographies were taken from 200 fabricated PFM single crowns of posterior teeth after cementation and before discharging the patient. To calculate the magnification of the images, a metallic sphere with the thickness of 4 mm was placed in the direction of the crown margin on the occlusal surface. Thereafter, the horizontal and vertical space between the crown margins, the margin of preparations and also the vertical space between the crown margin and the bone crest were measured by using digital radiological software. **Results:** Analysis of data by descriptive statistics revealed that 75.5% and 60% of the cases had more than the acceptable space (50 $\mu$ m) in the vertical (130 $\pm$ 20 $\mu$ m) and horizontal (90 $\pm$ 15 $\mu$ m) dimensions, respectively. Moreover, 85% of patients were found to have either horizontal or vertical gap. In 77% of cases, the margins of crowns invaded the biologic width in the mesial and 70% in distal surfaces. **Conclusion:** Parallel radiography can be expedient in the stage of framework try-in to yield some important information that cannot be obtained by routine clinical evaluations and may improve the treatment prognosis.

**Key words:** Marginal adaptation, metal-ceramic crowns, radiography.

## Introduction

Regardless of the place of margins, proper marginal fit of dental fillings and crowns is essential to prevent periodontal diseases and recurrent caries (1-3). Several researchers have announced that clinical methods (visual inspection and/or an explorer) can be used to evaluate the gingival margin of filling and crown. They have also considered it to be a difficult diagnostic task, particularly when the restoration margin is interproximal and subgingival (1,2). Some other researchers have taken the use of explorer into question, as it tends to stick, whether or not the tissue adjacent to the filling is carious; thus, radiographic methods are suggested to be used for diagnosis of the lesions adjacent to restorations (1,4). Despite the fact that all defective restorations do not necessarily bring about disease, marginal misfits are crucial to be appropriately diagnosed so that the tooth and the surrounding tissues can be maintained as much as possible; so it should be included as a part of the overall evaluation of the quality of the restoration. The margin of a single unit extracoronary restoration is the most critical item in long-term prognosis and the most susceptible part to distort (5). Therefore, success and failure of the fixed restoration are completely related to adaptation and location of the crown margin (5). Some other items that affect the marginal adaptation are marginal beveling, venting, type and thickness of the cement, type of the impression material (dimensional accuracy), and the design of the margin preparation (6,7).

The best place for the crown margin is where the best access is provided both for the dentist to make impression, and for the patient to clean the restoration (5). The four determining factors in choosing the marginal location are periodontal consideration, esthetic consideration, adequate retention, and finally extending the preparation to the sound tooth structure (2,8).

The teeth restored with full-crown tend to exhibit more gingival inflammation and pocket depth than

---

Fattahi F, Giti R, Torabi K. Marginal Assessment of Crowns by the Aid of Parallel Radiography. J Dent Mater Tech 2015; 4(1): 29-36.

nonrestored ones (9). The extent of inflammation around the restored teeth depends on particular elements such as emergence profile, adequate access to polish the subgingival margins and biologic width invasion (3). Biological width is defined as the distance between the alveolar crest and the junctional epithelium and is estimated to be approximately 2.04mm (10). Migration of the junctional epithelium and bone resorption are the consequences of marginal invasion of the crown to biologic width; which occurs to create the former biological distance (10).

Evaluation of the marginal adaptation can be performed either qualitatively or quantitatively. Qualitative assessment is done by direct visualization and sense of touch (by use of an explorer) (11), by using impression materials, or through radiological assessment (12). For quantitative assessment, employing a microscope in high magnification would be the best choice to measure the gap space. Graded explorers and parallel radiography can also be used for this purpose (13,14). Radiography is routinely used for quantitative evaluation in Nance and Hixon-Oldfather's methods which are specialized for space measurement in mixed dentition (15).

In the case of rehabilitation with dental implants, most implant systems consist of two components – the implant screw and a connecting transmucosal structure, the abutment. The prosthetic crown can be either connected to the abutment or be an independent element (16), consequently, a gap can exist between the implant and the abutment. Also between the crown and the abutment, there might be a gap or an overextension of the luting agent. Since the presence of excess cement may result in peri-implant inflammation, radiographic evaluation has been proposed by some studies to ensure the appropriate seating and debridement of subgingival restorations (17, 18). Marginal misfit in cement-retained implant single crowns can also be accompanied by changes in crestal bone (17). Researches on radiographic assessment have reported the radiopacity of the restorative material and the technique to have effects on the assessment of marginal misfits (1). A number of in-vitro studies have used conventional and digital radiography to evaluate the diagnosis of gaps, and adopted marginal discrepancies from 0.01 to 0.5 mm between the restoration and the tooth (12, 19). Also Bjorn used radiography to measure the size of overhang and the marginal gap, as well as the distance between the crown margin and the bone crest (20). Radiography is particularly essential to estimate and calculate the bone dimensions before dental implant surgery (21). Hence, various radiographic techniques such as digital radiography, periapical, and computed tomography have been devised to evaluate the proximal surfaces; however, within the literature there exists little

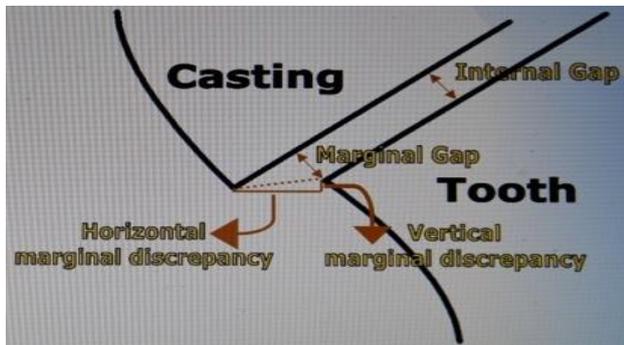
consensus on their individual use. Thus, in an attempt to search for a rationale on the use of parallel radiography and to suggest the best protocol, the current study was enrolled to evaluate the marginal adaptation and location of the crowns (the most critical item in fixed restoration) at the delivery point by employing radiographic assessment in Shiraz Dental School, Shiraz, Iran.

## Materials and Method

In this descriptive study, 200 fabricated single-unit crowns were evaluated for the location and adaptation of margins by parallel radiography using Kodak E speed dental x-ray film (Eastman Kodak, Rochester NY, USA). The study was performed in the Department of Fixed Prosthodontics and OMF Radiology of Shiraz Dental School, Shiraz, Iran in 2012. The research protocol was submitted for consideration, comment, guidance and was approved by the research ethics committee of Shiraz School of Dentistry (ID: EC-2013-166). Considering the Declaration of Helsinki as the ethical principles, all patients were informed in details about the nature of the trial, and individual voluntary informed consent was signed.

All the crowns were related to the posterior teeth and all of them were porcelain fused to metal (PFM). The type of margin preparation for all of them was shoulder bevel, and all of them were cemented by zinc phosphate cement.

All the radiographs were taken by parallel technique in the same condition (kvp:60, mA:8, exposure time:320ms). Then they were scanned and digital images were saved in computer. All the linear measurements were done using digital radiological software (Dr. Suni, China). To calculate the radiographic magnification, a metallic sphere (4mm in diameter) was placed on the occlusal surface and was fixed with a piece of sticky wax along the crown margin. The coefficients of magnification were calculated by measuring the diameter of the radiological image of the sphere divided by the actual diameter of it. Thereafter, the vertical and horizontal marginal discrepancies (Fig. 1) (the vertical and horizontal distances between the crown margin and the preparation margin in either vertical or horizontal axis respectively), and the distance between the crown margin and the bone crest were also measured using the previously mentioned software.



**Figure 1.** Method of measuring horizontal and vertical marginal discrepancy

The final values were recorded regarding the coefficient of magnification. The values for marginal discrepancies were evaluated by descriptive statistical analysis of the registered data.

Generally the biologic width around different teeth is different and can just be measured by histological evaluation. In the current study, however, the lowest biological width (2mm) was considered as standard and the extents less than that were considered as invasion to the biological width. Since a space of at least 0.5mm should be available between the preparation finishing line and the junctional epithelium crest (10), the spaces less than 2500 $\mu$ m between the crown margin and the bone crest were considered as biologic width violation; besides, the open margin was attributed to the marginal gap of more than 50 $\mu$ m (5).

## Results

The largest recorded value around the tooth is considered as the marginal discrepancy value; however, the buccal and lingual surface of the teeth could not be

detected in radiographic evaluation. Hence, only mesial and distal surfaces were evaluated in this survey. The acceptable marginal gap in this study was 50 $\mu$ m. Accordingly, the crowns with horizontal and/or vertical gap of more than 50 $\mu$ m in mesial or distal surfaces were considered as having open margin. As represented in table 1, 75.5% of the crowns had vertical and 60% of the crowns had horizontal discrepancy. Likewise, 85% of all crowns had a marginal gap more than the acceptable extent in either horizontal or vertical dimensions. As demonstrated in table 2, 77% and 70% of the crowns invaded the biological width in the mesial and distal surfaces, respectively.

Out of 200 evaluated teeth in this study, 70 teeth were detected to have some remaining cement around the teeth in the gingival sulcus, indicating that they had not been completely cleaned.

The margins of 15 crowns (7.5%) were on amalgam restoration with overhang. A total of 8 (4%) did not have the effective emergence profile, although they did not have marginal gap either. In 40 cases restored by a castable post, 8 core and 10 crowns had space between the post and Gutta-percha in the root canal and in 3 cases, the prepared post was deviated from the root canal direction.

**Table 1.** Number and percentage of crowns with or without horizontal or vertical gap

	Vertical dimension		Horizontal dimension		Either horizontal or vertical		Total
	With gap	Without gap	With gap	Without gap	With gap	Without gap	
Number	151	49	120	80	170	30	200
Percentage	75.5%	24.5%	60%	40%	85%	15%	100

**Table 2.** Number and percentage of crowns have more or less space than 2500 $\mu$  between the crown margin and the crestal bone

	Marginal space to the crestal bone( $\mu$ m)	Number	Percentage
Mesial	More than 2500	46	23%
	Less than 2500	154	77%
Distal	More than 2500	48	24%
	Less than 2500	140	70%

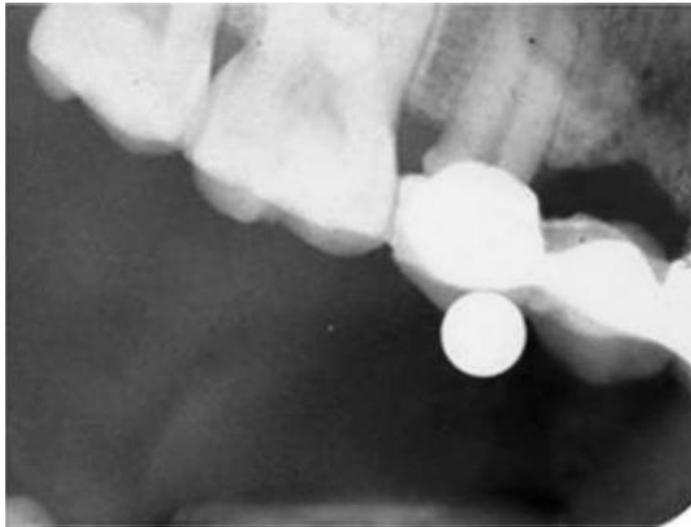
## Discussion

The current study was carried out to find a rationale on using radiography as an adjunct method for diagnosing the misfit in dental prostheses and restorations. When a filling or a crown is placed, the restoration surface should be aligned with the tooth margin (4, 22). Misfit is usually defined as the lack of adaptation between the restoration and the prepared tooth. They must be prevented because they are prone to cause accumulation of biofilm and consequently lead to development of carious lesions (1,2,23). It might be disadvantageous to the gingival and marginal bone tissues, as well (23,24). Likewise, healthy periodontal conditions are maintained through providing proper fitting of abutments on implants (17,25). There are a number of studies in which Radiographic examination has been recommended for the assessment of dental prosthesis or restorations (19,26) as well as the abutment adaptation (18). Two recent publications have suggested the presence of digital radiographic artifacts beside the metal restorations, which could impede the interpretation of such images (27,28). Another study compared the digital and conventional radiographs to assess the diagnostic accuracy of metal restoration misfit, and found no significant difference between conventional and digital original images (29). Based on the controversial results of this study, the presence of vertical marginal gap in 75.5% and horizontal gap in 60% of crowns can endorse the fact that evaluation of the marginal adaptation by using only explorer (30), rouge and chloroform, or even by an impression material would not be adequate. The results from clinical and radiographic examination were brought to comparison; the study that had assessed marginal gaps adjoining to implant components had reported higher accuracy from the radiographic recording (31). In the case of assessing Class II restorations, the number of false positive diagnosis was reduced due to making use of both clinical and radiograph evaluation together (32). On the other hand, the number of correct cases diagnosed by the two methods were found to have no difference in an in-vivo study (33), whereas another study reported radiographs to have helped diagnosing more correct cases (34). Some studies were conducted concerning the impact of x-ray beam angulation (35,36) and they all agreed that the most accurate angulation for marginal misfit diagnosis in dental restorations is the orthogonal projection. Regarding image acquisition system, conventional film radiography was used in majority of the studies, while some others had used digital radiography, both CCD-based sensors and PSP systems (12,21). However, the use of computed tomography in diagnosing the misfits was assessed by none of them. The vertical marginal gap could probably be due to incomplete seating of the crowns (37), and

incomplete seating by itself can be caused by tight proximal contact or presence of pressure spot. Vertical marginal gap can also be the result of short ditching in the laboratory by the technician and inaccuracy in making the impression of marginal preparation by the clinician (Fig. 2) (37). Practically, the subgingival margins, especially in the posterior regions, cannot be registered accurately by the impression material due to the poor access and the presence of blood (37). Some authors have proposed that radiography can assess the restored proximal surfaces better (1,2). In a study the proximal margins of Class II amalgam restorations were evaluated by employing radiographic examination solely and in association with clinical method. The result revealed better quality of diagnosis with the combined method (32). The horizontal flaws can be in two forms of ledge or overhang. Ledge is the result of wrong preparation (37); for instance, the chamfer margin should never be prepared wider than half of the thickness of a diamond bur tip, otherwise an unsupported lip of enamel may create marginal ledge (Fig. 3a) (37).

Presence of positive horizontal space (an overhang) can be allied to the technician or the operative dentist. In some instances, the technician may ditch the die beyond the finishing line of the preparation and subsequently this flaw would lead to an overhang margin that can invade the gingival tissue and develop inflammation (Fig. 3b) (23). Sometimes also the undercut which is created in the preparation of the crown by the operative dentist can cause the wax pattern distortion during removal from the die and would produce marginal gap and overhang (5). Invasion of the biologic width can reversely be associated with the operative errors of the dentist (23). It must be concerned that the preparation should not be extended more than 0.5mm into the gingival sulcus (Fig. 4) (23).

Despite the fact that the cement residue was cleaned out by the explorer and dental floss in the present study, radiographic evaluation revealed that it had not been completely cleaned in 70 cases, which could cause gingival irritation and inflammation as a consequent (Fig. 5) (38). Inappropriate emergence profile exhibited in 8 cases could be related either to the wrong ditching of the technician or to the inadequate preparation of the dentist. Both instances can cause gingival inflammation and periodontal problems due to inadequate access for proper oral hygiene (23). The current study only made use of conventional radiography, so further researches are recommended to compare the accuracy of various types of digital radiographies in assessing marginal adaptation of indirect restorations. Digital radiography methods are preferred because of their lower irradiation dosage and image processing which are the advantages of this type of radiography compared to older ones.



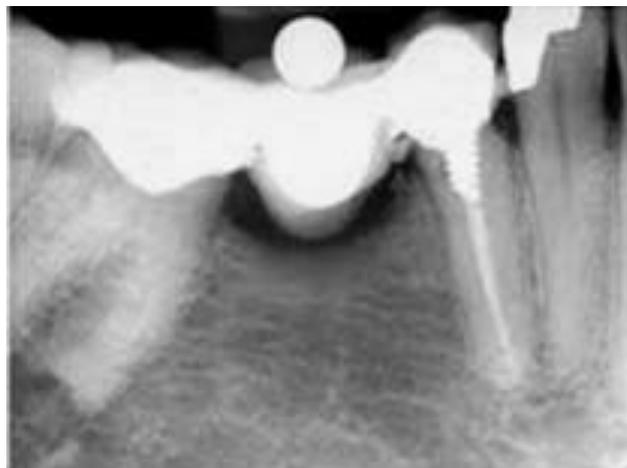
**Figure 2.** Radiographic image showing vertical marginal gap



**Figure 3.**a. Radiographic projection illustrating horizontal marginal discrepancy in the form of ledge formation.  
b. Radiographic picture showing horizontal marginal discrepancy in the form of overhang



**Figure 4.** Radiographic picture showing invasion of the restoration margin to the biologic width (arrow)



**Figure 5.** Radiographic projection displaying the Figure 3a. Radiographic projection illustrating horizontal marginal discrepancy in the form of ledge formation3b Radiographic picture showing horizontal marginal discrepancy in the form of overhang residual cement that has not been completely cleaned

### Conclusion

In general, dental radiography is used to show the proximal surfaces of the teeth but practical information can be obtained from it about adaption of the crown margins, its location and its relation to the bone crest. Accordingly, dental radiographic evaluation can be used as an adjunct to the clinical examinations to yield a better treatment prognosis.

### References

1. Mjor IA. Clinical diagnosis of recurrent caries. *J Am Dent Assoc* 2005;136:1426-33.
2. Larson TD. The clinical significance of marginal fit. *Northwest Dent* 2012;91:22-9.
3. Papageorgiou SN, Papadelli AP, Koidis PT, Petridis HP. The effect of prosthetic margin location on caries susceptibility. A systematic review and meta-analysis. *British Dent J* 2013;214:617-24.
4. Kidd EA. Caries diagnosis within restored teeth. *Adv Dent Res* 1990;4:10-3.
5. Shillingburg HT, Sather DA, Wilson EL, Cain JR, Mitchell DL, Blanco LJ. *Fundamentals of fixed prosthodontics*. Chicago: Quintessence publishing Co, Lnc, 2012.
6. Eames WB, O'Neal SJ, Monteiro J, Miller C, Roan JD, Jr., Cohen KS. Techniques to improve the seating of castings. *J Am Dent Assoc* 1978;96:432-7.

7. Henry PJ, Harnist DJ. Dimensional stability and accuracy of rubber impression materials. *Aust Dent J* 1974;19:162-6.
8. Gardner FM. Margins of complete crowns--literature review. *J Prosth Dent* 1982;48:396-400.
9. Reeves J. Periodontal health--challenges in restorative dentistry. *Primary Dent J* 2014;3:73-6.
10. Newman MG, Takei HH, Klokkevold PR, Carranza FA. *Clinical periodontology*. Tothed. ST. Louis: Elsevier/Saun Ders, 2006.
11. Akin A, Toksavul S, Toman M. Clinical Marginal and Internal Adaptation of Maxillary Anterior Single All-Ceramic Crowns and 2-year Randomized Controlled Clinical Trial. *J Prosth* 2014 (In Press).
12. Haak R, Wicht MJ, Hellmich M, Noack MJ. Detection of marginal defects of composite restorations with conventional and digital radiographs. *Eur J Oral Sci* 2002;110:282-6.
13. Varol S, Kulak-Ozkan Y. In Vitro Comparison of Marginal and Internal Fit of Press-on-Metal Ceramic (PoM) Restorations with Zirconium-Supported and Conventional Metal Ceramic Fixed Partial Dentures Before and After Veneering. *J Prosth* 2014 (In Press).
14. Alshiddi IF, Habib SR, Al-Mazrou FY, Aly AM, Al-Zaid AM. Comparing Government (School) vs. Private (non-school) Dental Laboratories in Marginal Adaptation of Single Porcelain-Fused-to-Metal Crowns. *Oral Health Dent Manage* 2014;13:707-11.
15. Dean JA, Avery DR, Mcdonalal RE. *Dentistry for the child and adolescent*. Mary land Heights: Elsevier Mosby, 2011.
16. Schwarz MS. Mechanical complications of dental implants. *Clin Oral Implants Res* 2000;11:156-8.
17. Wadhvani C, Rapoport D, La Rosa S, Hess T, Kretschmar S. Radiographic detection and characteristic patterns of residual excess cement associated with cement-retained implant restorations: a clinical report. *J Prosth Dent* 2012;107:151-7.
18. Pette GA, Ganeles J, Norkin FJ. Radiographic appearance of commonly used cements in implant dentistry. *Int J Periodont Res Dent* 2013;33:61-8.
19. Weyns W, De Boever J. Radiographic assessment of the marginal fit of cast restorations. *J Prosth Dent* 1984;51:485-9.
20. Bjorn AL, Bjorn H, Grkovic B. Marginal fit of restorations and its relation to periodontal bone level. II. Crowns. *Odontologisk Revy* 1970;21:337-46.
21. Sharkey S, Kelly A, Houston F, O'Sullivan M, Quinn F, O'Connell B. A radiographic analysis of implant component misfit. *Int J Oral Maxillofac Implants* 2011;26:807-15.
22. Holmes JR, Bayne SC, Holland GA, Sulik WD. Considerations in measurement of marginal fit. *J Prosth Dent* 1989;62:405-8.
23. Giollo MD, Valle PM, Gomes SC, Rosing CK. A retrospective clinical, radiographic and microbiological study of periodontal conditions of teeth with and without crowns. *Braz Oral Res* 2007;21:348-54.
24. Sorensen SE, Larsen IB, Jorgensen KD. Gingival and alveolar bone reaction to marginal fit of subgingival crown margins. *Scand J Dent Res* 1986;94:109-14.
25. Chen CJ, Papaspyridakos P, Guze K SM, Weber HP, Gallucci GO. Effect of misfit of cement-retained implant single crowns on crestal bone changes. *Int J Prosthodont* 2013;26:135-7.
26. Croll TP, Epstein DW, Castaldi CR. Marginal adaptation of stainless steel crowns. *Pediatric dentistry*. 2003;25(3):249-52.
27. Schweitzer DM, Berg RW. A digital radiographic artifact: A clinical report. *J Prosth Dent* 2010;103:326-9.
28. Brettle D, Carmichael F. The impact of digital image processing artefacts mimicking pathological features associated with restorations. *Br Dent J* 2011;211:167-70.
29. Liedke GS, Spin-Neto R, Vizzotto MB, Da Silveira PF, Silveira HE, Wenzel A. Diagnostic accuracy of

- conventional and digital radiography for detecting misfit between the tooth and restoration in metal-restored teeth. *J Prosth Dent* 2014 (In Press).
30. Spedding RH. Two principles for improving the adaptation of stainless steel crowns to primary molars. *Dent Clin North Am* 1984;28:157-75.
  31. Konermann AC, Zoellner A, Chang BM, Wright RF. In vitro study of the correlation between the simulated clinical and radiographic examination of microgaps at the implant-abutment interface. *Quintessence Int* 2010;41:681-7.
  32. Espelid I, Tveit AB. Diagnosis of secondary caries and crevices adjacent to amalgam. *Int Dent J* 1991;41:359-64.
  33. van Amerongen WE, Eggink CO. The cervical margin of amalgam restorations: a radiographic and clinical assessment. *ASDC J Dent Child* 1986;53:177-83.
  34. Kroeze J, Ruiken R, van 't Hof M. Evaluation of an indirect method for assessing the quality of amalgam restorations in epidemiological studies. *Commun Dent Oral epidemiol* 1988;16:208-11.
  35. Begona Ormaechea M, Millstein P, Hirayama H. Tube angulation effect on radiographic analysis of the implant-abutment interface. *Int J Oral Maxillofac Implants* 1999;14:77-85.
  36. Papavassiliou H, Kourtis S, Katerelou J, Chronopoulos V. Radiographical evaluation of the gap at the implant-abutment interface. *J Esthet Restor Dent* 2010;22:235-50.
  37. Rosental SF, Lond MF, Fuyimoto J. Contemporary fixed prosthodontics. St. Louis: Elsevier/Mosby; 2006.
  38. Antonijevic D, Obradovic-Djuricic K, Rakocevic Z, Medigovic I. In vitro radiographic detection of cement overhangs on cement-retained implant restorations. *Int J Oral Maxillofac Implants* 2013;28:1068-75.

**Corresponding Author:**

Kianoosh Torabi  
 School of Dentistry  
 Shiraz University of Medical Sciences, Shiraz, Iran  
 Tel: 00989171085682  
 E-mail: ktorabi@sums.ac.ir