Radiographic Evaluation of Implant Impression Component Misfit

Marzieh Alikhasi [a, b], Hakimeh Siadat [a, b], Saeed Mehraban Hassani [c], Elaheh Tabatabaee [d*]

[a] Dental Implant Research Center, Dental Research Center, Dentistry Research Institute, Tehran University of Medical Sciences, Tehran, Iran; [b]Department of Prosthodontics, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran; [c] Students' Scientific Research Center, School of Dentistry, Tehran University of Medical Sciences, Tehran, Iran; [d] Students' Scientific Research Center, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Corresponding author**: Elaheh Tabatabaee, Students' Scientific Research Center, School of Dentistry, Shahid Beheshti University of Medical Sciences, Daneshjou Boulevard, Evin, Tehran, Iran, P.O. 19839. ***E-mail: elahe_b_t@yahoo.com; ***Tel:*** +989122192184

Submitted: 2015-10-31; **Accepted:** 2015-11-16; **DOI:** *10.7508/rrr.2016.01.007*

Introduction: Radiographs are commonly used to detect misfit of implant components, but various factors including implant connection and component opacity could affect this decision. The purpose of this study was to evaluate the diagnostic capability of senior students and experienced dentists on the adaptation of implant and impression coping in different vertical and horizontal angled radiographs. **Materials and Methods:** The implant and the impression coping were attached to each other; once without any gap and once with a gap of 0.5 mm. Totally, 40 digital X-rays were taken with vertical inclinations of 0, 5, 10, 15, 20, 25, 30 degrees in positive and negative directions, and the rest were horizontally inclined with the same values. Forty senior students and twenty experienced dentists observed the radiographs. Their diagnoses were compared with the real status of components. **Results:** No significant difference was observed between the performance of students and experts (P=0.74). Statistical t-test analysis revealed that the directions (inclinations toward the implants or the impression copings) does not result in any significant difference in diagnoses of students (P=0.29) and dentists (P= 0.15). Nevertheless, general linear model showed the radiograph angulations had a significant impact on the diagnoses of students (P=0.003) and dentists (P<.001). Youden factor revealed that there was not a consistent trend regarding sensitivity and specificity of vertically angled radiographs; however, sensitivity and in particular, specificity decreased as a result of horizontal angle inclination. **Conclusion:** Increasing vertical angulations of the radiographs for diagnosing the adaptation of implant components is likely to reduce diagnostic capability of clinicians, even experienced ones. Specificity is more affected than sensitivity in both horizontally and vertically angled radiographs.

Keywords: Dental implant; Impression coping; Gap; Radiography; Angulation; Experience

Introduction

Due to increasingly growing use of dental implants, it is necessary to diagnose and eliminate the causes of failure in the treatments. One major reason for failure of implant restorations is the presence of gap between implants and abutments. Nevertheless, no dentist has reported to achieve complete fit as of date (1). Range of acceptable fit between the two components varies from 10 microns (2) to 150 microns (3) in different studies. Misfit between implant and abutment interfaces results in non-passiveness of implant components which brings about destructive forces to the adjacent bone (4, 5). Sensorial disturbances, soft tissue injuries, and peri-implantitis are biologic complications of non-passive fit that occurs as a result of functional failure in supporting structure (6). Moreover, fracture and loosening of abutment screw, and superstructure mobility are considered as mechanical complications (7-9) that clinician can prevent by achieving passive fit (1). Another biologic complication that can be considered as the result of gap between implant components is growing bacterial microleakage (10-12) and following gingivitis (13).

Imprecise machining of implant parts, improper hexagon male-female adaptation, (11) and clinical (14-19) and laboratory procedures (19, 20) could result in implant component misfit. Regarding clinical procedures, impression making is definitely considered as a noticeable stage and several studies have stated its remarkable effect on the fit of final components (14-19). First step to make a perfect impression is to fix impression coping

exactly in the appropriate location. To control the fit, various studies have introduced different methods, such as probing with dental explorers, visual control, use of periotest, (21, 22) cross sectional measurement after sectioning, and the impression technique (1, 23-25). With deeply positioned implants, the direct vision and the tactile sense are less efficient to diagnose the gap between the components.

One of the most routine methods to evaluate the accuracy of impression coping placement in clinic is radiography. Due to the variable distortion of image in panoramic radiography, (26) periapical radiography serves as a desirable method to assess the misfit between implant components (27, 28). There are several studies which have investigated the efficacy of radiography to help clinicians diagnose the implant components misfit (29-33). Furthermore, different studies have focused on the difference between the performance of students and experienced dentists (34-37). Due to the lower opacity of impression copings than that of abutments, present study aims to evaluate the effect of different angulations of x-ray tube on the diagnosis of the gap between an impression coping and the implant. The current study also investigates the role of experience in diagnosis capabilities by selecting the examiners from both students and senior dentists.

Materials and Methods

A thermoplastic sheet 0.5 mm in thickness was positioned between the octagon implant (RP implant, Straumann AG, Waldenburg, Switzerland) and square impression coping (Institute Straumann AG, Waldenburg, Switzerland) to create the gap. Subsequently, the fixing screw was used to tighten the complex of implant-thermoplastic sheet-impression coping. To fix the complex in an immobile place, a plastic box was utilized. This box was thoroughly filled with auto-polymerized acrylic resin and just before its setting, the implant components were placed. The plan was to use digital radiography. Hence, extra attention was paid to parallelism of the implant with the direct sensor (Kodak CS 2100, Carestream Health, Inc. Rochester, NY, USA) of digital radiography. To regulate X-ray tube angulations, an angle measuring device was fixed at the edge of mentioned box and a ruler was adhered parallel with the tube. The inclinations of X-ray tube for horizontal angulations were: 0', 5', 10', 15', 20', 25', and 30'. These values were also used when tube was inclined vertically in positive and negative degrees. The digital sensor was positioned in a fixed place while taking all radiography with less than 20 degrees, whereas for 25 and 30 degrees it was necessary to set it in another position, to prevent the image from disappearing. All the processes above were repeated with the fixed implant and the impression coping with no gap. A total of 40 X-rays were taken, 20 for the implant and the impression coping with no gap and 20 for the gap of 0.5 mm. In each group, 13 radiographs were vertically angled and the rest of them horizontally angled. Regulations of the digital radiography unit were 60 kV, 0.2 s and 7 mA while exposure. Digital images were saved in a computer and digitally sectioned. Each of the images received a blinded identity code. In the next step, the images were arranged randomly and shown to 20 experienced dentists and 40 senior under-graduate dentistry students, who had passed their implant courses successfully. To obtain a point of reference, initially; examiners observed set of components. Then, they were shown whole images and asked whether there was gap between impression coping and implant. Intra examiner variability was assessed by displaying the radiographs twice to the examiners. Those answers which revealed the real situation about existence of the gap were considered correct. Finally, the accuracy of examiners' diagnoses about directions and angles of the radiographs was evaluated using *t*-Test and general linear model. Moreover, sensitivity and specificity of diagnoses were appraised by Youden factor.

Results

Statistical *t*-Test analysis was used to compare students' responses about existence of gap between the implant and impression coping, with particular attention to directions (vertically positive or negative angulation of the x-ray tube) of the radiographs. No significant difference was observed for directions (P=0.29) of radiographs. Nevertheless, comparing the accuracy of students' diagnosis regarding the quantity of angles, General Linear Model showed significant difference (P=0.003). The angle exhibits drastic impact on the students' diagnoses based on the P value obtained from the experiments.

For the experienced dentists' answers, *t*-Test revealed no significant difference in directions (P=0.15) of the radiographs. General linear model results indicate that Correlation between quantity of angles and correct answers among experienced dentists is significant (P<.001). Table 1 illustrates the increasing number of errors due to growing angle of x-ray tube in student and experienced groups. Also, no significant difference was observed between the Performance of students and experts (P=0.74).

Table 2 shows the level of sensitivity and specificity of the diagnoses about horizontally and vertically angled radiographs.

Table 1. Error rate of students and experienced dentists in different X-ray tube angulations

Angle		0	5	10	15	20	25	30
Student	**Error rate**	0.16	0.46	0.36	0.4	0.4	0.36	0.53
	Error increasing rate	0	0.3	0.2	0.24	0.24	0.2	0.37
Experienced	**Error rate**	0.4	0.7	0.4	0.6	0.6	0.4	0.3
	Error increasing rate	0	0.3	0	0.2	0.2	0	0.1

Table 2. Level of sensitivity and specificity of diagnoses in different horizontal and vertical angulations of the X-ray tube.

Angle	Specificity	Sensitivity	Youden	Specificity	Sensitivity	Youden	Specificity	Sensitivity	Youden
	Vertical/Negative			*Vertical/Positive*			*Horizontal*		
0	1	1	1	1	1	1	1	1	1
5	0.975	1	0.975	0.975	1	0.975	0.9	1	0.9
10	0.825	0.975	0.8	0.975	0.975	0.95	0.95	1	0.95
15	0.85	1	0.85	0.925	0.925	0.85	0.925	1	0.925
20	0.875	0.975	0.85	0.975	1	0.975	0.875	1	0.875
25	0.9	0.95	0.85	1	0.925	0.925	0.875	0.975	0.85
30	1	0.975	0.975	0.925	0.725	0.65	0.925	0.975	0.9

Specificity shows whether the radiograph was diagnostic when there was no gap whereas sensitivity demonstrates accurate answers among examiners in the presence of the gap. The table suggests that increasing horizontal inclination of the X-ray tube to 25 and 30 degrees decreased diagnosis ability of the examiners with the gap present. However, this discrepancy was meaningless when compared to the confidence interval. Nevertheless, the addition of a horizontal angel exhibits a drastic impact on the specificity of diagnoses; the specificity diminished completely in 20 and 25 degrees. Regarding vertical angulation, there was no especial continuity in examiners' performance about sensitivity and specificity of diagnoses.

Discussion

Periapical radiography is considered a reliable method to evaluate dental implants (27, 28). Nevertheless, there are always factors which affect proper interpretation of a radiograph. To obtain more accurate information, clinician needs high-quality radiographs with appropriate contrast, density,(38) and projection.(38, 39). An improper projection can cause overlap, which may hide gaps between implant components (38). Sharkey *et al.,* (31) Papavassiliou *et al.* (32) and Ormaechea *et al.,* (30) stated that more angulated radiography can still be diagnostic in the presence of large gaps. In this study, the quantity of vertical angulation of the x-ray tube in any direction (either positive or negative angulation) negatively affected the diagnoses of experienced dentists (P<0.001) and students (P=0.003). Tube angulation results in distorted radiographs making it harder to observe a gap between components. Ormaechea *et al.,* (30) recommended that X-ray beam should be perpendicular to implants with less than 5 degree tube angulation fault; while Cameron *et al.,* (29) and Papavassiliou *et al.,* (32) gave a more flexible range and concluded that radiographs were not diagnostic when tube angulation exceeds 20 degrees. Papavassiliou *et al.,* also mentioned that it was more complicated to diagnose the gap when the tube is inclined toward the implant, which contradicts the current study. The reason for this discrepancy is due to the following fact. Papavassiliou *et al*., used implant and abutment whereas implant and impression coping were utilized in this study. Impression coping has less opacity than abutment and a different shape. The difference in shape results in a different geometrical distortion and a different distinguishing gap. Hollender *et al.,* claimed that blurring of internal tread angles of the implant occurs in a tube making an angle of nine degrees whereas the blurring of the external angles occurs around 13 degrees (40). Informed about this fact and knowing the inaccuracy of vertically angled radiographs, clinician would be able to understand about the usefulness of the radiograph.

Sensitivity of periapical radiography to reveal a real gap between an implant-abutment interface is 95% and its specificity is 93-100%, in the absence of any misfit (41).

Nevertheless, when the radiography is not well-prepared, the sensitivity and specificity decrease (see Table 2 for more details). Sharkey *et al.,* (31) and Ormaechea *et al.,* (30) claimed false positive diagnoses in their findings when using vertically angulated radiographs for evaluating gap between implant components. The specificity of diagnoses of vertically angulated radiographs was low in this study even in slightly angulated X-ray tube. However, sensitivity was reasonable when there was a gap and many of the answers were correct except in positive 25 and 30 degrees. Moreover, changing horizontal angles decreased specificity more than sensitivity especially in 25 and 30 degrees. Angled radiographs create confusion for the examiner as to whether there is not a gap or the gap is hidden behind the distorted components. This fact would influence many of the interpretations. Different radio-opacities of implant and impression coping might also be another misleading factor in diagnosis.

There are studies which compared performance of students and dentists to evaluate the impact of experience. Some declared experience had an important role in diagnosis ability (34). Some other stated that students could perform equally well in interpretation of defective areas but poorer in sound surfaces (35). However, some studies attribute less false negative and more false positive to students' diagnoses (36, 37). In the current study, there was no significant difference between performance of students and experienced dentists (P=0.74). This shows that dentists should not use improper radiographs relying on their experience. One possible opportunity to improve this work is performing the procedure in the oral environments to investigate the effects of adjacent structures and their superimpositions.

Conclusion

The aim of this study was to investigate the impact of horizontal and vertical angulations of the x-ray tube on identifying the gap between an internal octagon implant and an impression coping. The secondary aim was to compare the diagnoses of senior students and experienced dentists about the existence of gap between components. The following points summarize the major findings of this research study:

- The diagnosis ability of examiners decreased as a result of increasing vertical angulation; positive or negative direction did not affect the results.
- Performance of students and experienced dentists in diagnoses were identical.
- There was no continuity in diagnoses regarding the sensitivity and specificity in vertically angled radiographs.
- Increasing horizontal angulation reduced sensitivity in 25 and 30 degrees.
- Specificity decreased as the result of additional horizontal angle, especially in 20 and 25 degrees.

Suppression inspecificity was more drastic than sensitivity both in vertically angled and in horizontally angled radiographs.

Conflict of Interest: 'None declared'.

References

1. Sahin S, Çehreli MC. The significance of passive framework fit in implant prosthodontics: current status. Implant dent. 2001;10(2):85-92.
2. Branemark PI. Osseointegration and its experimental background. J Prosthet Dent. 1983;50(3):399-410.
3. Jemt T. Failures and complications in 391 consecutively inserted fixed prostheses supported by Branemark implants in edentulous jaws: a study of treatment from the time of prosthesis placement to the first annual checkup. Int J Oral Maxillofac Implants. 1991;6(3):270-6.
4. Millington ND, Leung T. Inaccurate fit of implant superstructures. Part 1: Stresses generated on the superstructure relative to the size of fit discrepancy. Int J Prosthodont. 1995;8(6):511-6.
5. Kunavisarut C, Lang LA, Stoner BR, Felton DA. Finite element analysis on dental implant-supported prostheses without passive fit. J Prosthodont. 2002;11(1):30-40.
6. Berglundh T, Persson L, Klinge B. A systematic review of the incidence of biological and technical complications in implant dentistry reported in prospective longitudinal studies of at least 5 years. J Clin Periodontol. 2002;29 Suppl 3:197-212; discussion 32-3.
7. Carlson B, Carlsson GE. Prosthodontic complications in osseointegrated dental implant treatment. Int J Oral Maxillofac Implants. 1994;9(1):90-4.
8. Jörnéus L, Jemt T, Carlsson L. Loads and designs of screw joints for single crowns supported by osseointegrated implants. Int J Oral Maxillofac Implants. 1991;7(3):353-9.
9. Dellinges MA, Tebrock OC. A measurement of torque values obtained with hand-held drivers in a simulated clinical setting. J Prosthodont. 1993;2(4):212-4.
10. Quirynen M, De Soete M, van Steenberghe D. Infectious risks for oral implants: a review of the literature. Clin Oral Implants Res. 2002;13(1):1-19.
11. Jansen VK, Conrads G, Richter EJ. Microbial leakage and marginal fit of the implant-abutment interface. Int J Oral Maxillofac Implants. 1997;12(4):527-40.
12. Guindy JS, Besimo CE, Besimo R, Schiel H, Meyer J. Bacterial leakage into and from prefabricated screw-retained implant-borne crowns in vitro. J Oral Rehabil. 1998;25(6):403-8.

13. Broggini N, McManus LM, Hermann JS, Medina RU, Oates TW, Schenk RK et al. Persistent acute inflammation at the implant-abutment interface. J Dent Res. 2003;82(3):232-7.
14. Carr AB. Comparison of impression techniques for a five-implant mandibular model. Int J Oral Maxillofac Implants. 1991;6(4):448-55.
15. Choi JH, Lim YJ, Yim SH, Kim CW. Evaluation of the accuracy of implant-level impression techniques for internal-connection implant prostheses in parallel and divergent models. Int J Oral Maxillofac Implants. 2007;22(5):761-8.
16. Assif D, Nissan J, Varsano I, Singer A. Accuracy of implant impression splinted techniques: effect of splinting material. Int J Oral Maxillofac Implants. 1999;14(6):885-8.
17. Wenz HJ, Hertrampf K. Accuracy of impressions and casts using different implant impression techniques in a multi-implant system with an internal hex connection. Int J Oral Maxillofac Implants. 2008;23(1):39-47.
18. Walker MP, Ries D, Borello B. Implant cast accuracy as a function of impression techniques and impression material viscosity. Int J Oral Maxillofac Implants. 2008;23(4):669-74.
19. Del'Acqua MA, Arioli-Filho JN, Compagnoni MA, Mollo Fde A, Jr. Accuracy of impression and pouring techniques for an implant-supported prosthesis. Int J Oral Maxillofac Implants. 2008;23(2):226-36.
20. Vigolo P, Millstein PL. Evaluation of master cast techniques for multiple abutment implant prostheses. Int J Oral Maxillofac Implants. 1993;8(4):439-46.
21. Jemt T. How do you test a cast framework fit for a full-arch fixed implant-supported prosthesis? Int J Oral Maxillofac Implants. 1994;9:471-2.
22. May KB, Edge MJ, Lang BR, Wang RF. The Periotest method: implant-supported framework precision of fit evaluation. J Prosthodont. 1996;5(3):206-13.
23. Binon PP. Evaluation of machining accuracy and consistency of selected implants, standard abutments, and laboratory analogs. Int J Prosthodont. 1995;8(2):162-78.
24. Sorensen JA. A standardized method for determination of crown margin fidelity. J Prosthet Dent. 1990;64(1):18-24.
25. Lie A, Jemt T. Photogrammetric measurements of implant positions. Description of a technique to determine the fit between implants and superstructures. Clin Oral Implants Res. 1994;5(1):30-6.
26. Klinge B, Petersson A, Maly P. Location of the mandibular canal: comparison of macroscopic findings, conventional radiography, and computed tomography. Int J Oral Maxillofac Implants. 1989;4(4):327-32.
27. Gher ME, Richardson AC. The accuracy of dental radiographic techniques used for evaluation of implant fixture placement. Int J Periodontics Restorative Dent. 1995;15(3):268-83.
28. Dula K, Mini R, van der Stelt PF, Buser D. The radiographic assessment of implant patients: decision-making criteria. Int J Oral Maxillofac Implants. 2001;16(1):80-9.
29. Cameron SM, Joyce A, Brousseau JS, Parker MH. Radiographic verification of implant abutment seating. J Prosthet Dent. 1998;79(3):298-303.
30. 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(1):77-85.
31. 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(4):807-15.
32. Papavassiliou H, Kourtis S, Katerelou J, Chronopoulos V. Radiographical evaluation of the gap at the implant-abutment interface. J Esthet Restor Dent. 2010;22(4):235-50.
33. 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(8):681-7.
34. Lazarchik D, Firestone A, Heaven T, Filler S, Lussi A. Radiographic evaluation of occlusal caries: effect of training and experience. Caries research. 1995;29(5):355-8.
35. Price C, Ergül N. A comparison of a film-based and a direct digital dental radiographic system using a proximal caries model. Dentomaxillofac Radiol. 1997;26(1):45-52.
36. Firestone A, Lussi A, Weems R, Heaven T. The effect of experience and training on the diagnosis of approximal coronal caries from bitewing radiographs. A Swiss-American comparison. Schweizer Monatsschrift fur Zahnmedizin= Revue mensuelle suisse d'odonto-stomatologie= Rivista mensile svizzera di odontologia e stomatologia/SSO. 1993;104(6):719-23.
37. Mileman PA, van den Hout WB. Comparing the accuracy of Dutch dentists and dental students in the radiographic diagnosis of dentinal caries. Dentomaxillofac Radiol. 2002;31(1):7-14.
38. Schropp L, Stavropoulos A, Spin-Neto R, Wenzel A. Implant image quality in dental radiographs recorded using a customized imaging guide or a standard film holder. Clin Oral Implants Res. 2012;23(1):55-9.
39. Zulqarnain BJ, Almas K. Effect of X-ray beam vertical angulation on radiographic assessment of alveolar crest level. Indian J Dent Res. 1998;9(4):132-8.
40. Hollender L, Rockler B. Radiographic evaluation of osseointegrated implants of the jaws. Experimental study of the influence of radiographic techniques on the measurement of the relation between the implant and bone. Dentomaxillofac Radiol. 1980;9(2):91-5.
41. Duarte GV, Oliveira-Santos C, Bonfim P, Crusoé-Rebello I. Assessment of conventional and digital radiographic methods in the diagnosis of marginal fit of the implant-abutment interface. Int J Dent. 2011;10:56-61.

Please cite this paper as: Alikhasi M, Siadat H, Mehraban Hassani S, Tabatabaee E. Radiographic Evaluation of Implant Impression Component Misfit. Regen Reconstr Restor. 2016; 1(1): 31-5. DOI: 10.7508/rrr.2016.01.007.