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Research Article

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Evaluating the Accuracy of Periapical Radiography in Determining Bone Level Around Dental Implants: A Cross-Sectional Study

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ABSTRACT

Objective: This study aimed to determine the accuracy of parallel periapical radiographs in the determination of peri-implant bone levels.

Methods: This cross-sectional study was performed on 154 patients who received dental implants. Bone level (the distance from the marginal bone to the shoulder of implants) was measured clinically by a probe and radiographically in a parallel peri-apical image immediately and four months after the placement of the dental implants (the recovery surgery). Data were analyzed by SPSS version 24.0 and MedCalc software version 18.9.1 using Bland–Altman plot and Intraclass Correlation Coefficient at the significance level of 0.05.

Results: The radiographic measurements of bone level were significantly lower than the clinical measurements on mesial and distal sides, immediately and four months after the placement of the dental implants. The differences between clinical and radiographic measurements were only significant in the posterior segment. So, the radiographic measurements of bone level were significantly lower than the clinical measurements in the posterior segment.

Conclusion: Although radiographic assessment is an acceptable measure to determine peri-implantitis and evaluate the bone level, the measurements in radiographs are underestimated.

Keywords: Bone Loss, Dental Implant, Intraoral Radiography

Background

Dental implants are one of the most successful aspects of modern dentistry, yet the biological and technical complexities of this treatment can sometimes lead to failure or complications. Some factors affect the success rate of dental implants such as osteointegration, the crestal bone level, etc [1-3]. The presence of stabilized crestal bone level guarantees the long-term function and survival of dental implants [4]. In fact, continuous crestal bone resorption is a threat to the success and survival of implant treatments [4,5].

Different methods were introduced to detect crestal bone loss around the dental implants, of which, radiographic assessments can be mentioned [6,7]. An acceptable measure to determine peri-implantitis is radiographic images provided by panoramic, cone beam computed tomography (CBCT), or intraoral peri-apical techniques [6,8].

Panoramic images only provide information about the mesial and distal sites of dental implants, they also, underestimate smaller defects and overestimate larger defects. CBCT can be used to overcome these drawbacks as it is more accurate and can reconstruct all sites around dental implants. However, the

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presence of metal artifacts and higher radiation doses (compared to 2D imaging techniques) are the disadvantages of CBCT [7-11].

Intraoral peri-apical images can help assess the alveolar bone around teeth and dental implants. Parallel peri-apical images have acceptable resolution with the least possible distortion. Also, they require lower radiation dosage compared to 3D imaging techniques [12-15]. Gedik et al. found that the assessments in 53% of peri-apical images were accurate while in panoramic assessments only 17% were accurate [16].

The accuracy of radiography in measuring the bone level around dental implants was assessed in previous studies [17-23]. As their results were inconsistent, this study was performed to determine the accuracy of parallel periapical radiographs in the determination of peri-implant bone level.

Materials and Methods

In this cross-sectional study, 154 patients referring to a dental clinic were assessed. The patients were included if they received dental implants in the last four months. Patients requiring mucoperiosteal flap to place the dental implants, requiring bone graft materials, receiving temporary prosthesis, or patients whose dental implants were immediately loaded, were excluded from the study.

This study was designed and performed according to the STROBE statement. The ethical code was obtained from the ethics committee of the university. All patients signed a written consent and then underwent dental implant surgery at the anterior segment (incisors and canines) or the posterior segment (premolars and molars).

To estimate the sample size, the statistical power was considered 80%, the error level was considered 0.05, the standard deviation was equal to 1.55 and d was equal to 0.35. The following formula was applied:

$$n = \frac{\left(z_{1-\frac{\alpha}{2}} + z_{1-\beta}\right)^2 \left(\sigma^2\right)}{\left(d\right)^2} = \frac{\left(1.96 + 0.84\right)^2 \left(1.55\right)^2}{\left(0.35\right)^2} = 153.76 \cong 154$$

Bone levels around the dental implants were measured clinically and radiographically immediately after the placement of the dental implants (the implant surgery) and four months after the placement of the dental implants (the recovery surgery).

To clinically measure the level of bone around the dental implant, the distance from the marginal bone to the shoulder of implants was recorded in mesial and distal sites using a periodontal probe (CP-12/thin Williams' color-coded probe, Hu-Friedy, Chicago, IL, USA).

To radiographically measure the level of bone around the dental implant, one peri-apical radiograph was obtained at the baseline and one after the recovery surgery; and the distance from the marginal bone to the shoulder of implants was measured in the mesial and distal sites in the radiographs.

The periapical radiographs were obtained using the long cone parallel technique by the VistaScan equipment (70 kV, 8 mA, 300 mm focus-film distance, and 0.2 s exposure time; VistaScan, Dürr Dental GmbH & Co. KG, Germany). The radiographs were scanned under dim lighting conditions using software (Viewbox© version 4.1.0.10, dHAL Software, Kifissia, Greece). The software settings were the same for all the radiographs. (Resolution of 25 LP/mm, gamma preset of 1.00, and without software plugins).

In clinical and radiographical assessments, if the marginal bone was more coronally than the dental implant shoulder, the measurement of the bone level was considered positive. If the marginal bone was more cervically than the dental implant shoulder, the measurement of the bone level was recorded as negative. If the marginal bone was the same level as the dental implant shoulder, the measurement of the bone level was reported as zero. All measurements were recorded by one calibrated dentist.

Data were analyzed by SPSS version 24.0 (IBM Corp, Armonk, NY, USA) and MedCalc software version 18.9.1 (MedCalc, Ostend, Belgium) using the Bland–Altman plot and Intraclass Correlation Coefficient. The significance level was 0.05.

Results

In this study, 308 peri-apical radiographs were assessed; 154 (50%) images belonged to the first stage of surgery, and 154 (50%) images belonged to the recovery surgery. 234 images (76%) were obtained from dental implants in the posterior segment and 74 images (24%) were obtained from dental implants in the anterior segment. The clinical and radiographic measurements of the bone level at the distal and mesial sites after the implant and recovery surgery were compared. (Table1)

Table 1: The Comparison of Bone Level Obtained from the Clinical and Radiographic Assessments After the Implant Surgery and the Recovery Surgery.

The differences between clinical and radiographic measurements (in mm)			P value	Comparison
At the implant surgery	Distal	0.51	0.002*	Radiographic < Clinical
	Mesial	0.52	<0.001*	Radiographic < Clinical
At the recovery surgery	Distal	0.51	0.002*	Radiographic < Clinical
	Mesial	0.50	0.004*	Radiographic < Clinical

*Significant

The differences between clinical and radiographic measurements after the implant surgery were significant at both mesial and distal sites. The same significant finding was reported between clinical and radiographic measurements at both mesial and distal sites after the recovery surgery. So, the radiographic measurements of bone level were significantly lower than the clinical measurements after the implant surgery and the recovery surgery.

The clinical and radiographic measurements of the bone level at the distal and mesial sites were compared according to the oral segment. (Table2) The differences between clinical and radiographic measurements were only significant in the posterior segment (in both mesial and distal sites). So, the radiographic measurements of bone level were significantly lower than the clinical measurements in the posterior segment.

Table 2: The Comparison of Bone Levels Obtained from the Clinical and Radiographic Assessments in the Anterior and Posterior Segments.

The differences between clinical and radiographic measurements (in mm)			P value	Comparison
Anterior oral segment	Distal	0.004	0.957	Radiographic = Clinical
	Mesial	0.34	0.082	Radiographic ≃ Clinical
Posterior oral segment	Distal	0.52	<0.001*	Radiographic < Clinical
	Mesial	0.56	<0.001*	Radiographic < Clinical

*Significant

Discussion

This study aimed to determine the accuracy of parallel peri-apical radiography in determining the bone level around the implant compared to clinical measures. The selection of the periapical radiography technique was based on the results of a clinical trial study conducted by Neto et al. and Dave et al. claimed that the use of periapical radiography is preferable to other radiographic procedures such as CBCT when assessing the bone around the dental implants [17,18].

The current study showed that in both mesial and distal surfaces, the overall error was about 0.5mm between the radiographic and clinical assessments. Also, the results showed that the radiographic assessments underestimated the bone level compared to the clinical measurements. It can be concluded that radiographic assessment is an acceptable measure to determine peri-implantitis and evaluate bone level.

Smet et al. (2003) assessed the accuracy of radiographs in measuring the marginal bone level around oral implants in the canine and premolar region of the left mandible of human cadavers. In line with the current study, Smet et al. stated that radiography had an overall error of less than 0.5 mm compared to clinical measurements. Their results showed that intra-oral images underestimate bone level. They also concluded that radiography techniques show an acceptable accuracy for peri-implant bone level measurements [19].

In another study, Ritter et al. (2014) compared the accuracy of bone defects in intra-oral radiography and also histology assessment. In their study, 26 implants were placed in 12 jaws of dogs and then the crestal bone level, as well as bone defects, were examined radiographically and histologically. The mean bone level was 0.84 mm (±1.00 mm) in peri-apical radiography and 1.23 mm (±0.57 mm) in histology. Similar to the current study, Ritter et al. reported that the mean differences between radiographic and histological measures were about 0.06 mm. Ritter et al. claimed that although assessments in radiography are underestimated compared to clinical assessments, radiography is a reliable measure to assess bone defects [20].

Serino et al. conducted a clinical trial on 46 dental implants in 24 patients. Serino et al. examined the rate of bone loss around dental implants intraorally during the surgery and also in the radiographs (parallel periapical technique). In agreement with our study, the mean bone loss measured on radiographs was underestimated. The mean difference between radiographic and clinical measures was 0.7 mm at the mesial and 0.6 mm at the distal site [21].

Cassetta et al. (2018) examined whether periapical radiographs are reliable for determining changes in the crest bone around the implant. In their study, 268 implants were examined in 142 patients. The bone level during the implant surgery was measured by a periodontal probe as well as by intraoral radiography. The parallel PA technique was used for radiographic examination. Cassetta et al. stated that in intraoral radiography with a parallel technique, the bone level around the implant is increased compared to the clinical measurements. Cassetta et al. reported that although radiography overestimates the bone level, periapical radiographs are reliable. The results of Cassetta et al. were consistent with our study regarding the reliability of bone level changes shown in periapical radiographs but were inconsistent with our result about the overestimation of radiography. This discrepancy may be due to different inclusion criteria, measuring methods, and statistical tests [22].

Christiaens et al. (2017) identified in their study the accuracy of intraoral radiography and clinical measures in the assessment of bone levels around implants with peri-implantitis. Their results found that intra-oral radiography underestimate the bone level by 2.3mm compared to probing measures. Christiaens et al. concluded that clinical assessments were a more reliable predictor for peri-implant bone level than radiography. The difference between the clinical and radiographic measures was less than 0.5 mm in the study of Smet et al., 0.5 mm in the current study, 0.06 mm in the study of Ritter et al., and 0.6 to 0.7 mm in the study of Serino et al. while this difference was about 2.3 mm in the study of Christiaens et al. [19-21,23].

These divergent results may be due to different study populations. The bone level around dental implants was assessed in human cadavers in the study of Smet et al. and dogs in the study of Ritter et al. In contrast, in the current study and the study of Serino et al. and Christiaens et al., the bone level was measured around the dental implants in humans. However, in the current study and the study of Serino et al. dental implants were intact while in the study of Christiaens et al. dental implants with peri-implantitis were included [19-21,23]

Conclusion

Considering the limitation of this study, it can be concluded that although radiographic assessment is an acceptable measure to determine peri-implantitis and evaluate the bone level, the measurements in radiographs are underestimated.

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References

1. Hasegawa T, Sasaki A, Saito I, Arimoto S, Yatagai N, et al. Success of dental implants in patients with large bone defect and analysis of risk factors for implant failure: A non-randomized retrospective cohort study. Clinical Oral Investigations. 2022. 26: 2743-2750.
2. Heshmatpour F, Haghbin S. Nanohydroxyapatite/graphene oxide nanocomposites modified with synthetic polymers: promising materials for bone tissue engineering applications. International Journal of Polymeric Materials and Polymeric Biomaterials. 2021. 70: 585-591.
3. Tavakoli M, Yaghini J. Evaluation of effect of low-dose methotrexate on osseointegration of implants: a biomechanical study on dogs. The Open Dentistry Journal. 2018. 12: 546-554.
4. Zaki J, Yusuf N, El-Khadem A, Scholten RJ, Jenniskens K. Efficacy of bone-substitute materials use in immediate dental implant placement: A systematic review and meta-analysis. Clinical implant dentistry and related research. 2021. 23: 506-519.
5. Guo Y, Kono K, Suzuki Y, Ohkubo C, Zeng JY, et al. Influence of marginal bone resorption on two mini-implant-retained mandibular overdentures: An in vitro study. The Journal of Advanced Prosthodontics. 2021. 13: 55-64.
6. Beretta M, Maiorana C, Manfredini M, Signorino F, Poli PP, et al. Marginal Bone Resorption Around Dental Implants Placed in Alveolar Socket Preserved Sites: A 5 Years Follow-up Study. Journal of Maxillofacial and Oral Surgery. 2021. 20: 381-388.
7. Faegheh G, Khosravifard N, Maleki D, Hosseini SK. Evaluation of Palatal Bone Thickness and Its Relationship with Palatal Vault Depth for Mini-Implant Insertion Using Cone Beam Computed Tomography Images. Turkish Journal of Orthodontics. 2022. 35: 120-126.
8. Jacob JE, Balan A, Bose CT, Nabeel AK, Girija KL, et al. Evaluation of the spatial relationship of impacted mandibular third molar to mandibular canal using CBCT: A descriptive study. Journal of Indian Academy of Oral Medicine and Radiology. 2022. 34: 423-431.
9. Rad FO, Mousavi E, Musapoor N, Maleki D, Khatibi N. Prevalence of C-Shaped Canals in Anterior and Posterior Teeth of Iranian Population Using Cone Beam Computed Tomography. Avicenna Journal of Dental Research. 2020. 12: 58-62.
10. Kajan ZD, Maleki D, Soleimani BA, Malekzadeh M. Correlation of gingival phenotype and schneiderian membrane thickness: A cross-sectional study. European Journal of General Dentistry. 2020. 9:170-173.
11. Poovannan S, Sarumathi T. Prevalence and anatomic variations of lingual foramina and lingual canal in anterior mandible using cone beam computed tomography–A cross-sectional study. Journal of Indian Academy of Oral Medicine and Radiology. 2022. 34: 324-328.
12. Sarfaraz H, Shetty M, Harini K, Shetty SK, Amreen S, et al. Evaluation of the accuracy of measurements made at probable implant site using cone-beam computed tomography: A retrospective in vivo study. Journal of Indian Academy of Oral Medicine and Radiology. 2022. 34: 333-337.
13. Joy R, Kannan A, Lakshmi KC, Lakshminrusimhan DS, Roy A. Comparison of Cone Beam Computed Tomography Performance at Different Voxel Sizes in the Evaluation of Mandibular Canal–An In vitro Study. Journal of Indian Academy of Oral Medicine and Radiology. 2022. 34: 309-313.
14. Bansal V, Konidena A, Nagi R, Kataria AP, Yumnam N, et al. Correlation of pulp-to-tooth area ratio with age and gender using CBCT of maxillary central incisor and canine: A comparative study. Journal of Indian Academy of Oral Medicine and Radiology. 2022. 34: 87-94.
15. Madani ZS, Mahjoub Khatibani SP, Maleki D, Simdar N. The Radiographic Evaluation of Root Canal Morphology in Mandibular Premolars of an Iranian Population. Journal of Dentomaxillofacial Radiology, Pathology and Surgery. 2020. 9: 34-39.
16. Gedik R, Marakoglu I, Demirer S. Assessment of alveolar bone levels from bitewing, periapical and panoramic radiographs in periodontitis patients. West Indian Medical Journal. 2008. 57: 1-10.
17. Silveira-Neto N, Flores ME, De Carli JP, Costa MD, Matos FD, et al. Peri-implant assessment via cone beam computed tomography and digital periapical radiography: an ex vivo study. Clinics. 2017. 72: 708-713.
18. Dave M, Davies J, Wilson R, Palmer R. A comparison of cone beams computed tomography and conventional periapical radiography at detecting peri-implant bone defects. Clinical oral implants research. 2013. 24: 671-678.
19. De Smet E, Jacobs R, Gijbels F, Naert I. The accuracy and reliability of radiographic methods for the assessment of marginal bone level around oral implants. Dentomaxillofacial Radiology. 2002. 31:176-181.
20. Ritter L, Elger MC, Rothamel D, Fienitz T, Zinser M, et al. Accuracy of peri-implant bone evaluation using cone beam CT, digital intra-oral radiographs and histology. Dentomaxillofacial Radiology. 2014. 43: 20130088.
21. Serino G, Sato H, Holmes P, Turri A. Intra-surgical vs. radiographic bone level assessments in measuring peri-implant bone loss. Clinical oral implants research. 2017. 28: 1396-1400.
22. Cassetta M, Di Giorgio R, Barbato E. Are intraoral radiographs reliable in determining peri-implant marginal bone level changes? The correlation between open surgical measurements and peri-apical radiographs. International journal of oral and maxillofacial surgery. 2018. 47:1358-1364.
23. Christiaens V, Jacobs R, Dierens M, Vervaeke S, De Bruyn H, et al. Intraoral radiography lacks accuracy for the assessment of peri-implant bone level: a controlled clinical study. European Journal of Oral Implantology. 2017. 10: 435-441.