Radiographic Assessment of Peri-implant Bone Level – A Comparative Study of Digital Intraoral and Digital Panoramic Radiography

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SUMMARY

Introduction The objective of this study was to compare two radiographic methods – digital intraoral and digital panoramic radiography in assessing marginal bone level around dental implants. The study also evaluated inter-observer and intra-observer reliability during repeated assessments.

Material and Methods Marginal bone around 29 implants in 17 patients was assessed using standardized digital intraoral and digital panoramic radiographs. Two observers evaluated bone level by noting the thread at which marginal bone seemed to be attached at distal and mesial surfaces of the implants. The assessments were repeated after one week. Kappa statistics was used to evaluate agreement between assessments, observers, and radiographical methods.

Results The agreement rate between digital intraoral and digital panoramic radiography was fair. Intra-observer agreement was very good, while inter-observer agreement was moderate.

Conclusion Digital panoramic radiographs can be used to evaluate marginal bone level in patients with multiple implants and also to supplement intraoral radiographs. However, observer variability should be considered when comparing values from follow up studies for implant maintenance.

Keywords: dental implants; intraoral radiographs; marginal bone; panoramic radiographs; peri-implant bone level; observer agreement

INTRODUCTION

Rehabilitation of partial or complete edentulism using dental implants has become preferred method for replacement of missing teeth. The success of implants greatly depends on the marginal bone around the implant. Marginal bone loss of a maximum 1.5 mm is acceptable in the first year of implant placement followed by an annual bone loss not exceeding 0.2 mm [1, 2]. Thus, measurements of the marginal alveolar bone levels in standardized and serial radiographs are considered to be important parameters to determine implants prognosis.

Intraoral radiography using parallel technique has long been preferred method for measuring marginal bone level [3, 4]. Intraoral radiographs have higher resolution but are more time consuming. Moreover, anatomic considerations like shallow palate or raised floor of mouth make use of intraoral radiography difficult. In such cases, panoramic radiography can be utilized. Panoramic radiography allows wider coverage and also reveals relations between anatomic structures such as sinuses and neurovascular canals.

The aim of the study was to compare the ability of two radiographic methods: digital intraoral and digital panoramic radiographs in the assessment of marginal bone level around dental implants. The study also aimed to evaluate inter-observer and intra-observer reliability during repeated assessments.

MATERIAL AND METHODS

17 patients referred to the Department of Oral Radiology for follow up examination after treatment with dental implants were included in the study. All patients had implant surgery within last 6 months. Standardized intraoral digital radiographs using paralleling technique were taken with intraoral radiation unit (70 kvp) and cylindrical tubehead, 2.5 mm aluminium filtration and focal spot distance of 21 cm. Digital panoramic radiographs were obtained at the same appointment using Kodak 8000c unit following standard exposure and positioning protocol.

Two dental specialists (oral radiologist and oral surgeon) evaluated all images. The observers were asked to assess marginal bone level by counting the number of threads between the implant–abutment connection and the level of marginal bone on the mesial and distal surfaces of the implant. The first thread completely imaged was designated thread number 1. In cases of double marginal bone contour, assessments were made at the most apical level. 29 implants were evaluated. Assessments were repeated after 1 week by both observers in random order resulting in a total of 232 sites being evaluated.

Data was analysed using SPSS software 19. Kappa statistics was used to compare the agreement between assessments, observers and methods of radiography. Kappa values were evaluated as follows: <0.20 was considered poor, 0.21–0.40 fair, 0.41–0.60 moderate, 0.61–0.80 good and 0.81–1.00 very good. The total proportion of agreement was calculated as percentage [5].

RESULTS

A total of 232 observations were done for each method. The agreement rates for digital intraoral and digital panoramic radiography for the two observers varied from 36% to 52% (Table 1). Intra-observer agreement expressed as kappa value ranged from 0.86 to 0.95 for observer 1 and 0.87 to 0.94 for observer 2 (Table 2). The inter-observer

Table 1. Comparison of digital intraoral and digital panoramic radiography
Tabela 1. Poređenje digitalne intraoralne radiografije i digitalne ortopantomografije

Parameter Parametar	Observer 1 Istraživač 1		Observer 2 Istraživač 2	
	Reading 1 Merenje 1	Reading 2 Merenje 2	Reading 1 Merenje 1	Reading 2 Merenje 2
Agreement (%) Slaganje (%)	51.72	48.28	36.48	37.93
Kappa coefficient Koeficijent kapa	0.3994	0.3527	0.2091	0.2139
Weighted kappa coefficient Težinski koeficijent kapa	0.7201	0.7085	0.6045	0.6086

Table 2. Intra-observer agreement for digital intraoral radiography (DIR) and digital panoramic radiography (DPR)

Tabela 2. Slaganje ponovljenih merenja istog istraživača za digitalnu intraoralnu radiografiju (DIR) i digitalnu ortopantomografiju (DOP)

Parameter Parametar	Observer 1 Istraživač 1		Observer 2 Istraživač 2	
	DIR	DPR DOP	DIR	DPR DOP
Agreement (%) Slaganje (%)	89.66	96.55	96.43	90.63
Mean difference between repeated measurements Prosečna razlika između ponovljenih merenja	0.10344	0.0344	0.0312	0.1132
Kappa coefficient Koeficijent kapa	0.8676	0.9566	0.9411	0.8786
Weighted kappa coefficient Težinski koeficijent kapa	0.9469	0.9817	0.9790	0.9656

Table 3. Inter-observer agreement for digital intraoral radiography (DIR) and digital panoramic radiography (DPR)

Tabela 3. Slaganje različitih istraživača za digitalnu intraoralnu radiografiju (DIR) i digitalnu ortopantomografiju (DOP)

Parameter Parametar	Reading 1 Merenje 1		Reading 2 Merenje 2	
	DIR	DPR DOP	DIR	DPR DOP
Agreement (%) Slaganje (%)	62.07	65.52	55.17	62.07
Kappa coefficient Koeficijent kapa	0.5145	0.5586	0.4365	0.5246
Weighted kappa coefficient Težinski koeficijent kapa	0.8054	0.8192	0.7711	0.8022

agreement was moderate for both digital intraoral and panoramic methods (Table 3).

DISCUSSION

Replacement of missing teeth with implants is the best available prosthetic therapy. Intraoral and panoramic radiographs are commonly used to evaluate the marginal bone level during follow up after implant placement. This study assessed the agreement between digital intraoral and digital panoramic radiographs for evaluating peri-implant bone level. These radiographical methods were chosen to limit radiation dose received by the patient.

Agreement between the two assessed radiographical methods in the present study ranged from 36% to 52%. This agreement rate was fair according to the kappa statistics [5]. Similar agreement rate was reported by Kullman et al. [6]. However, Rohlin et al. [7] found higher agreement rate of 72% between panoramic and intraoral radiography. Other studies [8, 9, 10] have also stated that panoramic radiographs can be used reliably for the assessment of marginal bone. Also, mean difference between repeated measurements was close to zero.

The agreement rate was higher within observers (89.6% to 96.4%) compared with that between observers (55.1% to 65.5%). Based on kappa values, the agreement was very good when the same observer repeated the assessments. However, inter-observer agreement was found to be moderate. Molander et al. [9] demonstrated lower intra-observer agreement rate but similar inter-observer agreement. The inter-observer agreement was higher for panoramic radiography than for intraoral radiographs. This is in accordance with findings of Kullman et al. [6] and De Smet et al. [3], but contrary to the findings of Mörner-Svalling et al. [11], who reported high inter-observer agreement of around 85% for intraoral digital and conventional radiographs.

The current study included assessment by two observers as well as repeated assessments by each observer after a gap of at least 1 week. This was done in accordance to Kullman et al. [6], who recommended using more than one observer to avoid bias of individual observers. Implant thread number was used to evaluate marginal bone instead of measuring distance in mm from implant abutment. Counting number of threads is the most commonly used in everyday practice. Moreover, different magnifica-

tion factors of the two radiographic methods will not affect the evaluation when counting implant threads, therefore that is recommended method for the evaluation of peri-implant bone level [12].

CONCLUSION

Agreement between digital intraoral and digital panoramic radiograph is fair and panoramic radiographs have acceptable accuracy for the evaluation of marginal bone levels around implants. As panoramic radiography is cost effective, time saving and has low radiation dose, it can be used to evaluate marginal bone level in patients with multiple implants and also to supplement intraoral radiographs when required. However, observer variability should be considered when comparing values from follow up studies for implant maintenance.

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Radiografska procena kosti oko zubnih implantata – studija poređenja digitalne intraoralne radiografije i digitalne ortopantomografije

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KRATAK SADRŽAJ

Uvod Cilj rada je bio da se uporede dve radiografske metode – digitalna intraoralna radiografija i digitalna ortopantomografija u proceni kosti oko dentalnih implantata. Upoređivana je i saglasnost istraživača prilikom procene, i to jednog istraživača u ponovljenim merenjima, kao i dva različita istraživača.

Materijal i metode rada Primenom standardizovane digitalne intraoralne radiografije i digitalne ortopantomografije procenjena je marginalna kost oko 29 implantata kod 17 pacijenata. Dva istraživača su ocenjivala nivo kosti procenjujući marginalnu kost koja je pripojena na mezijalnoj i distalnoj površini implantata. Merenje je ponovljeno nakon nedelju dana. Za procenu saglasnosti između merenja, istraživača i metode radiografije korišćena je kapa statistika.

Rezultati Uočena je dobra saglasnost između digitalne intraoralne radiografije i digitalne ortopantomografije. Takođe, saglasnost između ponovljenih merenja istog istraživača bila je vrlo dobra, dok je saglasnost merenja različitih istraživača bila umerena.

Zaključak Digitalna ortopantomografija može se koristiti za procenu marginalne kosti kod više dentalnih implantata i kao dopuna intraoralnoj radiografiji. Međutim, treba uzeti u obzir varijabilnost istraživača kada se upoređuju merenja u različitom periodu.

Glavne reči: dentalni implantati; intraoralna radiografija; marginalna kost; ortopantomografija; nivo periimplantantne kosti; slaganje istraživača

UVOD

Rehabilitacija delimične ili potpune bezubosti pomoću zubnih implantata je postala najbolji način za nadoknadu zuba koji nedostaju. Uspeh implantacije u velikoj meri zavisi od marginalne kosti oko implantata. Gubitak marginalne koštane mase od najviše 1,5 mm je prihvatljiv u prvoj godini nakon ugradnje implantata sa dodatnim godišnjim gubitkom koštane mase ne većim od 0,2 mm [1, 2]. Zato se merenje nivoa marginalne alveolarne kosti u standardizovanim i serijskim radiografijama smatra važnim parametrom za prognozu zubnog implantata.

Intraoralna radiografija, uz primenu paralelne tehnike, koristi se kao najbolji način za merenje nivoa marginalne kosti [3, 4]. Intraoralna radiografija ima veću rezoluciju, ali zahteva više vremena. Osim toga, anatomske varijacije, kao što su plitko nepce ili podignuti pod usta, čine intraoralnu radiografiju teškom ili čak nemogućom. U takvim slučajevima ortopantomografija može biti korisna. Panoramska radiografija omogućuje da se vide veća površina tkiva i odnosi između anatomske strukture, kao što su sinusi i neurovaskularni kanali.

Cilj ove studije bio je da se uporedi sposobnost dve radiografske metode, digitalne intraoralne radiografije i digitalne ortopantomografije, u proceni nivoa marginalne kosti oko dentalnih implantata. Takođe je procenjeno slaganje između ponovljenih merenja istog istraživača, odnosno saglasnost različitih istraživača.

MATERIJAL I METODE RADA

U studiju je bilo uključeno 17 pacijenata s Klinike za oralnu radiologiju koji su zahtevali kontrolu nakon ugradnje dentalnih implantata. Svi pacijenti su podvrgnuti dentalnoj implantaciji u

poslednjih šest meseci. Standardizovani intraoralni radiogrami su dobijeni koristeći paralelnu tehniku i zračenje od 70 KVP sa cilindričnom RTG cevi, 2,5 mm aluminijumske filtracije i žarišne tačke udaljenosti 21 cm. Digitalni panoramski radiogrami su dobijeni tokom iste posete koristeći rendgenski aparat Kodak 8000C, standardnu ekspoziciju i protokol za pozicioniranje.

Dvoje specijalista stomatologije (oralni radiolog i oralni hirurrg) ocenjivali su dobijene snimke. Marginalna kost je ocenjivana brojanjem koštanih niti između veze implantata i supstrukture i kosti na mezijalnoj i distalnoj površini implantata. Prva nit koja je prikazana u celosti je posmatrana kao broj 1. U slučajevima dvostruke konture marginalne kosti procena je vršena na najapikalnijem nivou. Ukupno je procenjeno 29 implantata. Merenje je ponovljeno posle nedelju dana, tako da su ukupno izvedena 232 merenja.

Podaci su analizirani pomoću statističkog programa SPSS ver. 19. Kapa (kappa) statistika je korišćena za poređenje saglasnosti između metoda radiografije i istraživača. Vrednosti koeficijenta κ su ocenjeni kao: loše slaganje ($<0,20$), dovoljno ($0,21-0,40$), umereno ($0,41-0,60$), dobro ($0,61-0,80$) i vrlo dobro slaganje ($0,81-1,00$). Ukupno slaganje je predstavljeno u procentima [5].

REZULTATI

Ukupno su izvedena 232 merenja za svaku metodu. Procenat saglasnosti za digitalnu intraoralnu i digitalnu ortopantomografiju za dva istraživača bio je od 36% do 52% (Tabela 1). Saglasnost merenja istih istraživača izražena kao vrednost koeficijenta κ bila je u rasponu 0,86–0,95 za istraživača 1 i 0,87–0,94 za istraživača 2 (Tabela 2). Saglasnost između digitalne intraoralne i panoramske radiografije bila je umerena (Tabela 3).

DISKUSIJA

Zubni implantati su najbolji način protetičke terapije nakon gubitka zuba. Intraoralna radiografija i ortopantomografija se obično koriste za procenu nivoa marginalne kosti nakon ugradnje implantata. Cilj naše studije je bio da se utvrdi slaganje između digitalne intraoralne radiografije i digitalne ortopantomografije u proceni nivoa kosti oko zubnih implantata. Ove radiološke metode su izabrane da bi se ograničila doza zračenja kojoj je pacijent izložen.

Saglasnost između testiranih radioloških metoda bila je u rasponu od 36% do 52%. Ova stopa saglasnosti je bila dovoljna prema koeficijentu κ [5]. Kulman (*Kullman*) i saradnici [6] su utvrdili sličnu stopu saglasnosti između ovih istih metoda. Međutim, Rolin (*Rohlin*) i saradnici [7] su zabeležili veću stopu saglasnosti (72%) između ortopantomografije u intraoralne radiografije. Druge studije su takođe potvrdile da ortopantomografija može biti korišćena kao pouzdana metoda u proceni marginalne kosti [8, 9, 10]. Takođe, prosečna razlika između ponovljenih merenja je bila blizu nule.

Procenat saglasnosti je bio veći za svakog od dva istraživača (89,6–96,4%) u odnosu na saglasnost između dva različita istraživača (55,1–65,5%). Koeficijent κ je potvrdio dobru saglasnost između ponovljenih merenja istog istraživača. Međutim, saglasnost između različitih istraživača je bila umerena. Molander (*Molander*) i saradnici [9] su uočili niži procenat saglasnosti između ponovljenih merenja istog istraživača, ali sličan procenat između različitih istraživača u poređenju s ovom studijom. Saglasnost između istraživača bila je veća za ortopantomografiju u odnosu na intraoralnu radiografiju. Ovakav rezultat je u skladu s nalazima Kulmana i saradnika [6] i De Smeta (*De Smet*) i saradnika [3], ali u suprotnosti s nalazima Merner-Svalingove (*Mörner-Svalling*) i saradnika [11], koji su ustanovili visok procenat saglasnost između istraživača (oko 85%) za intraoralnu digitalnu i konvencionalnu radiografiju.

Ova studija je obuhvatila procenu saglasnost merenja dva istraživača, kao i ponovljenih merenja svakog istraživača nakon pauze od najmanje nedelju dana. Ovakvo istraživanje je izvedeno u skladu s nalazom Kulmana i saradnika [6], koji su preporučili više od jednog istraživača da bi se izbegla pristranost. Broj koštanih niti oko implantata je korišćen za procenu marginalne kosti umesto merenja razdaljine (u milimetrima) od spoja implantata sa suprastrukturom do vrha kosti. Brojanje niti se češće koristi u svakodnevnoj praksi. Osim toga, različiti faktori uvećanja ove dve radiografske metode ne utiču na brojanje koštanih niti; stoga je preporučena metoda za procenu nivoa periimplantatne kosti [12].

ZAKLJUČAK

Saglasnost između digitalne intraoralne i digitalne ortopantomografije je dovoljna i panoramska radiografija ima prihvatljivu preciznost u oceni nivoa marginalne kosti oko zubnih implantata. S obzirom na to da je ortopantomografija isplativija, brža i zahteva manju dozu zračenja, ona se može koristiti u proceni nivoa marginalne kosti kod pacijenata s višestrukim implantatima, ali i kao dopuna intraoralnoj radiografiji kada je potrebno. Međutim, treba uzeti u obzir varijabilnost istraživača kada se porede vrednosti dobijene tokom postoperacionog praćenja.

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