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RESEARCH ARTICLE

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ASSESSMENT OF THE IMPLANT-ABUTMENT INTERFACE IN PERIAPICAL, BITEWING AND PANORAMIC RADIOGRAPHS

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ABSTRACT

Introduction: Lack of adaptationmay lead to failures of the prosthetic and implant components. **Objectives:** This study aimed to assess the implant-abutment interface (IAI) through periapical, bitewing and panoramic radiographs. **Methods:** The sample consisted of five mandible phantoms in which ten external hexagon implants and ten abutmentswere installed.The implants were positioned in the region of the mandibular first molar with IAI of 0.25mm and 0.50mm. Periapical, bitewing and panoramic radiographs (n=130) were obtained from the implants and were presented to three examiners for the assessment of the IAI. Mann-Whitney test was applied to investigate the influence of the IAI size on its assessment in radiographs. G- and Kruskal-Wallis test were applied to verify the performance of each type of radiograph in the assessment of the IAI. Inter-examiner reproducibility was quantified with Kappa statistics. Statistical significance was set at 5%. **Results:** The assessment of the IAI was not statistically different between the different types of radiographs ($p>0.05$). This outcomes was consistent both for IAI of 0.25mm ($p=0.073$) and 0.50mm ($p=0.080$). Statistically significant differences were observed only when the anatomic position of the implants was changed. **Conclusion:** These findings indicate that detection of IAI in radiographs depends on the position of the implant in the dental arch. Further studies are encouraged to assess the effectiveness of different types of radiographs and imaging modalities in different region of the dental arch.

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INTRODUCTION

The lack of adaptation in the implant-abutment interface (IAI) is an undesired clinical outcome that may lead to fractures of the prosthetic and implant components, unbalanced distribution of forces in the adjacent bone, and the accumulation of bacteria followed by a negative impact on osseointegration (Assenza, 2012; Dias, 2012; Karl, 2014). In 1983, Branemark was the first to set the ideal passive fit between implant components, which should not exceed openings of 10µm. However, such precise fit remains a challenging task in the clinical practice – if not utopia. Currently, clinically acceptable tolerance limits for microgaps in the IAI are not established to avoid mechanic or biological damages (Hecker, 2003). Previous studies on the field showed that clinical approaches, such as the use of elastomeric impression materials and dental probes, might not be accurate enough to assess the IAI (Jahangiri, 2005).

In this context, the radiographic investigations figure as alternatives to assess the effectiveness of prosthetic rehabilitations with dental implants. Panoramic and periapical radiographs are the most common techniques applied to assess the IAI. However, their performance may vary depending on the anatomy of the maxilla and mandible, as well on the size of the microgap in the IAI and the position of the implant in relation to the radiation beam (Papavassiliou, 2010). The present study aimed to assess the IAI within periapical, bitewing and panoramic radiographs. Additionally, the different radiographs were tested on their performance to detect different sizes of microgaps in the IAI.

MATERIAL AND METHODS

This study was conducted after the approval of the local Committee of Ethics in Research (protocol number: 2015/0499).

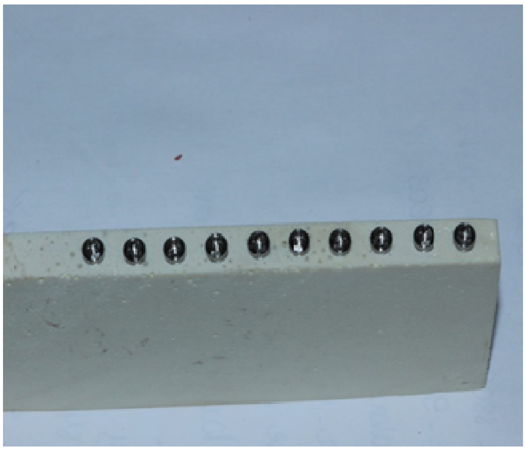

Figure 1- Implants placed in test body.

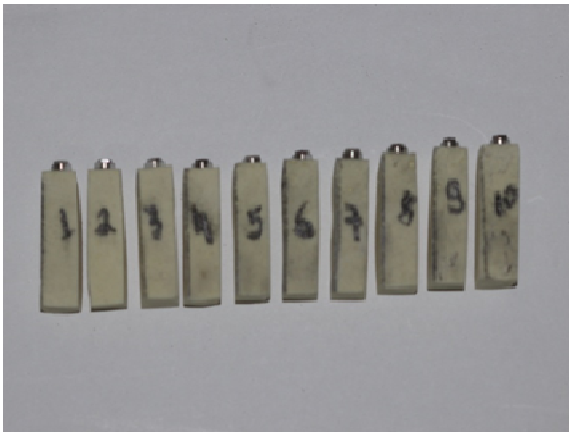

Figure 2. Test bodies numbered

Figure 3. Test bodies positioned in the mandibles

The study sample consisted of five mandible phantoms (Nacional OssosLtda, Jaú, SP, Brazil) in which ten external hexagon implants (4x13mm) and ten abutments (Implacil De Bortoli, São Paulo, SP, Brazil) were installed. Using a BLM 500 driller (VKDriller, Jaguaré, SP, Brazil) the implants were positioned in the region of the mandibular first molar bilaterally with IAI of 0.25mm and 0.50mm (Figure 1, 2 and 3). Radiographs were taken from each mandible using the Spectro 70X (DabiAtlante S. A., IndústriasMédico-Odontológicas, Ribeirão Preto, SP, Brazil) and the Orthopantomograph OP300 (Instrumentarium Dental, Tuusula, Finland) devices within six different techniques: I) periapical radiograph with a standard positioning device; II) bitewing radiograph with a standard positioning device; III) periapical

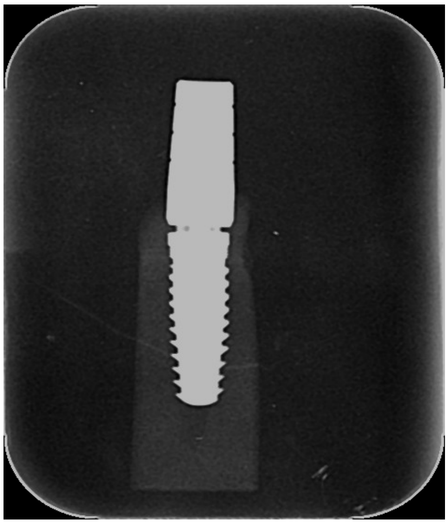

Figure 4 - Periapical radiograph of gold standard test body with 0.50mm gap

Figure 5. Periapical radiograph with 0.25 mm gap.

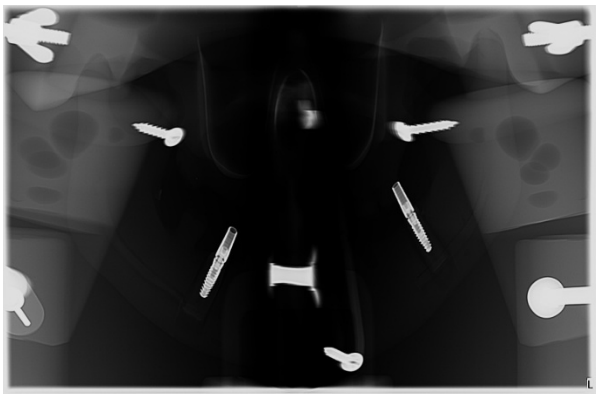

Figure 6. Panoramic radiograph of 0.5 mm gap bodies

Rinn; IV) bitewing Rinn; V) bisecting-angle periapical; and VI) panoramic radiograph. The radiographs (n=130) were registered in phosphor plates and read in the Scanner Express (Instrumentarium Dental, Tuusula Finland) device. Three examiners performed image analysis using Cliniview (Instrumentarium Dental, Tuusula Finland) software package. Images with no satisfactory quality were excluded from the sample. Re-sampling was performed replacing the implants among the phantom mandibles and enabling a new radiographic registration of the implants in different anatomic regions. Further on, in order to create a comparative standard reference, the implants with simulated microgaps (0.25 and 0.50mm) in the IAI were placed in acrylic resin block. Radiographs of these blocks were obtained and consisted of control images (Figure 4). Mann-Whitney test was applied to investigate the influence of the microgap size in the IAI on its detection in radiographs. G- and Kruskal-Wallis test were applied to verify the performance of each radiographic technique in the detection of the microgap in the IAI. Multiple comparisons were performed with Student-Newman-Keuls test. Inter-examiner reproducibility was quantified with Kappa statistics. Statistical tests were performed with SPSS 20.0 (IBM Corp., Armonk, NY, USA) and BioEstat 5.0 (FundaçãoMamirauá, Blém, PA, Brazil) software packages with significance set at 5%.

RESULTS

Mann-Whitney test showed that in all the radiographic techniques the detection of the microgaps in the IAI was not significantly ($p>0.05$) affected by its size (0.25 or 0.50mm) (Table 1). Kruskal-Wallis test revealed that the detection of microgaps of 0.25mm in the IAI was influenced by the radiographic technique. More specific, Student-Newman-Keuls test showed a statistically significant difference between the bitewing radiograph with a standard positioning device and the bisecting-angle periapical radiograph. However, none of these techniques differs from the control group. For the microgaps of 0.50mm no differences statistically significant ($p>0.05$) were observed between the radiographic techniques (Table 1). G-test showed no difference statistically significant in the quantity of implants detected with microgaps (0.25mm: $p = 0.077$; 0.50mm: $p = 0.251$) in the IAI in function of the different radiographic techniques (Table 2). Kappa statistics indicated that the inter-examiner reproducibility ranged between good (0.650) and optimal (0.836).

DISCUSSION

The microgaps formed in the IAI consist of critical and undesired outcomes of the improper placement of dental implants and their components. Clinically, the microgaps have a negative impact in the maintenance and durability of the implants in the oral cavity. The radiographic assessment of the IAI in the search for microgaps figures as an important step to follow-up patients that underwent oral rehabilitation. Testing the available radiographic techniques for the detection of microgaps in the IAI is essential towards the development of evidence-based practices in the clinical routine. The periapical, bitewing and panoramic radiographs were tested in the present study. The scientific literature describes theparalleling periapical radiograph as the ideal technique for taking intra-oral radiographs. This technique minimizes image distortion and incorporates better the principles of image formation. For optimal image registration, the paralleling periapical radiographs are taken with standard positioning devices[7]. In the present study, the radiographic techniques were performed with and without standard positioning devices. This procedure is justified to increase the range of techniques applied and to understand in practice the benefits of positioning devices. As highlighted in Table 1, the different radiographic techniques used in this study detected with no statistically significant differences the presence or absence of microgaps in the IAI. This outcome corroborates the importance of radiographic exams in the routine of Implantology and Oral Rehabilitation. Moreover, the position of the dental implants in the dental arch is also an aspect to be considered in the clinical practice, especially because it may lead to distortions during the process of image formation. Concerns on the anatomic position of dental implants and the formation of images were already raised by Papavassiliou et al. and must remain in additional studies in the field to support individual variations in the morphology of the maxilla and mandible in different patients.

Table 1 – Medians of the scores attributed to the presence or absence of gaps in the abutment-implant interface, according to the gap size and type of exam, and results of the Mann-Whitney and Kruskal-Wallis tests

Typeofexam	*Gap*		Mann-Whitney'stest
	0.25 mm	0.50 mm	
Control	1 Aab	0 Aa	*p = 0.117*
Panoramic	1Aab	1 Aa	*p = 0.706*
Periapical withpositioners	1 Aab	1 Aa	*p = 1.000*
Interproximalwithpositioners	0 Aa	1 Aa	*p = 0.257*
Periapical Rinn	1 Aab	1 Aa	*p = 0.706*
InterproximalRinn	1 Aab	1 Aa	*p = 0.257*
Bissetrixwithoutpositioners	1 Ab	1 Aa	*p = 0.131*
Kruskal-Wallis'stest	*p = 0.026*	*p = 0.518*	—

Medians followed by identical capital letters do not differ significantly within each line.
Medians followed by identical lowercase letters indicate no significant difference within the same column.

Table 2 - Absolute (n) and relative (%) frequencies of presence and absence of implant-abutment interface gap, according to gap size and type of exam

Typeofexam	*Gap*0.25 mm		*Gap*0.50 mm	
	Present	Absent	Present	Absent
Control	5 (100%)	0 (0%)	2 (40%)	3 (60%)
Panoramic	9 (90%)	1 (10%)	8 (80%)	2 (20%)
Periapical withpositioners	6 (60%)	4 (40%)	6 (60%)	4 (40%)
Interproximalwithpositioners	4 (40%)	6 (60%)	7 (70%)	3 (30%)
Periapical Rinn	5 (50%)	5 (50%)	6 (60%)	4 (40%)
InterproximalRinn	6 (60%)	4 (40%)	9 (90%)	1 (10%)
Bissetrixwithoutpositioners	6 (60%)	4 (40%)	9 (90%)	1 (10%)
Teste G	*p = 0.077*		*p = 0.251*	

Apart the position of the implants, Koutouzis et al. (2011) and Lin et al. (2013) indicate a high prevalence of microgaps in IAI in external and internal hexagon implants – which were used in the present study. More specifically, the authors explain that ideal sealing of the IAI is only achievable with conic implant systems. This statement triggers topics for further studies in the field.

In relation to further studies, it is important to note that the present investigation consisted of a controlled simulation of the radiographic detection of microgaps in the IAI in phantom mandibles. For outcomes closer to the clinical practiceanimal or human studies could be designed. These studies could contribute to understanding the tolerance levels of IAI microgaps in face of the potential clinical complications inherent to them. In parallel, other variables should be explore, such as the detection of microgaps in tilted implants (simulating a less controlled clinical performance).

Conclusion

The research outcomes showed that the radiographic detection of the microgaps simulated in the IAI was not significantly influenced by the different microgap sizes, namely 0.25mm and 0.50mm. Overall, the presence or absence of microgaps was detectable in all the radiographic techniques, namely the periapical, bitewing and panoramic radiographs. The assessment of microgaps in the IAI with periapical, bitewing and panoramic radiographs is encouraged in the clinical routine. Yet the choice for the best technique may depend on the position of the implants and well on the anatomy of the adjacent bone.

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