Change of Prevalence in Dental Implant Failures According to Different Criteria

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Abstract

To compare the occurrence of implant failures using proposed criteria in the literature by different authors, through retrospective clinical studies. One hundred and eleven patients, rehabilitated with 245 dental implants Straumann®, was clinically and radiographically evaluated for by the following parameters: mobility, persistent subjective complaints, recurrent peri-implant infection with suppuration, continuous radiolucent around the implant, probing depth ≥ 5 mm and bleeding on probing. These parameters were grouped by different authors. In the presence of either these criteria, the implant was considered as failure. The groups were categorized regarding the follow-up period after implant loading. A statistically significant difference (p<0.01) was found between different failure criteria used in this sample. This ratio ranged from 5.3% according to the Buser et al. 1990 criteria to 36.7% in accordance with Ong et al. [1] criteria. The presence of bleeding on probing was the item that most characterized the failure, being observed in 73 (19.8%) implants. It was concluded that there is difference in the occurrence of failure among the proposed criteria by Ong et al. [1] related to Schnitman et al. [2], Albrektsson and Isidor [3], Buser et al. [4] and Mombelli and Lang [5] criteria.

Keywords: Dental implants; Dental prosthesis; Peri-implantitis; Periodontal diseases

Introduction

Dental implants have revolutionized oral rehabilitation, dental prosthesis and maxillary reconstructions [1-3] and have become a predictable method for clinicians as well as patients. The success rate of osseointegration of dental implants is high, but it can be compromised by several biological and technical complications [4]; still remaining a small percentage of failed treatments [5], which must be carefully evaluated and prevented. However, osseointegration of dental implants is currently considered as a stable and lasting connection between the implant and the peri-implant tissue essential for its maintenance. If it does not occur, it is considered that there was a biological failure and, therefore, the loss of the implant [5].

Some biological and technical factors that can compromise the success of implant treatment have been reported in the literature including the medical conditions of the patient, infections, smoking, grafts, poor bone quality, advanced bone loss, excessive occlusal overload, unexpected implant fracture, macro/micro implant design and implant surface [6,7].

As the periodontal tissue is essential for the stability of the natural dentition, healthy peri-implant tissue is also essential for the long term stability of the dental implant. Over the years, emphasis was given to the technical, surgical and prosthetic procedures regarding dental implants. However, there is a lack of focus on basic supportive care and implants maintenance, which is essential to ensure the long-term success, similar to natural teeth [8].

Biological failures are related to peri-implant disease, which is a generic term relating to infectious reactions in tissues surrounding an implant in function, resulting in an inflammatory process [9]. Two conditions may be

distinguished: peri-implant mucositis and peri-implantitis. Peri-implant mucositis refers to a reversible inflammation of the peri-implant soft tissues without bone loss [10,11], corresponding, in basic terms, the gingivitis [12]. Meanwhile peri-implantitis is an inflammatory process around Osseo integrated dental implants which results in bone loss, affecting 5 to 10% of implant [11] and corresponds to adult periodontitis [10]. In relation to the diagnosis of peri-implant disease, periodontal probing is essential. An increase in the depth of the probe over time is associated with loss of attachment of the tissue and the underlying bone. The use of periodontal probe helps identify mucosal bleeding and suppuration while the alveolar bone is also monitored [8].

The literature points out several cases of successful implants in specific and diverse situations, as in cases that require bone grafts. However, it is also increasing the number of peri-mucositis and peri-implantitis reports as well as cases of treatment failure with loss of the implant. The results vary according to the criteria and definitions used by each author [12,13]. For instance, the definition of peri-implantitis and the criteria for the diagnosis are confusing in the previous literatures [14-16]. The reason for this confusion is the various types of implants, designs and procedures. The different selection of criteria for the peri-implantitis can give different prevalence, which can deliver incorrect understanding of the disease. Therefore, it is important to build an established definition and criteria for a certain disease.

The objective of this study was to compare whether there are differences between the failure occurrence rates of dental implants in the identical subjects groups according to the various established criteria in the literature by different authors.

Materials and Methods

This study was approved by the Ethics Committee in Research of the Federal University of Pernambuco-UFPE (Opinion 20932/CAAE 01219612.7.0000.5208). All volunteers agreed previously to participate in the study by signing the free and informed consent. A retrospective clinical study was conducted in patients rehabilitated with dental implants on the last 15 years at the Foundation for Scientific and Technological Development of Dentistry (Fundecto/USP), at the post-graduate in Implantology clinics. The data related to patients was collected through anamnesis. Regarding to implants, the following information was collected through clinical and radiographic examination: loading period, subjective complaints (pain, dysesthesia and foreign body sensation), mobility, in addition to periodontal and radiographic examination. The loading period of follow-up in years, was categorized into 3 groups: Group 1: <1 year; Group 2: ≥ 1 and <5 years and Group 3:≥ 5 years.

One hundred and fifty patients were called to participate in the study, 126 of these attended to the evaluation and 15 were excluded from the study (6 diabetics, 4 smokers, 3 total

edentulous and 2 with history of periodontitis). The sample consisted of 111 individuals and a total number of 245 implants, 13 bone levels and 232 tissue levels.

It was considered as inclusion criteria: patients who were ≥ 18 years old, partially edentulous and who were rehabilitated exclusively with well positioned Morse taper internal connection implant (Single crowns/bone and tissue level dental implants Straumann, Waldenburg, Switzerland), good health, negative medical history for chronic disease (diabetes mellitus, osteoporosis and cardiovascular disease) and no history of occlusal overload (bruxism and clenching). To avoid factors that could confuse the results of the study, smokers, patients with periodontitis history, who used grafts in the surgical procedure for implant placement, who used anticoagulant and chronic steroid medications, and who received radio or chemotherapy were excluded.

Anamnesis and clinical examination

All patients were evaluated by the same calibrated researcher. An interview based on clinical history was performed using a standardized questionnaire developed for the study. After anamnesis, the clinical parameters of probing depth (PD), bleeding on probing (BOP) and gingival recession (GR) were recorded for all implants. For this, a survey of four sites around each implant was performed using a periodontal probe PC15 (Trinity, Sao Paulo, Brazil).

Radiographs and bone loss

After the clinical examination, radiographs were taken of each implant using the parallelism technique (X-Ray Spectro 70X Seletronic, Dabi Atlante®, Voltage: 127/220, Power rating: 1,20 kVA, Power/Head: 70 kVP, Amperage/Head: 8 mA). For Bone Level implants, bone loss was calculated on the mesial and distal of each implant, from the junction of the prosthetic component to the level of the bone crest. For Tissue Level implants, bone loss was calculated from the most apical point of the transgingival portion of the implant to the bone crest level. This measure was used to observe the evaluation of vertical bone loss, as well as the presence of radiolucency around the implant. After the evaluation, control of biofilm was performed by the dentist and oral hygiene instructions were given to the patients.

Success criteria adopted

The dependent variable of this study was the failure of the implant. Thus, the success criteria used in this sample was based on widely cited studies in the literature **(Table 1)**, which have been proposed some clinical and radiographic criteria defined by Schnitman et al. [2], Albrektsson and Isidor [3] and adapted by Buser et al. [4] Mombelli et al. [5] Karoussis et al. [17], and Ong et al. [1], which includes several definitions of success in implants (including change in bone level). This study adopted the criteria proposed by Ong et al. [1] as standard.

Thus, the failure of the implants was considered when there was detection of any clinical or radiological criteria.

Table 1 Success criteria proposed by different authors.

Authors	Definition
Ong et al. [1]	Absence of mobility [4]; Absence of persistent subjective complaints (pain, foreign body sensation and/or diestesia) [4]; Absence of recurrent peri-implant infection with suppuration [4]; Absence of continuous radiolucency around the implant [4]; No probing depth ≥ 5 mm [5,12]; No bleeding on probing [5]; After the first year after loading, the annual vertical bone loss should not exceed 0.2 mm (mesial or distal) [3].
Mombelli et al. [5]	No probing depth ≥ 5 mm; No bleeding on probing.
Buser et al. [4]	Absence of mobility; Absence of subjective complaints (pain, foreign body sensation and /or diestesia); Absence of recurrent peri-implant infection with suppuration; Absence of radiolucency around the implant.
Albrektsson and Isidor [3]	Individual implant without mobility as clinically tested; Radiography do not show evidence of peri-implant radiolucency; bone loss lesser than 0.2 mm annually after the first year of loading; No pain, discomfort or persistent infection.
Schnitman et al. [2]	Mobility less than 1 mm in any direction; Radiolucency around the implant; bone loss lesser than a third of the implant height; treatable (reversible) gingival inflammation, absence of symptoms and infection, no damage to the adjacent tooth, absence of paresthesia or violation of the mandibular canal, maxillary sinus or floor of the nasal cavity.

Statistical analysis

After collection, the data were analyzed using Statistical Package Social Sciences software (SPSS) 20.0 trial version (IBM, Armonk, NY, USA). Descriptive analysis was performed using absolute and percentage of success criteria, age, gender, load period and failure. For inferential analysis, Chi-square test of adhesion between the failure variables, sex and loading period and Chi-square test between failure and the criteria by authors was used. Fisher exact test to analyze the success criteria individually in relation to the failure of Ong et al. [1] was used. The significance accepted was less than or equal to 0.05. The Kappa test was performed to evaluate the correlation between the criteria used by different authors in relation to failure.

Results

A number of 111 patients were examined, with a total of 245 implants, being 66.7% of females (n=74). The age ranged between 21 and 80 years old, with the average of 52.39. The loading period follow-up of the implants ranged from 4 months to 15 years; 48 implants (19.6%) belonged to Group 1; 103 implants (42%) to Group 2; 94 implants (38.4%) to Group 3.

Regarding the failure, statistically significant association was not found in relation to gender (p=0.24). The follow-up of loading period showed a statistically significant association with the failure of implants, where Group 1 presented 77.1% of failure, presenting the highest prevalence among the three groups (p<0.01) **(Table 2)**. 155 (63.3%) out of 245 implants were successful according to the criteria proposed by Ong et al. [1]. Bleeding on probing was detected in 73 implants, being the criterion that was most identified in the characterization of failure. The lowest frequency was observed for the presence of infection with suppuration, with just one implant (0.4%) presenting this condition **(Table 3)**.

Table 2 Distribution of implants in relationship with the gender, loading period and failures according to Ong et al.

Variables		Failure		Total	P-value[a]
		Yes	No		
Gender	Male	32 (42.1%)	44 (57.9%)	76 (100%)	0.24
	Female	58 (34.3%)	111 (65.7%)	169 (100%)	
	Total	90 (36.7%)	155 (63.3%)	245 (100%)	
Loading period	Group 1 (<1 year)	37 (77.1%)	11 (22.9%)	48 (100%)	<0.01[*]
	Group 2 (≥ 1 e <5 years)	29 (28.2%)	74 (71.8%)	103 (100%)	
	Group 3 (≥ 5 years)	24 (25.5%)	70 (74.5%)	94 (100%)	
	Total	90 (36.7%)	155 (63.3%)	245 (100%)	

[*]Statistically significant; [a]Chi-square Test

Table 3 Distribution of implant failure criteria according to Ong et al.

Failure criteria		Implants				Total		P-value[a]
		Failure		Success				
		N	%	N	%	N	%	
Mobility implant	Yes	2	2.2	0	0	2	0.8	0.134
	No	88	97.8	155	100	243	99.2	
Subjective complaints	Yes	2	2.2	0	0	2	0.8	0.134
	No	88	97.8	155	100	243	99.2	
Infection with suppuration	Yes	1	1.1	0	0	1	0.4	0.367
	No	89	98.9	155	100	244	99.6	
Radiolucent	Yes	8	8.9	0	0	8	3.3	<0.001*
	No	82	91.1	155	100	237	96.7	
Periodontal probing >5mm	Yes	20	22.2	0	0	20	8.2	<0.01*
	No	70	77.8	155	100	225	91.8	
Bleeding on probing	Yes	73	81.1	0	0	73	29.8	<0.01*
	No	17	18.9	155	100	172	70.2	
Vertical bone loss	Yes	14	14.4	0	0	13	5.3	<0.001*
	No	77	85.6	155	100	232	94.7	
*Statistically significant; [a]Fisher's exact test								

The implant failure rate of this sample varied among the criteria adopted **(Table 4)**, showing a statistically significant difference of all authors compared to Ong et al. [1] ($p < 0.01$) which was the criteria adopted for the present study. The highest incidence of failure (36.7%) was observed in the criteria by Ong et al. [1] and the lowest (3.3%) was observed considering the Buser et al. [4] criteria **(Table 5)**.

The correlation among the criteria of Ong et al. [1], Mombelli et al. [5] and Schnitmman et al. [2] was excellent. However, when correlation between the criteria of Ong et al. [1], Buser et al. [4] and Albrektsson and Isidor [3] was compared, a weak agreement was found **(Table 6)**.

Table 4 Comparison between failure rates related by author.

Success criteria		Ong et al. (2008)		Total		P-value[a]
		Yes	No	N	%	
Buser et al. [4]	Yes	8 (100%)	0	8	100	<0.001*
	No	82 (34.6%)	155 (65.4%)	237	100	
Mombelli et al. [5]	Yes	80 (100%)	0	80	100	<0.001*
	No	10 (6.1%)	155 (93.9%)	165	100	
Albrektsson and Isidor [3]	Yes	13 (100%)	0	13	100	<0.001*
	No	77 (33.2%)	155 (66.8%)	232	100	
Schnitman et al. [2]	Yes	78 (100%)	0	100	3.3	<0.001*
	No	12 (7.2%)	155 (92.8%)	100	96.7	
*Statistically significant; [a]Chi-square test						

Table 5 Failures according to the authors.

Authors	Failures	%
Ong et al. [1]	90	36.7
Buser et al. [4]	8	3.3
Mombelli et al. [5]	80	32.7
Albrektsson and Isidor [3]	13	5.3
Schnitman et al. [2]	78	31.8

Table 6 Concordance among the authors.

Criteria	Ong et al. [1]		Buser et al. [4]		Mombelli et al. [5]		Albrektsson and Isidor [3]		Schnitmman et al. [2]	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Ong et al. [1]										
Yes	-	-	8	82	80	10	13	77	78	12
No	-	-	0	155	0	155	0	155	0	155
Kappa	-	-	0.11		0.91		0.17		0.88	
Buser et al. [4]										
Yes	8	0	-	-	3	5	2	6	8	0
No	82	155	-	-	77	160	11	226	70	167
Kappa	0.11		-	-	0.009		0.15		0.13	
Mombelli et al. [5]										
Yes	80	0	3	77	-	-	8	72	73	7
No	10	155	5	160	-	-	5	160	5	160
Kappa	0.91		0.009		-	-	0.08		0.88	
Albrektsson and Isidor [3]										
Yes	13	0	2	11	8	5	-	-	8	5
No	77	155	6	226	72	160	-	-	70	162
Kappa	0.17		0.15		0.08		-	-	0.93	
Schnitmman et al. [2]										
Yes	78	0	8	70	73	5	8	70	-	-
No	12	155	0	167	7	160	5	162	-	-
Kappa	0.88		0.13		0.88		0.93		-	-

Discussion

Most studies that assessed dental implants performed clinical follow-up based on the implant survival, i.e., they analyzed only quantitatively, without discussing the biological complications that occurred during the follow-up period [18-20] or evaluated the possible relationship between risk factors and failure of these treatments [5]. The term "survival" means only the number or percentage of implants that present themselves physically in their site of installation, regardless of the biological situation, corresponding to only a quantitative classification [21]. Proponents of this method claim that this is a simpler way of presenting the results [22]. Moreover, the term "success" enables a qualitative analysis of biological conditions and mechanical complications occurred with the implant during the observation period [21].

For the success or failure of an implant to be assessed, some parameters are necessary [23]. Over time, many authors proposed parameters and indexes for the success of the implant. However, there is no standard or consensus in the literature, making difficult the classification and communication among professionals [24]. In this study, the lowest failure rate was found when the criteria proposed by Buser et al. [4] was applied and the highest rate was observed when the criteria grouped by Ong et al. [1] was applied. This can be explained by the changes of success criteria over time, leading to the seek of more stringent criteria. Moreover, Ong et al. [1] brought together several previous existing criteria in the literature, which contributed strongly to this result.

In the present study, implants from a single system were evaluated to avoid variables that could confound the results. This system uses internal connection (Morse taper) that proven results in lower turnover and peri-implant bone loss [25]. A few years ago, the peri-implant bone loss was also related to the diameter and length of the implant [26,27]. However, subsequent reports have not found any relationship between these characteristics of the implant and that bone loss [28,29]. In this study, there was not found association between sex and failure. This finding corroborates with other studies [28,30], which found no relationship between sex and bone loss by peri-implant disease. Vasquez Alvarez et al. [31] observed a statistical association between periodontitis and gender, and between gender and oral hygiene, and they also observed a higher proportion of periodontitis and worse oral hygiene in men than in women. As periodontitis and oral hygiene are risk factors for increased peri-implant bone loss, the association of gender with peri-implant bone loss could reflect, in part, a confusing effect.

The peri-implantitis diagnostic includes bleeding on probing and bone loss observed on radiographs. Furthermore, suppuration is also a frequent finding. In this research, the objective was not to study peri-implantitis, although it can also be a cause of bleeding on probing, suppuration and bone loss, as well as subjective complaints, accompanied by infection. Thus, it focused on the relationship between the clinical and radiographic conditions observed in the evaluated implants and the success rates that are proposed in the literature [14-19].

The bleeding on probing is used to assess the inflammatory condition of the peri-implant tissues [32]. The bleeding index evaluates inflammation through the presence or absence of bleeding [33] and is widely used due to its practicality. It can be associated with either the diagnosis of peri-implantitis and peri-implant mucositis, and therefore may be indicated for documentation in daily practice [34]. From a clinical point of view, the absence of bleeding is associated with peri-implant stable condition, and the presence of bleeding indicates an inflammatory condition. In this study, the clinical characteristic most frequently observed was bleeding on probing, so the authors that have included this feature in their assessment, observed higher failure values [14,17,19]. Moreover, the criteria that did not include bleeding on probing in the evaluations reported a lower prevalence of failure [15,16]. This explains the difference in certain failure rates of the sample, and consolidate the use of criteria proposed by Ong et al. [1], as more stringent.

Fransson et al. [15] evaluated the clinical characteristics of implants with bone loss. Bleeding on probing was observed in 94% of implants with progressive bone loss and in 90% of implants without progressive bone loss. Corroborating with these data, the study of Heitz-Mayfield [16] observed that the bleeding on probing has occurred in over 90% of the implants with no detectable progressive bone loss. Thus, it can be inferred that there is no correlation between the presence of bleeding on probing with the level of peri-implant bone loss. Therefore, this index cannot be used alone in the diagnosis of peri-implantitis, but bleeding presence in consecutive assessments can mean a future clinical attachment loss (CAL), due to the deleterious effects of the inflammatory infiltrate in this region [35,36]. In agreement with these findings, this study noted that the bleeding was the most frequent criterion, in practically one third of the evaluated implants, unlike bone loss, which obtained a low prevalence.

The probing depth is the distance from the gingival margin and the most apical point of probe penetration into the gingival sulcus or peri-implant pocket. In the peri-implant mucosa, the resistance on probing is lower, probably due to the parallel orientation of the collagen fibers in the connective tissue; thereby probing pressure is an important factor to evaluate the reliability of this parameter [37]. Probing with a light pressure is considered a viable diagnostic parameter, since it would have no potential to damage the perimucosal sealing between the soft tissue and the implant [38]. Thus, the survey was performed in this study by a trained examiner, preventing distorted results. As a standard measure, implants under normal conditions show a probing depth not exceeding 3 mm [39,40]. However, it is recognized as healthy up to 5 mm of probe depth, mainly in aesthetic regions [19]. Values above 5 or 6 mm may be indicative of peri-implant disease [40].

Even though periodontal indexes are often used to evaluate dental implants, they alone do not determine the success or failure of implants. These indexes must be related to other factors such as exudate or prosthetic overload [41].

The presence of the exudate on the implant can be identified spontaneously after probing [40] or with a light finger pressure on the mucosa [32]. The presence of this parameter is usually associated with tissue resorption and activity of peri-implant disease. Likewise, it was demonstrated that the presence of suppuration on probing was more frequent in progressive bone loss sites [35], being highly suggestive of advanced peri-implantitis. Therefore, this parameter is not sensitive for early diagnosis [42]. In contrast, the presence or absence of suppuration is a viable parameter in the differential diagnosis of mucositis and peri-implantitis [36]. In this study, there was a higher prevalence of periodontal parameters compatible with mild and reversible inflammation, such as bleeding on probing, while the presence of exudate was only observed in one implant.

Regarding the mobility of the implant, it uses two rigid instruments that apply a force in buccolingually alternately [43]. However, not always, the decreased stability will indicate the presence of peri-implant disease; it may indicate only a non-pathological resorption of the alveolar bone crest. In peri-implantitis, this mobility indicates the final stage of the disease characterized by complete loss of bone on the implant surface [39]. Even if a substantial portion of bone has been lost, the mobility of the implant may not be present due to contact of the remaining bone with the implant surface [38]. Therefore, this parameter is not considered a sensitive index for diagnosing the health or disease condition [39], but highly specific, since its presence indicates failure in osseointegration and necessity for implant removal [44]. Thus, the mobility assessment must be applied in conjunction with other parameters, whereas it is not very sensitive on early diagnosis of bone loss [36].

Radiographic evaluation has shown to be a good method for identification of bone loss. In normal conditions, implants lose an average of 1 mm to 1.5 mm of bone in the first year of function and then about 0.1 mm to 0.2 mm per year [37,39]. Despite the limitation in detecting early bone loss, conventional periapical radiographs using the technique of parallelism are widely used in clinical peri-implantitis diagnosis [45]. Radiographs should be performed when clinical parameters indicate the presence of inflammation in order to evaluate if there is bone loss and its extension [46]. The standardization of X-rays through devices that allow them to be reproduced in the same position and angle, as well as set a fixed reference point on the implant, is important to enable comparisons in subsequent radiographs. One can take as a reference the shoulder, the connection to the prosthetic abutment or the first thread of the implant to evaluate the amount of bone loss [38,42]. Given the limitations of conventional periapical radiographs, the radiographic evaluation is presented as an important diagnostic parameter; however, it should be seen as an additional parameter to clinical evaluation, in order to detect the extent of bone loss and help in the planning of therapeutic management [32].

It is important to remember the fundamental role of follow-up visits after completion of dental implants for the treatment success. It is concluded that the annual professional maintenance is critical for the survival of the implants, reducing by 90% the failure rate when compared to patients who did no maintenance.

Within the limitation of this study, it is observed that there is a difference in failure rates according to the various criteria proposed by different authors and, when considering the bleeding on probing as a failure, there is a higher incidence of this rate.

Conclusion

It is concluded that there is difference in the occurrence of failure among the proposed criteria by different authors.

Conflict of Interest

"No potential conflict of interest relevant to this article was reported".

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Author Contributions

Conceptualization: Rodrigo Ribeiro, Pedro Tortamano, Renata Cimoes ; Data curation: Roberto Pinho, Rayanne Dias, Rodrigo Ribeiro, Formal analysis: Roberto Pinho, Rayanne Dias, Rodrigo Ribeiro, Investigation: Rodrigo Ribeiro, Pedro Tortamano, Methodology: Rodrigo Ribeiro, Pedro Tortamano, Software: Rodrigo Ribeiro, Validation: Renata Cimoes, Andre Vajgel, Jung-Chul Park, Writing-Original Draft: Rodrigo Ribeiro, Pedro Tortamano, Renata Cimoes, Writing–Review and Editing: Roberto Pinho, Rayanne Dias, Andre Vajgel, Jung-Chul Park

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