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Radiographic Evaluation of Marginal Adaptation, Framework Overhangs and Residual Cement in Implant-supported Fixed Prostheses

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ABSTRACT

Marginal gaps, overhanging frameworks and residual cement result in plaque accumulation, finally leading to peri-implantitis. The aim of this study was to radiographically evaluate marginal adaptation, residual cement and overhanging frameworks in implant-supported fixed prostheses. In the present descriptive/cross-sectional study, 96 implant-supported fixed prostheses fabricated and delivered in Tabriz Faculty of Dentistry underwent radiographic examinations using the paralleling technique. The radiographs were scanned, saved on a computer and analyzed with Digimizer software program in relation to marginal adaptation, framework overhangs and residual cement. Data were analyzed with descriptive statistics (frequencies, percentages, means and standard deviations) using SPSS 21. The results showed mean marginal gaps of 119.32±113.96 and 205.53±214.02 µm in single-unit and multi-unit fixed prosthesis, respectively; 43.7% and 53.4% of single-unit and multi-unit restorations, respectively, did not exhibit good marginal adaptation. In addition, 53% of samples had no overhangs, and 11.5%, 11.5% and 24% had overhangs only at the mesial, only at the distal and on both aspects, respectively. There was no cement around the prostheses on any radiograph. Half of the prostheses evaluated exhibited framework overhangs. In addition, there was inadequate marginal adaptation in approximately one-third of the prostheses. No residual cement was detected around any of the prostheses.Half of the prostheses had framework overhangs and there was inadequate marginal adaptation in one-third of them.

Key words: Dental implants, marginal adaptation, framework overhang, residual cement.

INTRODUCTION

Marginal adaptation of tooth crowns, absence of overhangs and complete elimination of cement from the periphery of the implant or the abutment tooth are the most important factors in the long-term success of implant prosthetic treatments[1-6]. Marginal adaptation of the tooth crown is defined as the maximum adaptation between the margin of the prosthesis and the finish line of the underlying supporting structure (i.e. the prepared tooth or the implant)[3,5]. If the marginal gap is very large, the cement between the crown and the implant will dissolve, leading to accumulation of bacterial plaque and periodontal problems[3,5,6]. The marginal gaps in fixed prosthetic restorations have been evaluated by researchers under clinical and in vitro conditions; however, there is controversy

over the exact size of the marginal discrepancy that is considered marginal gap[6 8]. The largest size of marginal gap that is considered clinically acceptable has been reported to be 120 µm[7,9].

Overhang refers to the amount of restorative or prosthetic material (including cement or framework) which protrudes from the cavity or the finish line of the tooth and results in plaque accumulation, impingement on the biologic width and induction of periodontal diseases and gingivitis[1,2,4]. If the excess cement is not eliminated from the implant periphery completely, plaque accumulation will result in peri-implant diseases[10].

Mokeem *et al.,* reported a significant decrease in pocket depth, gingival index and gingival crevicular fluid after correction of overhanging restorations[4]. In a study by Wadhwani *et al.,* (2012), 4 patients with peri-implant diseases were evaluated, who had soft and hard tissue involvement, bone loss, pain and hemorrhage due to residual cement around the implant; however, after surgical treatments and debridement of the area, there was a significant improvement of their condition (11).

In studies carried out to measure, marginal discrepancy, several techniques have been described, the majority of which have depended on the use of a microscope due to its high magnification, use of graded dental explorers and use of radiographs on the condition that their magnification could be accurately calculated[12]. In addition, there are two principal techniques to evaluate residual cement around dental implants. The first technique uses a dental endoscope and is not very common. The majority of dental practitioners used the second technique, which depends on the use of radiographs.

Given the importance of contour and proper marginal adaptation in implant-supported prostheses and complete elimination of cement from the gingival sulcus in the success of implant treatments, it is necessary to follow all the guidelines in such treatments. Therefore, the aim of the present study was to radiographically evaluate marginal adaptation, framework overhangs and residual cement in implant-supported fixed prostheses.

MATERIALS AND METHODS

The study population in the present descriptive/cross-sectional study consisted of patients referring to the Department of Prosthodontics, Tabriz Faculty of Dentistry in 2015, who were treated with implant-supported fixed prostheses. The sample size was determined at 96 implant-supported fixed prostheses by considering d=0.1, p=0.5, Za=1.96 and á=0.05, using the sample size formula. Overall, 53 single-unit and 43 multi-unit prostheses (26 three-unit, 11 four-unit and 6 six-unit prostheses) were evaluated. Simple random sampling technique was used to select samples. To this end, the list of the patients who had received their prostheses almost a year previously was provided by the Department and the subjects were randomly selected from the list using the website at www.randomizer.org. Each selected patient was recalled and the area with the implant-supported prosthesis underwent a periapical radiographic examination (Gendex Expert, KaVo Dental, Germany) using the paralleling technique by an operator in the Department of Head and Maxillofacial Radiology, Tabriz Faculty of Dentistry. During the radiographic procedures, a metal ball, measuring 3 mm in diameter, was placed on the occlusal surface of the crowns along the implant margin for determining magnification on the radiographs. Then the radiographs were scanned and saved on a computer. All the linear measurements were carried out by Digimizer 4.1 (Medcalc Software; USA) software program. To measure the vertical discrepancy (gap) at mesial and distal margins of prostheses, the outermost points on the abutment finish line and prosthetic framework were measured and their distance was measured by the Digimizer software program by considering the magnification on the radiograph. In this study, a distance more than 120 µm[7,9] was considered lack of marginal adaptation for single-unit and multi-unit (bridge) implant-supported prostheses. The radiographic images were evaluated by two prosthodontists to assess the amount of cement remaining and overhangs, and the results were recorded in the relevant checklist. Kappa coefficient was used to evaluate inter-observer agreement, which was estimated at 98%. Data were analyzed with descriptive statistics (frequencies and percentages), using SPSS 21.

RESULTS

Table 1 presents the frequencies of overhanging frameworks in the evaluated implant-supported prostheses; Table 2 presents lack of marginal adaptation in single-unit prostheses; and Table 3 presents lack of marginal adaptation in multi-unit prostheses.

Of 53 single-unit implant supported prostheses, 41.5% exhibited marginal gaps over 120 µm and 58.5% exhibited marginal gaps under 120 µm. In addition, 35.8% of the samples had distal marginal gaps over 120 µm and 64.2% had distal marginal gaps under 120 µm. Overall, 43.7% of the samples had marginal gaps in a range that was not acceptable.

Table 1. The frequencies of overhanging frameworks in implant-supported fixed prostheses

	Overhanging framework	
	Number	Percentage
Without overhang	51	53
Mesial overhang	11	11.5
Distal overhang	11	11.5
Overhang on both aspects	23	24
Total	96	100

Table 2: Means and standard deviations of marginal gaps in single-unit implant-supported prostheses

	Mean (µm)	SD
Mesial marginal gap	137.07	115.11
Distal marginal gap	101.56	113.20
Total	119.32	113.96

Table 3: The means and standard deviations of marginal gaps in multi-unit implant-supported prostheses

	Mean (µm)	SD
Mesial marginal gap	221.16	233.32
Distal marginal gap	189.90	197.81
Total	205.53	214.02

Table 4: Means and standard deviations of marginal gaps in multi-unit implant-supported prostheses

	Number	Mesial marginal gap (µm)	Distal marginal gap (µm)	Total
3-unit	26	138.42±203.31	125.46±169.56	131.94±183.05
4-unit	11	200.09±184.28	148.00±116.02	174.04±145.89
6-unit	6	318.33±178.56	301.00±134.18	309.66±150.86

Of 43 implant-supported prostheses evaluated, 26 were 3-unit, 11 were 4-unit and 6 were 6-unit and the results are presented in Table 4.

Based on the results of the present study, there was an increase in marginal gap sizes with an increase in the number of implant units. No residual cement was detected around prostheses in any of the radiographs.

DISCUSSION

During the past 15 years, implant dentistry has made more progress than any other field. Although the principal aim in the past was to achieve osseointegration, currently the chief aim of implant treatments is rehabilitation of lost teeth in a manner to look like a natural tooth with the same function, esthetic appearance and durability. In addition, reconstruction of the oral function through dental implants has attracted a lot of

attention[13,14]. If the basic principles are not followed during the manufacturing process of a restoration, the resultant problems might be an etiologic factor for periodontal diseases and other problems[15,16]. In this study, 96 implant-supported prostheses, consisting of 53 single-unit and 43 multi-unit prostheses, were evaluated in relation to marginal adaptation, overhanging frameworks and cement remaining around the implants. The results showed that the mean marginal gaps in single-unit and multi-unit restorations were 119.32±113.96 and 205.53±214.02 µm, respectively. In addition, the mean marginal gaps increased with an increase in the number of prosthetic units. Jemt et al evaluated the adaptation of frameworks in single-unit implant-supported prostheses under a stereomicroscope and reported a gap range of 42-74 µm between the frameworks cast with gold and the implant abutment[17].

Jemt et al carried out another retrospective study on 7 patients after 5 years and reported a mean marginal gap of 111 µm between fixed prostheses and implants, with a maximum of 275 µm. They reported that poor adaptation was the most important reason for biologic failure[18].

Marginal adaptation is a key factor in the success or failure of fixed prostheses. If the gap between the prepared tooth or the dental implant and the margins of crowns is more than the acceptable level, the dental cement will rapidly dissolve. Then microorganisms will accumulate in the resultant void, resulting in a change in subgingival flora, gingival inflammation, discoloration at gingival margins, an increase in pocket depth and loss of gingival attachment[18,19].

In the present study, a marginal gap over 120 µm was considered lack of marginal adaptation and the results showed that 43.7% of single-unit implant-supported prostheses and 53.4% of multi-unit cases exhibited lack of marginal adaptation. Att et al evaluated marginal adaptation in 96 all-ceramic single-unit implant-supported crowns and reported that all the samples (100%) had marginal gaps at an acceptable range (under 100 µm)[19]. In another study, Wilson et al (2009) reported that cement remaining in the gingival sulcus behaves like calculus and results in peri-implant disease. In that study, approximately 80% of dental implant surfaces were contaminated with residual cement[20].

However, in the present study, no residual cement was detected around any of the prostheses. It should be pointed out that not visualizing cement on radiographs cannot be considered a definitive reason for its absence because some commonly used cement types have poor radiopacity and might be invisible on radiographs[11]. In addition, a minimum thickness is required for cements to be visible on radiographs. Wadhwani et al evaluated this minimum thickness and concluded that ZnO cement should be at least 1-2 mm and glass-ionomer and resin cements should be at least 2 mm in thickness to be visible on radiographs[11]. On the other hand, the cement position is also a determinant factor and when the residual cement is on the buccal or lingual aspect, it is not visible on the radiographs due to superimposition[10,11]. Therefore, some studies have suggested that the first visit of the patients be scheduled in less than a week so that initial changes in peri-implant tissues can be identified. These signs include inflammation, bleeding on probing and the presence of suppurative exudate. The subsequent visits should be scheduled at 1-, 3- and 6-month intervals. Therefore, when residual cement is detected, proper therapeutic interventions are carried out[21,22].

In the present study, 53% of the samples had no overhangs, on both the mesial and distal aspects. Therefore, in general, 47% of the restorations exhibited framework overhangs. Although only a limited number of studies have evaluated the overhangs of crowns, some of these studies have reported a range of 26-50% for crowns with framework overhangs[23].

It is generally believed that overhanging restorations might cause gingival inflammation due to the retention of plaque, and mechanical irritation has no role in inflammation. The composition of plaque, too, is more important than its volume[24].

In a clinical study, Lang et al evaluated the effects of subgingival restorations with and without overhangs on bacterial flora. Margins with overhangs had microbial floral similar to that of chronic periodontitis; however, accurate and normal

margins had bacterial flora similar to that in health (24). In the present study, due to the use of radiographs that provide a 2- dimensional view of 3-dimensional structures, there were some limitations and due to the superimposition of buccal and lingual areas, it was not possible to evaluate these areas in relation to the presence of overhangs and residual cement and determine marginal gaps. Therefore, only the mesial and distal aspects were evaluated and the results showed that the majority of prostheses evaluated had more framework overhangs in the mesial and distal aspects, compared to similar studies. In addition, almost half of the single-unit and multi-unit prostheses exhibited marginal gaps over 120 µm, with larger marginal gaps in multi-unit prostheses compared to single-unit ones.

The possible reasons for greater marginal gaps might be the use of Duralay instead of inlay wax for framework wax-up and also inadequate attention and concentration during the procedural steps. Duralay exhibits polymerization shrinkage and has more dimensional changes compared to inlay wax. In addition, its handling is more difficult at the margin (25). Therefore, it is recommended that after Duralay wax-up and testing it in the oral cavity, its marginal adaptation should be corrected with the inlay wax. In addition, since the implant is not affected by caries, some technicians and clinicians erroneously attach less importance to the adaptation of the framework margin with the finish line. In addition, the majority of finish lines on abutments are in the knife-edge form, which might increase the odds of gap formation or overhang creation by making it difficult for the clinician to read the finish line. Therefore, more emphasis should be placed on prevention of defects during prosthetic treatments, early diagnosis during clinical examinations and prompt correction of them in educational programs for dentists so that the odds of periodontal disease can be lowered in future. In addition, it is advisable to pay special attention to patients' annual examinations and resolve the prosthetic problems as soon as possible before periodontal problems appear.

CONCLUSION

The results of the present study showed that 47% of the samples had overhanging frameworks, which is higher than that in other studies. In addition, 47.3% of single-unit and 53.4% of multi-unit prostheses had marginal gaps over 120 µm, which was considered lack of marginal adaptation. In addition, no residual cement was observed around any of the prostheses.

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