

Original Article

Survival Rate, Biomechanical Complications, and Patient Satisfaction of Implant-Supported FRC Full-Arch Prostheses: A Retrospective Study with Follow up of 5 Years

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KEY WORDS

Dental implants;
Dental Prosthesis;
Implant-supported;
Survival Rate;
Patient Outcome
Assessment;
Patient satisfaction;

ABSTRACT

Statement of the Problem: The satisfaction of patients with dentures on implants has different points of view that become fundamental aspects for the development of research on the quality of life of these patients, the eventual biomechanical complications to which these prostheses and implants can be subjected, and design considerations for cantilever extensions.

Purpose: The objective of research was to assess the implants and prosthesis survival rates, biomechanical complications relative to the length of the distal extensions (cantilevers), and the satisfaction of the patients with a fixed implant-supported full-arch fiber-reinforced composites prosthesis.

Materials and Method: A retrospective clinical and radiographic cohort study was developed. Clinical records of a selected cohort were analyzed according to inclusion and exclusion criteria. Data on a patient who underwent to fixed implant-supported full-arch fiber-reinforced composites prosthesis at least of five years of function were collected. Data analysis was performed using Kaplan-Meier curves and Fisher's Exact Test. P values less than 0.05 were considered statistically significant.

Results: After insertion, 1 of 29 prostheses failed, the overall prosthetic survival rate observed at 5 years was 96.5%. Of the 120 implants placed in 28 patients, only 4 patients experienced loss of an implant during the 5 years of observation; the implant survival rate throughout the observation period was 86.2%. Distal extension seems to negatively affect the prognosis of implant-supported rehabilitation. Regarding the level of satisfaction of the patient with the prosthesis, none reported being uncomfortable or dissatisfied neither with their appearance nor with the taste of food throughout the studied period.

Conclusion: No relevant associations were found between the variables involved. The study found the improvement in quality of life following the installation of fixed rehabilitation on the patients. Once the potential benefits of patients are obtained, controlled clinical trials are encouraged.

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Introduction

Implant-supported full-arch fixed prostheses are well-studied long-term treatment for the edentulous patient

[1]. A survival rate of 93.3% after 10 years and 87.1% after 20 years was presented by Chrcanovic *et al.* [1]. Chochlidakis *et al.* [2] reported possible biological and

mechanical complications of the prosthesis. To avoid these potential complications and to achieve predictable long-term success with the full-arch implant-supported prosthesis, certain biomechanical concepts are important: the number and position of the implants [3], the extension of the cantilever (distal extension) [4], and the fabrication material of the prosthesis [5].

The number and position of the implants in an edentulous jaw varied in recent publications. The initial protocol proposed by Branemark [6] was six implants for the maxilla and five for the mandible. Recent systematic reviews and meta-analysis studies suggest four implants for the maxilla and three for the mandible show no statistical difference relative to five or more implants for each jaw [3].

The position and distribution of the implants was associated with distal cantilevers [4], which can biomechanically overload the prostheses causing biological or mechanical complications such as screw loosening, debonding, prosthesis delamination or fracture, peri-implantitis, and abutment or implant fracture. There is no a proven scientific formula for the length of cantilever to optimize the survival rate of the prosthesis; however, Purcell *et al.* [9] have postulated rules. For example, one considers the ratio between the anterior-posterior spread (AP spread) of the implants and the cantilever's length (CL) to be significant. This ratio (AP/CL ratio) should be less than 2 [7].

Moreover, the material used for prosthesis fabrication is crucial for the biomechanical behavior of the implant-prosthetic restoration [5]. Originally, Branemark [6] proposed the use of cast metal reconstructions with acrylic resin teeth; however, with the CAD/CAM manufacturing technology, a wide range of materials such as Cr-Co alloys, titanium, zirconia, and ceramics have been used [five]. McGlumphy *et al.* [8] demonstrated that there were frequent complications of acrylic fracturing or porcelain chipping, even with the use of minimal cantilever lengths (AP/CL ratio < 1). Currently, there is research interest in fiber-reinforced composites (FRC), that have more flexible strength and significantly better biomechanical attributes. FRC is an elastic and anisotropic material, that can be deformed without being permanently distorted and can adsorb the occlusal loads even in case of long cantilever (AP/CL ratio > 2) more than rigid materials like titanium or zirconia (AP/CL ra-

tio < 1) [9].

Da Cunha *et al.* [9] have shown improved patient satisfaction, positive psychological behavior, and a better quality of life, when fixed implant-supported prostheses were used. The most common way to assess the perception of implant treatment is the Oral Health-Related Quality of Life (OHRQoL) [12], although the Oral Health Impact Profile (OHIP) is the most widely accepted protocol [13]. The shorter version of this OHIP instrument with 5 questions is sufficient and may still be practical and informative [14]. The questionnaire assesses five macro-area, chewing, pain, appearance, food flavor, and personal limitation. This version has been translated in many languages; it is coming to be routinely used in clinical practice [15].

Accordingly, this study aimed to evaluate the survival rate of cantilever extension prostheses, biomechanical complications, and the satisfaction of patients with a fixed implant-supported full-arch fiber-reinforced composites prosthesis.

Materials and Method

A retrospective clinical and radiographic cohort study was developed. An electronic and manual review of available clinical records was collected from patients treated between February of 2013 and November of 2016 at Dental School of Cartagena (Colombia) and Dental School of La Sapienza University of Rome (Italy). After this period, the evaluators started the following up for each patient.

The inclusion criteria for the participants were total edentulous patients restored with a FRC, full arch implant-supported fixed prostheses under functional loading at least 5 years, with ages between 18 and 80 years old. All patients were informed in detail about the objectives of the study and were given a written informed consent form according to the *Declaration of Helsinki*.

The data collected included gender (male/female), age (expressed in completed years), medical status ("healthy" and "mild" according to ASA classification); smoking habits (dichotomic, yes or not); opposing dentition (denture, natural teeth, fixed prosthesis, partial edentulous), distal extension (short: $<$ than 21 mm and long: $>$ than 21 mm).

The clinical records were analyzed to assess (1) Prosthesis survival rate (prosthesis remaining in situ

without modifications during the entire observation period), (2) Patient implant loss experience (the report of at least an event of implant loss in each patient), and (3) Biomechanical complications (screw loosening, debonding, prosthesis delamination or fracture, peri-implantitis, and abutment or implant fracture) according to Moraschini *et al.*'s study [16].

Technical processes were evaluated by at least two different team members. To avoid disparity in criteria, the decision of a third evaluator was relied upon to resolve any lack of uniformity.

The patient satisfaction was evaluated according to the OHIP5 questionnaire adapted to Spanish language by Simancas *et al.* [13] administered annually after prosthesis insertion in both Dental School. Responses were presented on a 5-point ordinal scale (0, never; 1, hardly ever; 2, occasionally; 3, fairly often; and 4, very often). Summing all responses resulted in a score ranging from a minimum of 0 to a maximum of 20. A larger score indicated a more negative impact of oral health problems. The technical processes were evaluated by at least two different team members. To avoid disparity in criteria, the decision of a third evaluator was relied upon to resolve any lack of uniformity.

Data analysis was performed using R version 4.02 for Windows. Descriptive statistics were calculated for categorical and numerical variables. Frequencies and percentages were obtained for categorical variables; numerical summaries were calculated to obtain means and standard deviations. Kaplan-Meier curves were generated to estimate the overall survival probability for prosthesis, patient experience of implant loss, and incidence of biomechanical complications. The estimation of the relationship between prosthesis survival, patient experience of implants loss, biomechanical complication cumulative incidence, and covariates were analyzed using the Fisher's Exact Test. P values less than 0.05 were considered statistically significant.

Results

28 patients (13 males and 15 females) with 29 full arches fixed prostheses have met the selection criteria between the two dental schools. The average age was 67.8 years-old, 89.7% of patients were healthy, and 86.2% were non-smokers. All patients received at least one implant supported full-arch, cement-retained, metal-free

rehabilitation made of FRC material (Trinia, Bicon, LLC) veneered with a zirconium silicate micro ceramic material (Ceramage, Shofu, Fukuine, Japan). 18 patients had an opposing denture, 2 patients had partial edentulous dentition, 6 had completed natural teeth, and 3 had porcelain fused to metal fixed prosthesis. 24 prostheses were at the lower and 5 were at the upper. 21 patients belonged to the "short" distal extension group, while 8 to the "long" group. 27 prostheses were supported by 4 implants, while 2 were supported by 6 implants. The total number of implants placed in the population was 120.

Prosthesis survivor

After insertion, 1 of 29 prostheses failed in the "long" distal extension group, the overall prosthetic survival rate observed at the follow up was 96.5%. The only prosthetic failure was during the first year of the observation period (Figure 1).

Patient implant loss experience

Of the 28 patients, only 4 patients (14.2%) experienced loss of at least one implant during the follow up period, while patients who did not experience any implant loss were 85.7%. The incidence of event "implant loss" during the 5 years of follow-up and the overall survival rate can be seen in Figure 2.

On 120 implants placed, 6 of them were lost in 4 patients during the follow up. Three patients belonged to the "long" distal extension group and one to the "short" distal extension group. The overall implant survival rate was 95%. All implant failure occurred in the first 2 years of follow up. 3 of the failed implants were lost in the same patient during the first year of follow-up. In the same period, two patients lost one implant each. While the last implant failed in a patient at two years of follow up.

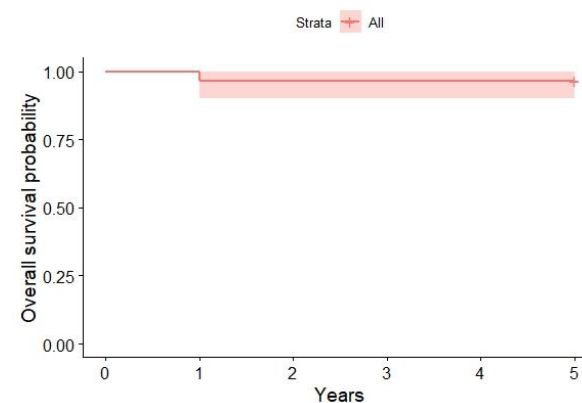


Figure 1: Kaplan- Meier curve estimates for prosthesis survival

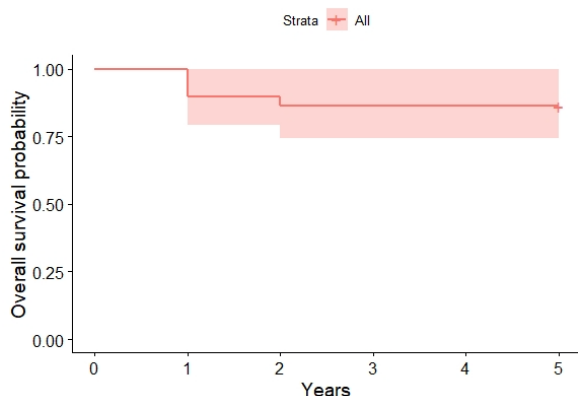


Figure 2: Kaplan- Meier curve estimates for patient implant loss experience survival

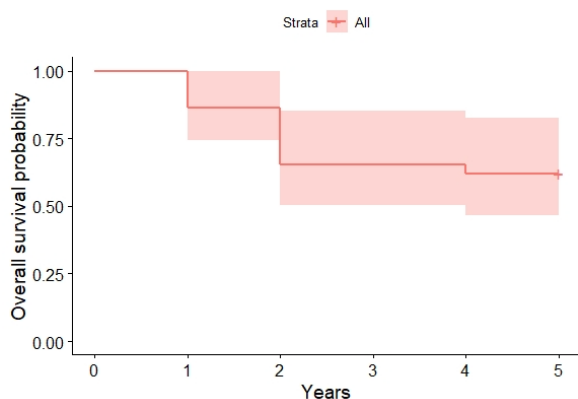


Figure 3: Kaplan- Meier curve estimates for biomechanical complications.

Biomechanical complications

There were recorded only 11 prosthetic complications among the population during the observation period. During the first year, there were 3 teeth dislodgements.

Subsequently, there was 1 abutment fracture and decementation of the prosthesis from their implant abutments. The incidence of these biomechanical complications during the observation period is presented in Figure 3.

Of the 11-patient affected by biomechanical complications reported, 8 belonged to the “short” distal extension group, while 3 belonged to the “long” distal extension group.

The biomechanical complications, prosthesis and implant survival have been placed in relation to the distal extension (See Table 1).

Patients’ satisfaction

The OHIP questionnaire, administered annually in the two dental schools, allowed checking over the time the patient’s perception and satisfaction about the rehabilitation. Data are listed in Table 2; it is important to note that none of the patients reported to be uncomfortable or dissatisfied neither with their appearance nor with the taste of food throughout the studied period. Additionally, only in the first year, a difficulty during function with a mean punctuation of 0.34 ± 1.04 was reported.

The items “difficulty in chewing” and “painful aching” had a higher mean punctuation (0.72 ± 1.22 and 0.59 ± 1.2 , respectively) at the first year, which decreased during the 5 years of follow-up (Table 2).

Discussion

The main aim of this study was to assess the possible

Table 1: Analysis of prosthesis survival, implant survival and biomechanical complications cumulative incidence according to study covariates

Variable	Prosthesis		p value	Implant		p value	Biomechanical complications		p value
	Survival n (%)	Failure n (%)		Survival n (%)	Failure n (%)		No n (%)	Yes n (%)	
Gender									
Female	16 (55.2)	0 (0)	0.4483	13 (44.8)	3 (10.3)	0.6059	10 (34.5)	6 (20.7)	1.000
Male	12 (41.4)	1 (3.4)		12 (41.4)	1 (3.4)		8 (27.6)	5 (17.2)	
General health									
Healthy	26 (89.7)	0 (0)	0.1034	24 (82.8)	2 (6.9)	0.0422	17 (58.6)	9 (31)	0.5394
Mild	2 (6.9)	1 (3.4)		1 (3.4)	2 (6.9)		1 (3.4)	2 (6.9)	
Medications									
No	22 (75.9)	0 (0)	0.2414	21 (72.4)	1 (3.4)	0.0339	15 (51.7)	7 (24.1)	0.3746
Yes	6 (20.7)	1 (3.4)		4 (13.8)	3 (10.3)		3 (10.3)	4 (13.8)	
Smoking									
No	24 (82.8)	1 (3.4)	1.000	21 (72.4)	4 (13.8)	1.000	16 (55.1)	9 (31)	0.6221
Yes	4 (13.8)	0 (0)		4 (13.8)	0 (0)		2 (6.9)	2 (6.9)	
Number of implants									
Four	26 (89.7)	1 (3.4)	1.000	24 (82.8)	3 (10.3)	0.2611	17 (58.6)	10 (34.5)	1.000
Six	2 (6.9)	0 (0)		1 (3.44)	1 (3.44)		1 (3.4)	1 (3.4)	
Distal extension									
Short	21 (72.4)	0 (0)	0.2759	20 (69)	1 (3.4)	0.0525	13 (44.8)	8 (27.6)	1.000
Long	7 (24.1)	1 (3.4)		5 (17.2)	3 (10.3)		5 (17.2)	3 (10.3)	

Table 2: Patient satisfaction

OHIP item	Follow-up				
	1 Mean (SD)	2 Mean (SD)	3 Mean (SD)	4 Mean (SD)	5 Mean (SD)
Difficulty in chewing	0.72 (1.22)	0.39 (0.87)	0.14 (0.59)	0.07 (0.38)	0.15 (0.53)
Painful aching	0.59 (1.2)	0.10 (0.31)	0.07 (0.37)	0.07 (0.38)	0.11 (0.42)
Uncomfortable with appearance	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Less flavor in food	0 (0)	0 (0)	0 (0)	0 (0)	0 (0)
Difficulty doing usual jobs	0.34 (1.04)	0 (0)	0 (0)	0 (0)	0 (0)
Total score ^a	1.65 (3.15)	0.50 (1.03)	0.21 (0.95)	0.14 (0.76)	0.26 (0.94)

^a Maximum total score = 20

influence of the cantilever on performances of prosthetic rehabilitations made of fixed, full-arch, and implant supported FRC prosthesis in an average observational period of 5 years. Attention was given to patient perception and satisfaction.

The cumulative prosthetic survival rate was 96.5%. The overall implant surviving rate was 95%. 11 patients experienced at least one biomechanical complication.

In terms of expected results, the authors' hypothesis was to find comparable outcomes of implant/prosthesis survival rate to previous reported studies by Meriç *et al.* [17], and Cicconetti *et al.* [18]. As it stands, the performance of implant-supported FRC-prostheses studied are comparable to the state of art for this kind of total-arch fixed rehabilitation [19].

With respect to the position of the implants and consequently, the length of the distal extensions (cantilevers), even with a numerical disparity between the two groups (21 short and 8 long), the only failure of prosthetic rehabilitation was observed in the long distal-extension group (see table 1). 4 patients experienced the loss of at least one implant during the observation period. 3 belonged to the "long" distal-extension group and 1 to the "short". 11 patients experienced at least one biomechanical complication. 8 of these patients was enrolled into the "short" distal-extension group and 3 of them into the "long" distal-extension group. The statistical analysis did not reveal any association between the three variables and the cantilever.

Analyzing data, 4 patients lost at least one implant but only a patient loses the prosthesis thus there are 3 patients with prosthesis working on a limited number of implants for at least 3 years. The biomechanical behavior of FRC prostheses could play a crucial role in the survival of these prostheses, because of its capability to bear loads and extensions.

Finally, in the present study, the perception of the pa-

tients was considered. It should be noted that, compared to Duong *et al.*, [20] the quality of life increases during the years. It has already been stated by other authors that an improvement in masticatory ability and patient comfort results in an increase in self-esteem and personal security according to Fueki *et al.*, [21] Haraldson *et al.* [22], and Strassburger *et al.* [23]. The data recorded on patient satisfaction indicate that the assessed population positively perceives the benefit of rehabilitation. On the population observed, we found a better performance of the treatment when administered to people with good general health and no intake of medication ($p < 0.05$).

Conclusion

According to the findings and within the limitations of the present retrospective clinical study, the cumulative survival rate of prostheses and implants was comparable to the previously reported study. Although no relevant associations were found between the variables involved, statistically relevant indications cannot be drawn except only the recommendation not to exceed 21 mm of cantilever. The study considered the improvement in quality of life following fixed rehabilitation. Once the potential benefits of patients are obtained, controlled clinical trials are encouraged. The properties of FRC materials can allow rehabilitations to an increasing number of patients, thanks also to the possible cantilever.

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Author contributions

Hernández-González D, Marincola M. designed the study, collected, analyzed, presented the data; approved the

final version of the document. Díaz-Caballero A, Cicconetti A, Passaretti A. analyzed the edited the data's final presentation, approved the final version of the document.

Conflict of Interest

Authors state there are not any conflict of interest.

References

- [1] Chrcanovic BR, Kisch J, Larsson C. Retrospective evaluation of implant-supported full-arch fixed dental prostheses after a mean follow-up of 10 years. *Clin Oral Implants Res.* 2020; 31: 634-645.
- [2] Chochlidakis K, Einarsdottir E, Tsigarida A, Papaspyridakos P, Romeo D, Barmak AB, Ercoli C. Survival rates and prosthetic complications of implant fixed complete dental prostheses: An up to 5-year retrospective study. *J Prosthet Dent.* 2020; 124: 539-546.
- [3] Daudt Polido W, Aghaloo T, Emmett TW, Taylor TD, Morton D. Number of implants placed for complete-arch fixed prostheses: A systematic review and meta-analysis. *Clin Oral Implants Res.* 2018; 29 Suppl 16: 154-183.
- [4] Drago C. Ratios of Cantilever Lengths and Anterior-Posterior Spreads of Definitive Hybrid Full-Arch, Screw-Retained Prostheses: Results of a Clinical Study, *J Prosthodont.* 2018; 27: 402-408.
- [5] Bagegni A, Abou-Ayash S, Rücker G, Algarny A, Att W. The influence of prosthetic material on implant and prosthetic survival of implant-supported fixed complete dentures: a systematic review and meta-analysis, *J Prosthodont Res.* 2019; 63: 251-265.
- [6] Brånemark PI, Hansson BO, Adell R, Breine U, Lindström J, Hallén O, Ohman A. Osseointegrated implants in the treatment of the edentulous jaw. Experience from a 10-year period. *Scand J Plast Reconstr Surg Suppl.* 1977; 16: 1-132.
- [7] Purcell BA, McGlumphy EA, Yilmaz B, Holloway JA, Beck FM. Anteroposterior Spread and Cantilever Length in Mandibular Metal-Resin Implant-Fixed Complete Dental Prostheses: A 7- to 9-Year Analysis, *Int J Prosthodont.* 2015; 28: 512-518.
- [8] McGlumphy EA, Hashemzadeh S, Yilmaz B, Purcell BA, Leach D, Larsen PE. Treatment of edentulous mandible with metal-resin fixed complete dentures: A 15- to 20-year retrospective study. *Clinical Oral Implants Res.* 2019; 30: 817-825.
- [9] Passaretti A, Petroni G, Miracolo G, Savoia V, Perpetuini A, Cicconetti A. Metal free, full arch, fixed prosthesis for edentulous mandible rehabilitation on four implants. *J Prosthodont Res.* 2018; 62: 264-267.
- [10] Da Cunha MC, Santos JFFD, Santos MBFD, Marchini L. Patients' expectation before and satisfaction after full-arch fixed implant-prosthesis rehabilitation. *J Oral Implant.* 2015; 41: 235-239.
- [11] Goodacre C, Goodacre B. Fixed VS removable complete arch implant prostheses: A literature review of prosthodontic outcomes. *Eur J Oral Implantol.* 2017; 10 Suppl 1: 13-34.
- [12] ELSyad MA, Elgamal M, Mohammed Askar O, Youssef Al-Tonbary G. Patient satisfaction and oral health-related quality of life (OHRQoL) of conventional denture, fixed prosthesis and milled bar overdenture for All-on-4 implant rehabilitation. A crossover study. *Clin Oral Implants Res.* 2019; 30: 1107-1117.
- [13] Simancas-Pallares M, John MT, Enstad C, Lenton P. The Spanish Language 5-Item Oral Health Impact Profile. *Int Dent J.* 2020; 70: 127-135.
- [14] Baba K, Inukai M, John MT. Feasibility of oral health-related quality of life assessment in prosthodontic patients using abbreviated Oral Health Impact Profile questionnaires. *J Oral Rehabil.* 2008; 35: 224-228.
- [15] Naik A, John MT, Kohli N, Self K, Flynn P. Validation of the English-language version of 5-item Oral Health Impact Profile. *J Prosthodont Res.* 2016; 60: 85-91.
- [16] Moraschini V, Poubel LADC, Ferreira VF, Barboza EDSP. Evaluation of survival and success rates of dental implants reported in longitudinal studies with a follow-up period of at least 10 years: a systematic review. *Int J Oral Maxillofac Surg.* 2015; 44: 377-388.
- [17] Meriç G, Erkmen E, Kurt A, Eser A, Ozden AU. Biomechanical comparison of two different collar structured implants supporting 3-unit fixed partial denture: a 3-D FEM study. *Acta Odontol Scand.* 2012; 70: 61-71.
- [18] Cicconetti A, Passaretti A, Rastelli C, Rastelli E, Falisi G. Innovations in oral and maxillofacial surgery: biomimetics meets physiology, *J Biol Regul Homeost Agents.* 2019; 33: 1609-1613.
- [19] Zaparolli D, Peixoto RF, Pupim D, Macedo AP, Toniollo MB, de Mattos M. Photoelastic analysis of mandibular full-arch implant-supported fixed dentures made with different bar materials and manufacturing techniques, *Mater Sci Eng C Mater Biol Appl.* 2017; 81: 144-147.

- [20] Duong HY, Rocuzzo A, Stähli A, Salvi GE, Lang NP, Sculean A. Oral health-related quality of life of patients rehabilitated with fixed and removable implant-supported dental prostheses. *Periodontol.* 2000; 88: 201–237.
- [21] Fueki K, Kimoto K, Ogawa T, Garrett NR. Effect of implant-supported or retained dentures on masticatory performance: a systematic review. *J Prosthet Dent.* 2007; 98: 470–477.
- [22] Haraldson T, Carlsson GE, Ingervall B. Functional state, bite force and postural muscle activity in patients with osseointegrated oral implant bridges. *Acta Odontol Scand.* 1979; 37: 195–206.
- [23] Strassburger C, Kerschbaum T, Heydecke G. Influence of implant and conventional prostheses on satisfaction and quality of life: A literature review. Part 2: Qualitative analysis and evaluation of the studies. *Int J Prosthodont.* 2006; 19: 339–348.