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A within-subject comparison of short implants in the posterior region: retrospective study of up to 10 years

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PURPOSE. This intra-patient retrospective study of up to 10 years evaluated the clinical success and risk factors of 6- and 8-mm long implants and their respective prostheses. **MATERIALS AND METHODS.** The sample consisted of patients treated at a Military Polyclinic dental service, who received both 6- and 8-mm long tissue level implants in the posterior region of the same arch. Data were collected from the dental charts, clinical and radiographic exams, self-report of sleep bruxism, measurement of maximum occlusal force, and clinical crown-to-implant (C/I) ratio. Data were analyzed by descriptive and inferential statistics with univariate and hierarchical multivariate models, at the 0.05 significance level. **RESULTS.** The 30 patients (27 women) had 85 implants and 83 prostheses. Two implants were lost before prosthesis installation (implant survival: 97.6%). Ten events of prosthetic complication (screw tightening loss) occurred in five patients (success rate: 87.9%) in a single moment. Only the variable C/I ratio had a significant effect for repairable prosthesis complication (P<.05). **CONCLUSION.** The results suggest that 6- and 8-mm long implants have similar long-term clinical success for implants and prostheses. [J Adv Prosthodont 2021;13:172-9]

KEYWORDS
Short implants; Clinical success; Survival; Risk factors; Crown-to-implant ratio

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INTRODUCTION

The use of short implants may simplify surgical procedures in regions with reduced bone height, avoiding bone graft or damage in complex anatomical structures, such as the maxillary sinus or inferior alveolar nerve. However, the comparison of outcome measures from studies on short implants may depend on the exact implant length as its operational definition varies as much

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as 50% in the literature. For example, some authors define short implants to be 10-mm long or less, while extra-short implants would have a length of 6-mm or less.[1-3] Others consider extra-short implants to be only 4-mm long.[4]

The success rate for implants 8-mm long or less, with treated implant surface and supporting different types of prosthesis, vary from 95.7% to 98% in follow-up over five years.[5-7] Widely adopted clinical criteria for a successful implant therapy include implant mobility or loss, persistent pain, neuropathy, progressive bone loss, increasing probing depth, persistent inflammation and/or infection, suppuration, fracture of occlusal materials, fracture or loss of prosthetic components, and implant fracture.[8,9] In addition, the main prosthetic complications include loss of retention for prosthesis or abutment, screw loosening or fracture, and fracture/chipping of the ceramic or resin veneer.[10]

Patient-related biological variables and technical factors of the implant-prosthesis system may have a combined effect on the clinical success of short implants with different length, but the scientific evidences are not conclusive. For instance, a systematic review showed that the crown-to-implant ratio was not a significant factor for marginal bone loss in implants less than 10-mm long, but 8-mm or shorter implants had a higher rate of biological and prosthetic failures or complications.[11] Thus, it is difficult to assess the long-term success of short implants without a controlled and direct comparison of implants of different length and considering both technical and biological factors for each patient.

This within-subject and retrospective study aimed to assess the clinical success of 6- and 8-mm long implants, installed in the same arch, in the posterior region of the maxilla or mandible. This research evaluated the occurrence of biological and technical failures/complications in implants and prostheses up to ten years and analyzed their possible risk factors.

MATERIALS AND METHODS

The present work was designed as an observational, retrospective study. The research protocol was approved by the committees of research ethics of the Military Policlinic of Porto Alegre (PMPA Session 001 - 06/29/2018 - ATA 001) and of the Pontifical Catholic University of Rio Grande do Sul (CAAE 03434118.9.0000.5336), following the national regulations (CNS 466/12) and precepts of the Declaration of Helsinki (Amendment 2009). This report followed the STROBE guidelines.

The sample consisted of consecutive adult patients treated at the Dental Implantology Service of the Military Policlinic of Porto Alegre (PMPA), in Porto Alegre, Brazil, from January 2008 to October 2018. All patients who received 6- and 8-mm long implants (Straumann® Dental Implant System, tissue level type), installed in the posterior region of the same arch (maxilla or mandible) and restored with metal-ceramic or zirconia prostheses, were included. The exclusion criteria were patients who had undergone a grafting procedure in the region of interest, except for maxillary sinus lift using Summers' technique; removable prosthesis in the opposing arch; non-compensated systemic or mental health problems. Eligible patients were identified by manual search in the service's clinical records and contacted by telephone. Some patients moved to another city and/or could not be reached by telephone. The patients who accepted the invitation to participate in the research were selected and signed an informed consent form.

Patients were examined by a trained investigator (D.B.S.) during a single recall appointment at the PMPA Dental Implantology Service. Clinical data were collected on current general health, oral conditions of hard and soft tissues, occlusal status, level of oral hygiene, gingival probing, and presence of any problems with implants and prostheses. Data on implant surgery and prosthetic procedures, such as implant region (premolar or molar site), type of prosthesis (screwed or cemented prosthesis), length of prosthesis (single or splinted crowns), as well as any complications and dental appointments before the research session, were retrieved from the clinical charts and confirmed by face-to-face interview.

The maximum occlusal force was measured using a cross-arch compressive force transducer (Sensotec 13/2445-02, Columbus, OH, United States).[12] After verbal explanation of the procedure and training, the participant was asked to bite the transducer with

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maximum force. The average of three measurements was computed as the participant's maximum occlusal force value.

A self-report questionnaire[13] was used to record possible presence of nocturnal (sleep) bruxism, according to a dichotomous variable (yes/no).

Digital periapical radiographs were obtained by using a film positioner and the parallelism technique with the following equipment: X-ray machine Timex 70 E Pantographic Mobile Column 70 KvP 7mA (SAE-VO, Ribeirão Preto, Brazil), the Image Plate phosphor plate (Dürr Dental SE, Bietigheim-Bissingen, Germany), Vista Scan Mini Plus digitizer device (Dürr Dental SE, Bietigheim-Bissingen, Germany), and Viewbox Studio software, version 0.15.0.0 (dHAL Software, Kifissia, Greece).

Using the Adobe Photoshop CC 2018 software (version 19.1.5, Adobe World Headquarters, San Jose, CA, USA), the image calibration was performed by measuring the actual implant size (6- or 8-mm of the implant body and 1.8-mm of the neck), i.e., from the implant apex to the implant platform, parallel to the long axis. Bone levels were measured from the implant platform to the most coronal level of the bone-implant contact, on both mesial and distal surfaces. The mean bone level was subtracted from the actual implant size to compute the clinical implant length. The clinical crown was measured from the most coronal bone-to-implant contact point to the highest cusp point (Fig. 1). All measurements were performed by a single trained examiner (D.B.S.).

The clinical crown value was divided by the clinical implant value to compute the clinical C/I ratio.[14,15]

Data were analyzed by using descriptive and inferential statistics with univariable and multivariable models, at the significance level of 0.05. The predictor variables were: implant length (6-mm, 8-mm), implant region (premolar, molar), type of prosthesis (screwed, cemented), length of prosthesis (single, splinted), bruxism (present, absent), maximum occlusal force (in Newtons), occlusal contact in the prosthesis (present, absent), relative implant position (free-end, interleave), and clinical C/I ratio. The outcome measures were implant failure and prosthesis failure/complication. The observational unit was the implant, which was nested hierarchically within the

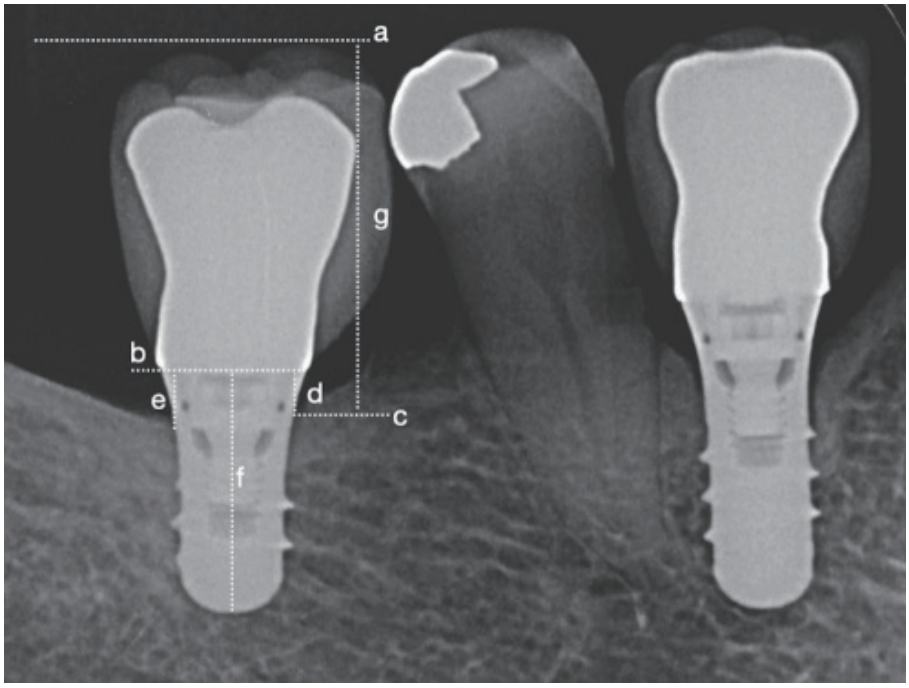

Fig. 1. Reference lines for linear measurement on periapical radiographic image: (a) highest cusp point, (b) implant platform, (c) the most coronal bone-to-implant, (d) vertical distance from the implant platform to the most coronal point of the bone-to-implant contact (mesial side), (e) vertical distance from the implant platform to the most coronal point of the bone-to-implant contact (distal side), (f) long implant axis, (g) clinical crown height.

patient. A Generalized Estimating Equations (GEE) approach was used with the PROC GENMOD procedure in the SAS Studio (SAS OnDemand for Academics).

RESULTS

A total of 57 eligible patients were retrieved from the service dental records, but 27 could not be selected because they did not want to participate in the study, have moved from the city, or could not be reached. The study sample consisted of 30 patients (27 women), who received 85 implants and 83 prostheses. The patients' mean (standard deviation) age was 67.7 (11.0) years. Only four implants were installed in the maxilla. Table 1 shows the descriptive statistics of the sample.

Two out of 85 implants had failure, yielding a success rate of 97.6% for implant survival, with average clinical time of 98 months (from 4 to 131 months) since implant surgery. Both implants were placed in the mandibular premolar region and were lost before prosthetic procedures (Table 2).

Seventy-five of 83 prostheses had SynOcta® abut-ments (Straumann® Dental Implant System, Basel, Switzerland), three were restored with solid abutments (Straumann® Dental Implant System, Basel, Switzerland) and cemented, and five were hybrid, with Variobase® abutments (Straumann® Dental Implant System, Basel, Switzerland) cemented in the laboratory model and screwed in the mouth. Ten events of prosthetic complication occurred in five patients, yielding a success rate of 87.9%, with

Table 1. Description of the clinical characteristics of the sample

Variable		Frequency (%)	Mean	SD	[Min - Max]
Presence of sleep bruxism	No	70 (82.4)			
	Yes	15 (17.6)			
Maximum occlusal force (N)			350.2	129.97	[160.1 - 711.7]
Implant length	6-mm	45 (52.9)			
	8-mm	40 (47.1)			
	Total	85 (100.0)			
Implant region	Premolar	26 (30.6)			
	Molar	59 (69.4)			
Prosthesis type	screwed	76 (91.6)			
	cemented	07 (8.4)			
Implant union	non-splinted	69 (83.1)			
	splinted	14 (16.9)			
Occlusal contact in prosthesis	No	23 (27.7)			
	Yes	60 (72.3)			
Relative implant position	Free-end	35 (42.2)			
	Interleave	48 (57.8)			
Clinical crown-to-implant ratio			2.1	0.56	[1.2 - 3.8]

Table 2. Description of events of the outcome implant failure (n = 2)

Patient #	Gender	Age (years)	Implant size (mm)	Implant torque (Ncm)	Implant region	Time to failure (months)
09	Female	60	8	between 15 and 35	Premolar	9
28	Female	62	6	< 15	Premolar	4

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average clinical time of almost 5 years (precisely 58 months, ranging from 1 to 127 months) since prosthesis installation. All events were prosthetic screw loosening with the SynOcta® abutment and occurred in a single moment (Table 3).

Table 4 and Table 5 show the univariable and multivariable models for the outcome prosthesis complication, where only the predictor C/I ratio had a statistically significant effect. It was not possible to estimate the odds ratio for some predictors (type of prosthesis, length of prosthesis, bruxism) due to the lack of events or the low number of events per category.

Table 3. Description of events of the outcome prosthesis complication (prosthetic screw loosening) (n = 10)

Patient #	Gender	Age (years)	Bruxism	Occlusal force (N)	Implant length (mm)	Implant region	Implant union	Occlusal contact	Relative implant position	C/I ratio	Time to failure (months)
02	F	69	No	351	6	Molar	Non-splinted	Yes	Free-end	2.1	37
02	F	69	No	351	8	Premolar	Non-splinted	Yes	Interleave	1.9	96
07	F	68	No	302	6	Molar	Non-splinted	No	Free-end	3.2	01
07	F	68	No	302	8	Molar	Non-splinted	No	Free-end	1.4	01
08	F	55	No	342	6	Premolar	Non-splinted	Yes	Interleave	3.3	23
08	F	55	No	342	6	Molar	Non-splinted	Yes	Free-end	3.1	23
08	F	55	No	342	8	Premolar	Non-splinted	Yes	Interleave	2.8	28
08	F	55	No	342	6	Molar	Non-splinted	Yes	Free-end	3.8	28
19	F	79	No	458	8	Molar	Non-splinted	Yes	Interleave	2.0	21
20	M	73	No	560	6	Molar	Non-splinted	No	Free-end	2.1	02

Table 4. Odds Ratio (OR) estimates of the predictive variables for the outcome prosthesis complication in univariable models

Variable	OR estimate	95% CI	*P*
Implant length (6-mm vs 8-mm)	1.38	[0.36, 5.31]	.6379
Implant region (premolar vs molar)	1.06	[0.25, 4.50]	.9357
Occlusal contact (yes vs no)	0.88	[0.21, 3.74]	.8631
Implant position (free-end vs interleave)	2.28	[0.59, 8.77]	.2322
Occlusal force (increase of 100 units)	1.00	[0.99, 1.00]	.3580
C/I ratio (one-unit increase)	5.79	[1.56, 21.51]	.0088

Table 5. Adjusted odds ratio (OR) estimates for the predictor variables of the outcome prosthesis complication in a multivariable model

Variable	OR estimate	95% CI	*P*
Implant length (6-mm vs 8-mm)	0.22	[0.03, 1.47]	.1184
Implant region (premolar vs molar)	2.81	[0.16, 47.66]	.4751
Occlusal contact (yes vs no)	0.66	[0.14, 3.02]	.5951
Implant position (free-end vs interleave)	7.59	[0.58, 99.86]	.1232
Occlusal force (increase of 100 units)	1.00	[0.999, 1.008]	.1192
C/I ratio (one-unit increase)	9.31	[2.17, 39.96]	.0027

DISCUSSION

This retrospective study showed that 6- and 8-mm long implants in the posterior region presented similar clinical success for implants and prostheses with a follow-up of up to ten years. Both 6- and 8-mm long implants were installed in the same arch of each patient and functioned under the same clinical conditions regarding occlusal forces, eating and hygiene habits, and eventual presence of nocturnal bruxism. Thus, the within-subject design and multivariate hierarchical model allowed some control of variables in this retrospective study.

In the present sample, the two cases of implant loss, one for each implant length, occurred several months after surgery and before functional load. The implant survival (97.6%) and prosthesis success (87.9%) rates are comparable to those reported by previous studies on short implants in the molar and premolar regions.[16,17]

Three out of ten cases of prosthetic complication occurred in the first two months of functional load, and the others occurred beyond 20 months after prosthesis installation. All cases were of screwed prostheses over SynOcta® abutments, which comprised the most frequent type of prosthetic rehabilitation in the sample. It is relevant to discuss the difference of final screw torque between SynOcta® and Variobase® (Straumann, Basel, Switzerland) abutments. The manufacturer's recommendations for prosthetic screw torque are 15 Ncm for SynOcta® abutments and 35 Ncm for Variobase® abutments. In addition, the contact surface area between prosthetic screw and abutment would relate to the forces keeping the abutment stable. The Variobase® screw is in contact with the internal part of the implant, which could provide greater stability than other types of prosthetic abutments.[18] The torque loss in prosthetic screws seems to be the most frequent event, although loosening of the abutment screw or the abutment itself also are common.[10,19-21] Nevertheless, this type of prosthetic complication is repairable and easily resolved with a retightening of the same screw or its replacement during a single clinical appointment. It is noteworthy that all cases had only one event of screw loosening, without recurrence after solving the problem. Thus, no loss of prosthesis or need for additional laboratory procedure occurred during the study period.

The clinical C/I ratio was the only significant predictor for prosthetic failure, and the estimated chances of prosthesis failure were associated with an increase in the C/I ratio. Previous studies on implants of different lengths also suggested that a larger vertical lever would lead to prosthetic screw loosening and eventually to fatigue and fracture.[15,20,22-24] In contrast, other studies reported that C/I ratio did not affect clinical outcomes in short single implants.[11,25-27] However, most studies have not simultaneously analyzed or controlled for patient-related biological variables, mainly occlusal forces, as the present study did.

All ten cases of prosthetic complication occurred in implants with single (non-splinted) crowns, although only 14 out of 83 implants had splinted crowns. Thus, it was not possible to compare implants with single and splinted crowns statistically, which still is controversial in the literature. While some authors advocate the use of splinted and screwed crowns on short implants in the posterior region in order to better distribute the load stresses,[22] others reported no statistically significant difference between splinted crowns on short dental implants and non-splinted ones, showing similar function with low marginal bone loss over time.[27-29] It is possible that splinting crowns supported by short implants offer a biomechanical advantage over non-splinted ones, which could be clinically safer in cases with large ridge resorption and history of bruxism. However, up to date, there is no conclusive evidence from long-term clinical studies or systematic reviews considering technical and biological patient's characteristics.

Some limitations of the present study include its retrospective design and the number of variables in relation to the sample size. The low number of prosthetic failures, which is excellent clinically, did not allow the comparison of some variables, such as type of prosthesis, type of abutment, length of prosthesis, and presence of sleep bruxism. Furthermore, some eligible patients were relocated to military units in other cities and could not be recalled. On the other hand, the sample consisted of patients treated in a specialized dental service under strict protocols showing ex-

ternal validity in a "real-world" clinical environment.

CONCLUSION

In summary, the results suggest that 6- and 8-mm long implants do not differ in the long-term clinical success of implants and prostheses in the posterior region. Among the tested biological and technical variables, only the increase in the clinical C/I ratio had an effect on the occurrence of prosthetic failure. However, all cases were of prosthetic screw loosening, which was easily resolved in the clinics.

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