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Clinical evaluation of the incidence of prosthetic complications in implant crowns constructed with UCLA castable abutments. A cohort follow-up study

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ABSTRACT

Objectives: To evaluate the incidence of prosthetic complications in implant-retained crowns made with UCLA castable abutments and to identify possible risk factors with a view to establishing recommendations to help predict the success of such restorations.

Methods: A cohort follow-up study was carried out in 71 partially dentate patients rehabilitated with 93 implant-retained single crowns. Data regarding socio-demographic background, anatomical features, implant-, and prosthesis-related variables were recorded. The incidence rate (%), relative risk (RR) and odds ratio (OR) were applied for predictive risk factors. ANOVA and Student *t*-tests were used to compare quantitative variables, the chi-square test was used to compare proportions and also a logistic regression analysis was performed. The statistical significance was set at $\alpha = 0.05$.

Results: Two implants (2.2%) were lost during the first year of function. The incidence of prosthetic complications in the observed mean period (26.2 ± 15.4 months) was 11.9%, consisting of screw loosening (10.8%) and ceramic fracture (1.1%). A higher tendency for prosthetic complications was noticed in posterior mandibular crowns restoring saddles longer than 10 mm with mesiodistal cantilevers longer than 6 mm, having natural antagonists, after long-term use (>20 months), with initial torque values superior than 30 Ncm.

Conclusions: Screw loosening is the most frequent complication in implant-retained crowns fabricated with UCLA abutments cast in cobalt–chromium. Nevertheless, the connection usually remains stable after retightening the screws. A high survival rate was recorded, and these prostheses may be a suitable treatment option.

Clinical significance: Based on the study findings, the risk of prosthetic complications is expected to increase when long-span posterior edentulous areas are rehabilitated with single implant-supported crowns. The antagonist occlusal plane should be restored to prevent torsional forces and overloading. Implant systems with initial torque values less than 30 Ncm should be selected.

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1. Introduction

The indications for use of implant-supported prostheses have expanded in recent years due to their recognized biological, functional, and aesthetic properties. However, numerous clinical studies[1,2] have presented the outcome of implant therapy by focusing only on implant survival without providing detailed information on the prosthodontic rehabilitation.[3]

Among the variety of abutments that can be satisfactorily utilized for implant-retained prostheses, the UCLA castable type is one of the most popular. This abutment consists of a plastic cylinder that directly connects to the implant and may be customized by waxing and casting using a base metal alloy such as cobalt–chromium. Its low cost, ability to overcome problems such as limited inter-occlusal spaces and small interproximal distances between implants, and the possibility of implant angulation error correction are its main advantages.[4,5] However, a drawback of this abutment is that the required laboratory steps could cause implant/abutment misfit, which may result in screw loosening and/or fracture along with other biological complications. Therefore, further clinical research is necessary.[5]

Moreover, the biomechanical behaviour of implant-retained restorations may be compromised by, amongst other factors, accumulated errors in the casting of the structures or in the veneering procedure. After stress concentrations that exceed the ultimate strength of the restorative materials, screw loosening, deformation or fracture of the prosthetic framework, and ceramic chipping or breakage may occur.[6,7] In this regard, loosening and fracturing of the screws that attach the abutments to the implants are the most prevalent prosthetic problems, ranging from 4.5 to 12.7% of cases.[3,8–13]

Preload is induced in a screw when a torque is applied to fix the implant/abutment connection. Such preload keeps the screw threads tightly secured to the screw's mating counterpart and holds the parts together by producing a clamping force between the screw head and its seat.[14–16] The screw elongates, placing the shank and threads in tension. The elastic recovery of the screw creates the clamping force that pulls together the prosthesis and the implant.[17] The strength of the union is usually proportional to the torque of the screw when it is tightened, and is expressed as a moment magnitude measured in Ncm.[14,15] A specific torque is recommended for each implant system, and even for different diameter abutments within the same system (http://www.genieoss.com/abutmenttorque.html).

If a flexion force exerted on a single implant restoration is greater than the resistance of the screw,[14] such screw suffers a permanent plastic deformation and consequent loss of tensile strength in its nucleus. This phenomenon elicits a reduction in the contact forces and the screw loosens easily. Also a settling effect (embedment relaxation)[15] is produced because the micro-roughened surfaces in contact are progressively flattened under occlusal loading, which results in a partial decrease of the initial preload.

After screw loosening, micro-movements of the restoration under load conditions may irritate the peri-implant tissues.[14,16,18] Although the solution usually consists in tightening or replacing the screw, it is very inconvenient for the patient and the dentist. However, if the screw cannot be retrieved, an extensive repair, such as disuse of the involved implant or remake of the prosthesis becomes critical.[15] Similarly, when the framework or veneering material breaks down, the restoration must be changed.

In an attempt to prevent prosthetic failures in implant crowns and overcome possible economic constraints of patients, the aims of this paper are to: (a) assess the incidence of prosthetic complications in screw-retained and cement-retained crowns made with UCLA castable abutments; (b) describe the socio-demographic, anatomical, and implant- and crown-related risk factors for prosthetic complications; and (c) design an approach to minimize the underlying causes of prosthetic problems in these types of implant crowns.

2. Materials and methods

2.1. Study protocol

A cohort follow-up investigation was carried out in partially dentate patients with implant-supported single crowns over osseointegrated external hex implants located in either the maxilla or the mandible. All patients were rehabilitated at the Dental Clinic of the Salamanca University (Spain) between 2005 and 2010. The exclusion criteria were cognitive impairment, motility disorders, and serious illness or death. Additionally, single crowns supported by two implants were excluded from the study because of their different biomechanical implications. The study was conducted following the ethical principles of medical investigation involving human subjects under the Helsinki Declaration of the World Medical Association (http://www.wma.net) and the Spanish Law 14/2007 of July 3rd for Biomedical Research (http://www.boe.es). All of the participants were briefed about the purpose and process of the study and the patients' approved written consent were obtained. Confidentiality was maintained.

All of the evaluated crowns were constructed in a standardized manner. The structures were vacuum-cast in a base metal alloy of white Co–Cr for ceramics (Heraenium CoCr metal ceramic alloy, Heraeus-Kulzer, Wehrheim, Germany). UCLA castable abutments were used in all cases to manufacture either screw-retained or cement-retained prostheses. The patterns of the screw-retained structures were custom-shaped by applying modelling wax (Classic modelling wax-blue, Renfert GmbH, Hilzingen, Germany) on the UCLA castable abutments. The patterns were then invested with a commercial phosphate-bonded stone (IPS Press Vest Speed, Ivoclar-Vivadent AG, Schäan, Liechtenstein) by using cylinders without a metal ring. The vacuum casting of the Co–Cr specimens was performed with an induction centrifugal machine (MIE-200 C/R, Ordenta, Arganda del Rey, Madrid, Spain) under vacuum pressure (580 mm Hg) at a temperature of 1465 °C. Cast frameworks were then retrieved and carefully cleaned using an airborne-particle abrasion with aluminium-oxide powders (50 μm) for 10 s at a working distance of 5 mm and a pressure of 50 ± 3.5 N/cm^2 to remove the investment residues.[19] In the case of cement-retained crowns, the abutments and the structures were waxed-up and cast separately, in two consecutive steps, following the described procedure in each phase (i.e. waxing-up the structures over the cast abutments).

Oxidation of the crown frameworks was completed in a ceramic oven following the manufacturers' instructions. Then, two layers of opaque porcelain were applied that underwent two separate firing cycles of 30 min/cycle in a vacuum ceramic oven (Programat P500/G2, Ivoclar-Vivadent AG, Schäan, Liechtenstein). The first layer was heated at 950 °C.[20] Subsequently, the structures were coated with a compatible feldspathic ceramic (HeraCeram, Heraeus Kulzer, Wehrhein, Germany) through a stratification technique using dentine and enamel ceramics in the same oven at 850 °C in every cycle. Finally, the glaze firing was made at 810 °C.

Titanium screws with hexagonal heads were used to connect the abutments to the corresponding implants. The screws were tightened with a torque of 20–35 Ncm according to the manufacturer's specifications for each implant system. Cement-retained prostheses were luted with resin-modified glass-ionomer cement (Ketac Cem Plus, 3M ESPE, St. Paul, MN, USA). The excess cement was removed with a plastic scaler to avoid scratching or gouging the abutments and restorations.[19]

All implant crowns were reviewed every six months during the first year, and then annually, using visual and radiographic investigation. Data collection was performed by a single operator (DB). The study variables were grouped as follows: Group 1: socio-demographic background (gender, age, smoking habits); Group 2: anatomical features (type of bone, length of the edentulous saddle filled with the single implant restoration, mesiodistal cantilever of the crown, type of antagonist, intensity of the occlusal contact); Group 3: clinical parameters related to the implant (location in the dental arch, implant diameter and length, duration of the healing phase, loading protocol, period of function, implant brand); and Group 4: clinical parameters related to the restoration (type of retention, torque of the screws, number of times the screws had to be retightened, other prosthetic complications) (Tables 1 and 2). The torque of the screws was measured in Ncm with a manual torque driver (Ref: RTI2035, Biomet 3i, UK, Ltd.). In the established periods of revision, each patient was evaluated twice by the same observer (DB).

The mesiodistal length of the edentulous saddle restored with the implant crown was measured by standardized intraoral digital radiovisiography (Kodak RVG, Kodak, Germany) using specific software (Kodak Dental Imaging Software 6.10.8.3, Kodak, Germany). Each image was calibrated using the diameter of the implant platform as a reference. Then, the saddle length was calculated between the greatest convexities of the adjacent teeth. When the restoration rehabilitated a free-end edentulous area or did not fill an intertooth space completely, the size of the saddle was considered as the highest mesiodistal dimension of the implant crown. Fig. 1 shows an example of the measuring technique.

For the purposes of this study, the difference between the highest mesiodistal dimension of the crown and the diameter of the implant platform was taken as the "mesiodistal cantilever of the crown" when more than a 2 mm-difference was observed.[21] The same radiovisiography equipment (Kodak RVG) and system software (Kodak Dental Imaging Software 6.10.8.3) were used (Fig. 1). All of the measurements were made by the same specialized operator.

The type of antagonist and the intensity of the occlusal contact with the implant crown were determined by direct inspection and the use of articulating paper of 200 μm (Bausch Company, Germany).

2.2. Statistical analyses

The intra-examination error was evaluated by the Kappa test. All of the data gathered were statistically analyzed according to well-established evaluation methods used in related research.[9,10] Descriptive statistics were calculated for all of the study variables.

Risk factors were expressed using the incidence (%), the relative risk (RR) and the odds ratio (OR) coefficients with a 95% confidence level. Parametric tests were used to compare quantitative variables (Student *t*-test for variables with two categories and ANOVA for variables with three or more categories). The chi-squared test was applied to compare proportions. A stepwise logistic regression model was estimated using the occurrence of crown removal (either to retighten the screws or because of other prosthetic complications) as the dependent variable. The statistical analyses were completed using the Statistical Package for the Social Sciences (software v.17.0) (SPSS/PC+, Inc.; Chicago, IL, USA) taking the cut-off level for statistical significance at $\alpha = 0.05$.[7,19,20]

3. Results

Eight patients were excluded from the reference population because they could not be contacted due to changes in their phone number and/or address details. Nine other patients refused to participate in the study for personal reasons (rejection rate = 10.2%).

Thus, the study sample comprised seventy-one partially dentate patients (44 males and 27 females) who were rehabilitated, between 2005 and 2010, with a total of 93 individual crowns supported by external hex implants in both the maxilla (47 implants) and the mandible (46 implants). None of these patients were lost during the observation period. The mean follow-up period was 26.2 ± 15.4 months. Kappa statistics showed a perfect intra-assessment coefficient of reliability ($k = 1$).

Table 1 – Patient sample data ($n = 71$).

	Sample size (N)	%
Gender		
Male	44	62.0
Female	27	38.0
Age (mean ± SD = 46.9 ± 12.3)		
≤35 years	13	18.3
36–50 years	32	45.1
51–64 years	21	29.6
≥65 years	5	7.0
Smoking habits		
Active smoker	26	36.6
Non-smoker	19	26.8
Past smoker	26	36.6

Table 2 – Location of the restorations, type and features of the implants, and causes of prosthetic complications in the implant-supported crowns ($n = 93$).

	Position in the arch				
	Incisor, *n* (%)	Canine, *n* (%)	Premolar, *n* (%)	Molar, *n* (%)	Total
Maxilla	10 (10.7)	1 (1.1)	21 (22.6)	15 (16.1)	47 (50.5)
Mandible	1 (1.1)	1 (1.1)	2 (2.1)	42 (45.2)	46 (49.5)
Total	11 (11.8)	2 (2.2)	23 (24.7)	57 (61.3)	93 (100)

	N	%
Implant brand and initial torque (mean ± SD = 29.5 ± 5.7 Ncm)		
Biomet 3i[a] (20 Ncm)	22	23.6
Defcon[b] (35 Ncm)	9	9.7
Microdent[c] (32 Ncm)	12	13.0
Mozograu[d] (30 Ncm)	30	32.3
Nobel Biocare[e] (35 Ncm)	20	21.5
Implant platform (diameter)		
Narrow	9	9.7
Standard (4.1 mm)	76	81.7
Wide	8	8.6
Implant length		
<13 mm	59	63.4
≥13 mm	34	36.6
Type of retention		
Screw-retained	84	90.3
Cement-retained	9	9.7
Complications in implant-supported crowns		
Screw loosening	10	10.8
Osseointegration failure	2	2.2
Ceramic fracture	1	1.1
Without problems	80	86.0

[a] Osseotite. Biomet 3i, Palm Beach Gardens, FL, USA.
[b] Defcon TSA. Impladent, Barcelona, Spain.
[c] MK. Microdent SL, Barcelona, Spain.
[d] MG Osseous. Mozograu SL, Valladolid, Spain.
[e] MK III. Nobel Biocare AB, Göteborg, Sweden.

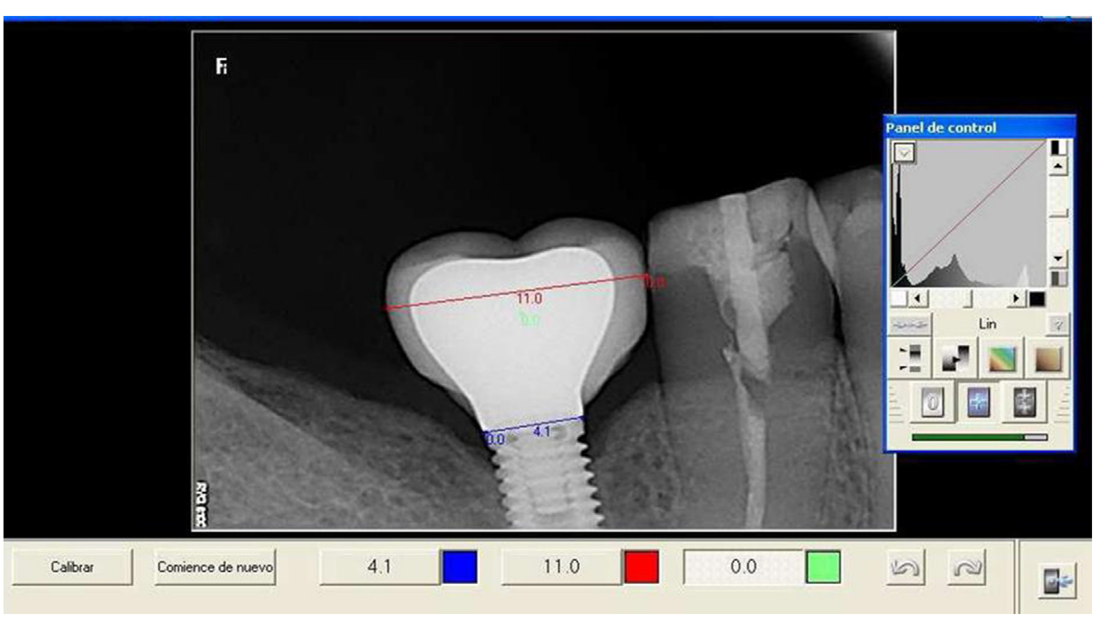

Fig. 1 – Measurement of the highest mesiodistal dimension of the crown by calibrating the image using the diameter of the implant platform as a reference.

Regarding socio-demographic backgrounds (Group 1), the study sample was drawn mainly from men (62.0%), aged 21–80 years (94%), being active or past smokers (73.2%) (Table 1).

Concerning the anatomical features (Group 2), the majority of implants were placed in healed bone (90.3%), whereas the remaining implants were placed in fresh extraction sockets (9.7%). The mean length of the saddle restored was 9.7 ± 2.3 mm, and the average mesiodistal cantilever of the crown was 5.8 ± 1.8 mm. Of the antagonists, 75.2% were natural teeth, 18.3% were ceramic, 5.4% were acrylic, and 1.1% was metallic. Most restorations had proper occlusal contacts (95.7%). Three implant crowns showed partial contact with their antagonists (3.2%) and one crown was infra-occluded (1.1%).

Regarding the implant-related variables (Group 3), 80% of the implants were located in the posterior sextants of the mouth, mainly in the mandibular molar (45.2%) and the maxillary premolar regions (22.6%). The canine area was the least frequently treated (2.2%). Of the implants, 81.7% had a standard diameter and 63.4% were shorter than 13 mm (Table 2). 96.8% followed a single-phase healing procedure, and 98.9% underwent a delayed loading protocol. On average, implants healed during 5.5 ± 2.6 months before loading and were in function for 20.6 ± 16.1 months. Two (2.2%) implants failed due to loss of integration in the first year of function. The distribution of implant brands is displayed in Table 2.

With reference to the restoration (Group 4), all of the implants were rehabilitated with single metal–ceramic crowns. Eighty-four of the crowns (90.3%) were screw-retained and 9 (9.7%) were cement-retained. The screws were tightened with an average torque of 29.5 ± 5.7 Ncm. Eleven screw-retained crowns (11.9%) had prosthetic complications: screw loosening occurred in ten restorations (10.8%), whereas another screw-retained prosthesis (1.1%) suffered from ceramic fracture (Table 2). The loose screws were retightened and remained stable afterwards, except one that had to be re-tightened twice. The incidence of prosthetic problems was significantly different depending on the implant brand ($p = 0.02$), and was higher in Defcon Implants (44.4%) than in MozoGrau (13.3%), Microdent (8.3%), Nobel Biocare (5%) and 3I Implants (4.5%), which showed no significant differences in comparison with one other ($p > 0.05$).

The risk of failure was higher in posterior (13.8%) mandibular (15.2%) restorations. An edentulous saddle longer than 10 mm to be restored with a single implant restoration and a crown with a mesiodistal cantilever longer than 6 mm augmented the risk of breakdown. A clear trend towards a greater risk of complications may be observed in restorations with natural antagonists (14.3%) with respect to the presence of prosthetic ones (4.3%). The risk (RR) of failure increased after 20 months of function (18.2%). A greater tendency towards prosthetic complications was detected in restorations screwed

Table 3 – Risk factors for prosthetic complications in single implant-supported restorations ($n = 93$).

	Incidence (%)	Chi-square test p-value	RR	Confidence interval of 95% for RR	
				Lower	Upper
Prosthodontic factors					
Location					
Posterior	13.8	0.15	1.2	1.1	1.3
Anterior	0.0		NS	NS	NS
Jaw					
Maxilla	8.5	0.31	0.6	0.3	1.3
Mandible	15.2		1.5	1.0	2.3
Length of the edentulous saddle					
>10 mm	18.2	0.07	1.7	1.1	2.6
≤10 mm	6.1		0.5	0.2	1.3
Mesiodistal cantilever of the crown					
>6 mm	15.9	0.25	1.4	0.9	2.3
≤6 mm	8.2		0.7	0.3	1.5
Type of antagonist					
Natural	14.3	0.20	1.2	1.0	1.6
Prosthetic	4.3		0.3	0.1	2.3
Duration of function					
>20 months	18.2	0.07	1.7	1.1	2.6
≤20 months	6.1		0.5	0.2	1.3
Initial torque					
>30 Ncm	14.6	0.46	1.3	0.7	2.3
≤30 Ncm	9.6		0.8	0.4	1.6
Patient-related factors					
Smoking habits					
Smokers	14.5	0.26	1.3	0.9	1.8
Non-smokers	6.5		0.5	0.1	1.9
Age					
>45 years	17.1	0.16	1.5	0.9	2.6
≤45 years	7.7		0.6	0.3	1.4

RR, risk ratio; NS, no sense.

with initial torque values of 32–35 Ncm (14.6%) in comparison with those inserted at 20–30 Ncm (9.6%). Active smoking was associated with a higher incidence of prosthetic problems than non-smoking, and patients older than 45 years showed higher risk of prosthetic failures (17.1%) (Table 3).

In a stepwise logistic regression model in which all potential predictors are included to envisage the occurrence of prosthetic complications and all of the confounding variables are kept under control, a significant effect was found for the saddle length (OR = 6.7; IC 95% 1.5–30.6; $p = 0.01$), the type of antagonist (OR = 9.4; IC 95% 1.0–88.8; $p = 0.05$), and the initial preload value introduced as a quantitative variable (OR = 1.2; IC 95% 1.0–1.4; $p = 0.05$). The proportion of the variation of prosthetic complications explained by this model is 23% according to the Nagelkerke R^2 statistic.

4. Discussion

A wide variety of therapeutic options may be considered in contemporary practice for replacing teeth with fixed rehabilitations; ranging from resin-bonded bridges or fixed partial dentures (FPDs), up to the use of implant-retained prostheses.[2,22,23] However, for decision making, it is important to know the survival proportions and the incidence of biological and technical complications not only for the implants, but also for the restorations[18]. In the present study, the results observed during a mean follow-up period of 26.2 months have been documented.

This research attempts to explore the factors associated with prosthetic complications in implant-retained crowns with a view to establishing clinical recommendations to help reduce the incidence of such problems in future patients. Implant crowns have shown high survival rates after the observation period but also an increased prevalence of technical complications,[3] which is still a concern for clinicians and patients.

In this study, standardized laboratory procedures for restoration fabrication were used and clinical periodic assessments were made twice by a single operator (DB), obtaining a perfect intra-examination reliability. Conversely, limitations of the study included the impossibility of measuring the occlusal forces in each case, and the fact that the patients were recruited only from a single university dental clinic. Furthermore, as the tested variables were not randomly assigned, a cause–effect relationship cannot be established. Therefore, the risk factors envisaged are just based on the distribution of prosthetic complications concerning such study variables.

The major finding of this investigation is that during a mean period of 26.2 ± 15.4 months, the most frequent prosthetic complication was screw loosening showing an incidence of 10.8% (Table 2), which was higher than that previously reported in five to ten years of follow-up studies.[10,11,13] This may be attributable to differences in the type of abutment, the implant system and the initial torque. Nonetheless, all of the loose abutments remained stable after being retightened with the recommended torque, except for one that was retightened twice. Our results are in accordance with the systematic review performed by Jung et al.[3] in which an accumulated incidence of 12.7% of screw loosening was estimated after five years of follow-up, doubling the incidence rated in previous studies on implant-supported FPDs.[11,13]

The use of UCLA castable abutments may have contributed to the high frequency of prosthetic complications because their casting procedure is very technique-sensitive and may have somewhat altered the fit at the implant/abutment interfaces. It must also be taken into account that great vertical misfits dot not necessarily imply higher detorque values.[24]

Less prosthetic failures have been reported for premachined[25] and gold-machined UCLA abutments.[26] To cast the UCLA abutments, a cobalt–chromium alloy was selected as its high fracture strength, elastic modulus, hardness, corrosion resistance and low cost[27] make it an alternative for constructing screw-retained prostheses and customized abutments for cement-retained crowns, offering an economic solution for patients. However, further research on the long-term success of implant-supported restorations fabricated with the described method is required.

Another explanatory factor of the high incidence of screw loosening lies behind the use of titanium screws in all restorations. Greater stability has been reported for gold or surface-treated titanium screws because of their higher preload values for any given torque force.[28]

In keeping with the conclusions of other authors,[9] screw loosening mainly occurred in the posterior mandibular area (Table 3). In addition to the length of the molar restorations, the chewing forces exerted on the posterior sectors of the arch are three to five times greater than those received by the anterior teeth.[29] Hence, that 80% of the restorations were located in the premolar and molar regions (Table 2) could somewhat justify the high incidence of screw loosening found in this study.

Our results can infer several factors that improve the risk of screw loosening. The length of the edentulous saddle to be restored with a single implant restoration (>10 mm), the type of antagonist, and the initial preload or torque value significantly increased such risk according to a multivariate logistic regression model. These findings are in keeping with the literature.[9,11,30,31] The patient age and the period of function were not significant in the multiple regression model, although they were in the expected direction according to other authors,[14,16,32–36] so that the older the patients and the restorations, the higher the rate of screw loosening (Table 3).

A long saddle to be restored with a single implant restoration and a crown with a long mesiodistal cantilever enhances the risk of screw loosening (Table 3). The negative influence of cantilevers on the long-term success of prosthetic restorations has been documented in the literature.[30–32] When compressive occlusal loads are exerted nearer to the marginal crest than to the implant axis, a torsional force is created that may increase the risk of screw loosening or fracturing. Bakaeen et al.[31] concluded that the risk of screw loosening could decrease by reducing the occlusal table of molar implant crowns in both their buccolingual and mesiodistal dimensions to minimize the torsional forces.[15] Given that the longer the distance of the load from the implant axis, the higher the torsion moment and the lever forces,[30–32] standard or wide implant platforms would be preferred over narrow ones whenever possible for reducing cantilevers. However, this was not the focus of the present study.

A significant relationship was observed between screw loosening and restorations having natural antagonists (Table 3). When a tooth is in infra-occlusion, it often erupts to seek occlusal contact.[37] This physiological process is not present when the antagonist is an implant-retained prosthesis, a fixed or a removable partial denture.[36,37] Moreover, most natural teeth are not located in the ideal intercuspal relationship given their tendency for migration and mesial inclination. This phenomenon generates oblique and torsional forces that cause overloading on the restorations.[38] On the contrary, prosthetic antagonists tend to have the occlusal plane at the proper level and inclination, which optimizes the stress distribution. The results of the present study are in agreement with the discussed conclusions on such biomechanical factors.[39]

Furthermore, the higher the initial torque, the more elevated the incidence of complications (Table 3). This finding should be viewed with caution because it is related to the implant brand, as the initial preload is based on the manufacturers' instructions (Table 2) and cannot be considered as an independent variable. Another possible explanation for this apparently contradictory observation could be the settling effect.[15] A high torque can lead to effective erosion of the micro-roughened surfaces of the screwed joint and, thereby, to a preload decrease. Between 2% and 10% of the initial preload is estimated to be lost because of the settling effect.[40,41] Several authors suggest re-tightening the screws ten minutes after tightening them for the first time.[40,42,43] Moreover, to assure the longevity of the implant–abutment union, the use of morse-tapered connections instead of hex implants has been suggested.[44]

Ceramic fracture was found only in a screw-retained prosthesis (Table 2). The veneering ceramic used has a stabilized leucite structure (SLS) that makes it particularly resistant to stress and crack propagation.[45] Moreover, even when the metal–ceramic bond is predictable in both types of implant–prosthetic connections, screw-retained crowns are more prone to suffer occlusal microcracking (near to the screw access) in comparison with cement-retained prostheses.[46] Acrylic resin has more resilience than ceramic as veneering material and, therefore, lower fracture rates,[47] which is in accordance with that recorded in the current study.

Therefore, based on the findings of this study, the risk of prosthetic complications is expected to increase when long-span posterior edentulous areas (>10 mm) are rehabilitated with single implant-supported crowns. The antagonist occlusal plane should be restored to prevent torsional forces and overloading, and implant systems with initial torque values less than 30 Ncm should be selected. Notwithstanding the prosthetic complications discussed here, the high survival rates obtained in this research, which are similar to that presented in prospective multicenter studies for single-tooth restorations,[8,9] may lead to the conclusion that this treatment modality with UCLA castable abutments seems reliable for routine use.

Furthermore, the durability of these implant restorations may depend on other critical factors that may be addressed in future clinical trials, such as the surgical technique, implant design, and surface characteristics,[48,49] mean clinical attachment level at implant,[50] correlation between occlusal scheme and failure mode of the restorative materials,[51,52] and presence bruxism and tooth wear.[53] Also the operator experience may influence the long-term success of implant-supported crowns.[54] Accordingly, the teaching programmes in both conventional fixed and implant-retained prostheses are evolving and are sensitive to current clinical trends and evidence-based practice.[55,56]

5. Conclusions

Within the limitations of this study, the following conclusions may be drawn:

1. Screw loosening is the most frequent prosthetic complication in implant crowns fabricated with UCLA abutments cast in cobalt–chromium. Nevertheless, the connection usually remains stable after re-tightening the screws.
2. A long saddle to be restored with a single implant restoration (>10 mm), a crown with a long mesiodistal cantilever (>6 mm), a natural antagonist, and a high initial torque (Ncm), which depends on the implant brand, are the main risk factors for treatment failure.
3. A high survival rate was recorded after the observation period (26.2 $\pm$ 15.4 months), and the use of UCLA castable abutments may be recommended to fabricate implant-supported crowns as a suitable treatment option.

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