Frequency of Technical Complications in Fixed Implant Prosthesis: The Effect of Prosthesis Screw Emergence Correction by Computer-Aided Design/Computer-Aided Manufacturing

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Computer-aided design/computer-aided manufacturing (CAD-CAM) technology permits the angular correction of screw emergence into the prosthesis; however, there is lack of controlled clinical studies that assess the frequency of technical complications in angled screw channel restorations. This controlled clinical study was designed to assess technical incidences in angled screw channel restorations. Patients who underwent placement of implant prosthesis between November 2014 and December 2015 were screened. The patients were selected if they received a prosthesis with up to 30° correction of the prosthesis screw emergence and had at least 1 nonangulated prosthesis (screw retained). All prostheses were located completely/partially in the posterior region. The frequency of technical complications was the principal variable. A total of 52 patients with a mean age of 62 ± 10 years participated, with a total of 110 prostheses (55 in the test group and 55 in the control group). A total of 11 technical complications occurred (7 in the test group and 4 in the control group). These differences were not statistically significant. All prostheses in both groups survived the follow-up. The correction of the screw emergence into the prosthesis has not increased the risk of technical complications in CAD-CAM implant prostheses.

Key Words: dental prosthesis, CAD/CAM, implant-supported framework, screw retained, fixed dental prostheses

INTRODUCTION

Dental implants are placed into the alveolar bone to support the prosthetic reconstruction of the occlusion. Screw-retained implant prosthesis has the advantages of retrievability, minimal interocclusal space, and easier maintenance (hygiene, repairs). However, restoratively driven and precise implant placement are required because of the position of the screw emergence in the prosthesis.[1] The emergence into the labial/buccal aspect of the prosthesis may hinder the achievement of good esthetic outcomes.[2–5] Indeed, the cement-retained prosthesis has the advantages of compensating nonideal implant positioning, passive fit, and improved esthetics.[1,3–5]

Screw-retained implant prosthesis exhibited less technical and biological complications than the cement-retained implant prosthesis.[1] In another systematic review, screw-retained prostheses had higher technical complications but lower biological complications (higher marginal bone loss) than the cemented prosthesis. A preference toward screw retention was noted because of its retrievability.[6]

Solutions for improper screw emergence in the prosthesis may increase the tolerability toward discrepancy of the implant positioning and permit graftless rehabilitation of jaw atrophy.[3,4] One of these solutions is the use of angled implant abutments.[7] Unlike straight abutments, this type of abutment has been reported to increase the stress on implants and the adjacent bone.[7] The use of angled abutments would vertically shift the restoration at the occlusal aspect and increased the risk of metal appearance if adequate running room is not provided.[7] The degree of angular correction is determined by the angle of prefabricated abutments. Avoiding the unesthetic vestibular screw channel is not always successful.[7] Nowadays, computer-aided design/computer-aided manufacturing (CAD-CAM) technology offers a possibility of personalizing the screw channel angulation according to the clinical needs of each case.[3–5,8] This

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correction can be done in any direction, and the magnitude of correction is infinite but with an upper limit.[3] One of the challenges that motivated the application of CAD-CAM technology in implant dentistry is that of correcting the screw channel angulation in screw-retained prostheses.[3–5,8] CAD-CAM may be of big help in creating restorations with a natural appearance and good esthetic outcomes.[3–5,9]

Today, implant-supported restorations fabricated by CAD-CAM technology are routinely used in dentistry.[8,9] For that reason, there is a need for more scientific evidence to support the use of CAD-CAM implant restorations as compared with conventionally fabricated restorations, for which there are considerable long-term data on survival and complication rates.[10–12]

One aspect that needs more scientific documentation is the use of CAD-CAM technology in the fabrication of angled screw channel restorations to compensate for improper implant positioning.[4] Although few studies are available, they show favorable outcomes.[2–5] There are no controlled clinical studies that assess the frequency of technical complications in angled screw channel restorations fabricated by CAD-CAM. These technical complications could vary in their severity from veneer fracture or screw loosening to screw fracture.[7–13]

The purpose of the retrospective study is to determine whether the frequency of technical complications is higher in angled screw channel restorations. A controlled study with straight screw channel restorations was designed. The investigators hypothesize that the correction of screw channel angulation would not increase the frequency of technical complications in screw-retained implant prosthesis. The specific aims of the study were (1) to assess the frequency and type of the technical complications and (2) to assess the effect of the magnitude of screw channel angulation on the frequency of technical complications.

Materials and Methods

Study design

To address the objectives of this study, a retrospective cohort split-mouth study was designed and implemented. The study population included all patients who had received an implant-supported prosthesis between November 2014 and December 2015. Patients were selected if they were older than 18 years, had received a prosthesis with up to 30° correction of the prosthesis screw channel (angled screw channel), had at least 1 nonangulated prosthesis (screw retained), and the prosthesis was located completely/partially in the posterior region (premolar and molar regions). None of the prostheses had a cantilever extension. Patients were excluded from the study if they did not fulfill all and each of the inclusion criteria. There were no specific exclusion criteria.

This research was conducted in a single center in Vitoria, Spain. The study evaluated a medical device (dental implants, BTI Biotechnology Institute, Vitoria, Spain) that was already approved for clinical use (CE mark). This research was performed following the Helsinki Declaration regarding investigation with human subjects.

Variables

The predictor variable was the angulation of the prosthesis screw channel. The CAD-CAM technique was employed to correct the angulation of the prosthesis screw channel up to 30° in chrome-cobalt (Cr-Co) metal frameworks. For the virtual design of the Cr-Co structure, extraoral scanning (Imetric, Cougenay, Switzerland) was performed for the cast. For this step, body scans for transepithelial abutments (BTI Biotechnology Institute) were connected. The superstructure design was performed in exocad software, and the screw channel was angulated with PowerShape CAD software (AUTODESK, San Rafael, Calif). A computer-steered 5-axis milling machine produced the Cr-Co structure. It is worth mentioning that the control prosthesis was produced following the same workflow but without correction of the screw channel (there was no clinical need for this correction). The prosthesis screw was the same for both groups (Ti Black screw, BTI Biotchnology Institute). The screw insertion torque as recommended by the manufacturer was given by a manual multitorque wrench.

The primary outcome was the frequency of prosthetic complications. The patients' records were reviewed to document any technical complications such as abutment screw loosening, abutment screw fracture, loss of retention of the permanent crown, or fracture of veneer material.

The secondary outcomes were (1) patients' demographic data, (2) the anatomical location of the prosthetic rehabilitation, (3) the number of the prosthetic units and the supporting dental implants, (4) the correction magnitude of the prosthesis screw channel, and (5) follow-up time of the prosthesis.

Data collection methods

Patients were included in a maintenance program with visits every 6 months. Two independent examiners (other than the restorative dentist and the surgeon) performed data collection and analysis. The patients' charts were reviewed to collect data about age and sex. The CAD-CAM design file was reviewed to identify the location of the prosthesis, the type of prosthesis, the number of prosthetic units, and the angulation correction (location and magnitude) of the screw channel. The technical complications were also identified from the patient's charts. The follow-up time since implant loading was calculated.

Data analysis

The statistical analysis was reviewed by an independent statistician. Descriptive statistics were performed considering the implant and the patient as a unit of analysis. Absolute and relative frequency distributions were calculated for qualitative variables and mean values and standard deviations for quantitative variables. Qualitative variables of frequency of complication and anatomical location (mandible/maxilla) were compared by χ^2 test. The χ^2 test was also applied to compare the type of the prosthesis (complete prosthesis, partial prosthesis, and single-unit prosthesis). Shapiro-Wilk test was selected to check the normal distribution of the data. Accordingly, Mann-Whitney test was selected to compare the variables of the number of the prosthetic units, the supporting dental implants, and the follow-up time. Statistical significance

Table 1

Description of the prostheses inserted in patients with/without angulations

	Prosthetic Group		
	Angulated	Not Angulated	*P* Value
Median number of implants	2 (range, 2–8)	2 (range, 2–8)	.061*
Median number of units	3 (range: 2 to 13)	3 (range: 2 to 12)	.783*
Location			
Mandible	29	34	.335†
Maxilla	26	21	
Type of prosthesis			
Complete prosthesis			
15°	4	8	.221†
30°	0		
Partial prosthesis			
15°	42	47	
30°	9		

* Mann-Whitney test.

† Chi-square test.

was set at $P < .05$. SPSS version 15.0 for Windows statistical software package (released 2006, SPSS for Windows, SPSS Inc, version 15.0, Chicago, Ill) was used for statistical analysis.

Results

A total of 52 patients participated in this study. Thirty-three patients were female, and the mean age at the time of prosthesis insertion was 62 ± 10 years. Each patient had at least with 2 prostheses: angled screw channel restoration (experimental group) and straight screw channel restoration (control group). A total of 110 fixed implant-borne prostheses were evaluated: 55 prostheses in the test group and 55 prostheses in the control group. All prostheses were located completely or partially in the premolar-molar region.

In the experimental group, the screw channel was corrected either by 15° (46 prostheses) or 30° (9 prostheses). The CAD/CAM technology was employed to design and execute this correction. In 11 prostheses, screw emergence correction was performed for less than 50% of the total number of supporting implants. In 44 prostheses, this correction was performed for more than 50% of the supporting implants.

Table 1 presents a comparison between the 2 groups in relation to the number of the supporting implants, the number of the prosthetic units, location, and type of the prosthesis. The statistical analysis showed the absence of statistically significant differences.

Table 3

Prosthetic complications according to the angulation of the screw channel and the location of the prosthesis

	Angulation				
	15°		30°		
	Mandible	Maxilla	Mandible	Maxilla	Total
Porcelain fracture	2	2	1	0	5
Screw loosening	1	0	0	0	1
Screw fracture	0	1	0	0	1
Total	3	3	1	0	7

During follow-up, a total of 11 events occurred, giving a frequency of 10%. Seven and 4 complications were reported in the experimental and control groups, respectively (Table 2). These differences were not statistically significant ($P = .343$). Most of the complications in both groups were related to the veneering material. The event of screw loosening in the experimental group occurred only once. After screw retightening, this event did not occur again. Table 3 shows that the distribution of the prosthetic complications was not related to the degree of angulation correction. All prostheses in the experimental and control groups survived the follow-up.

The follow-up time of the prostheses was 15 ± 4 months and 16 ± 8 months in the experimental and control groups, respectively. The Mann-Whitney test indicated the absence of statistically significant differences ($P = .598$).

Discussion

This controlled clinical study aims to analyze the frequency of prosthetic complications in screw-fixed implant prostheses in which an angular correction of the screw emergence has been performed (by CAD/CAM technology). The outcomes of this study indicate that the correction of the screw channel angulation has not significantly increased the frequency of prosthetic complications. To the best of our knowledge, this would be the first controlled study to assess the correction of screw channel angulation on the frequency of technical complications.

Gjelvold et al[3] used individualized abutments with an

Table 2

Frequency of prosthetic complications according to the type of the prosthesis

	Angulated		Not Angulated		
Event	Complete Prosthesis	Partial Prosthesis	Complete Prosthesis	Partial Prosthesis	*P* Value
No complications	4	44	7	44	
Porcelain fracture	0	5	1	2	
Screw loosening	0	1	0	0	
Screw fracture	0	1	0	1	
Total number of complications	7		4		.343*

* χ^2 test.

angled screw channel to restore single labially inclined implants and thus avoid vestibular access channel. Sakamoto et al[5] described a technical report of an esthetic abutment design for an angled screw channel.

In a previous study, Greer et al[4] assessed the mechanical complications of angled screw channel restorations in 60 patients. The mean follow-up time was 216.3 days, and 3 complications occurred: screw loosening, porcelain fracture, and implant failure. However, there was no control group, and most of the implants were placed in the incisors area.[4] In the present study, all of the restorations were located completely or partially in the premolar-molar region, and a control group (split-mouth) was included.

Porcelain fracture was the most frequent prosthetic complication in control and experimental groups (8 incidents in 110 prostheses). In the systematic review by Pjetursson et al,[13] fracture of the veneer material was the most frequently reported technical complication (13.5%). This technical complication was also the most common in CAD-CAM implant prostheses.[8] In a systematic review, a total of 104 incidents were recorded in a total of 221 prostheses.[8]

Screw loosening happens when the functional load exceeds the screw preload or when screw settling occurs.[14,15] Repetitive screw loosening could be a sign of eccentric/excessive occlusal loads. The inability to apply a sufficient torque during tightening would also increase the probability of screw loosening.[4,14] Herein, one event of screw loosening was encountered in the experimental group. After screw retightening, this event did not occur again. This incident could be related to the failure to apply adequate torque at the time of prosthesis placement.[4] In a recent study, screw retightening once after the first torqueing significantly enhanced the removal torque.[14] Compared with manual screwdrivers, the use of torque-limiting devices (such as a wrench) more efficiently delivers the torque to the screw.

One event of screw fracture was observed in the experimental and control groups. In one mechanical study of screw-angled channel restorations (5 million cycles of mechanical loading with 100 N as the upper load limit), screw loosening or failure was not observed.[2] Thus, this type of screw failure could be related to other factors. All included prostheses have been located partially/completely in the premolar-molar region. Most of the screw fractures have occurred in the premolar and molar regions, where mastication and lateral mandibular movements in association with cusp inclination generate undesirable forces.[16] Biomechanical overloading of the prosthetic reconstruction has been identified as the most common cause of fracture.[17] Rangert et al[16] identified implant fracture to coexist with bruxism and excessive occlusal loads in 56% of the study group. Moreover, the lack of optimum preload may negatively affect the fatigue life of the retaining screw.[18]

It is worth mentioning that prosthetic reconstruction has been performed herein on prefabricated machined transepithelial abutment (not on the implant platform). This would bring the prosthetic platform close to the gingival margin and minimize errors during impression making. In the study by Geramipanah et al,[19] impression making at the fixture level has not been superior to the one made at the abutment level (angular accuracy and linear errors). However, in the event of highly diverged posterior implants, the abutment-level method showed a better linear accuracy.[19]

Angled screw channel restorations seems not to have a higher frequency of technical complications and thus permits the selection of screw-retained prosthesis where a cemented restoration would otherwise be needed. This study suffers from the limitation of a retrospective design in which the dependency on the availability and accuracy of medical/dental records could not be excluded. It is difficult to control bias and confounders because of the retrospective design. However, this study had a control group and followed a split-mouth design (each patient contributed with a experimental prosthesis and a control prosthesis). The short follow-up time is another limiting factor. Future research should analyze the outcomes at the dental implant level. Prospective and controlled clinical studies are needed to satisfy the need for more scientific evidence of the predictability of CAD-CAM technology in the fabrication of angled screw channel restorations.

Conclusions

The correction of the screw channel angulation has not increased the risk of technical complications. The most common technical complication was related to the veneering material. Angled screw channel restorations is an alternative to restoring improper implant positioning with a screw-retained prosthesis where a cemented restoration would otherwise be needed.

Note

E.A. is the scientific director of the BTI Biotechnology Institute (Vitoria, Spain). He is the head of the Foundation Eduardo Anitua, Vitoria, Spain. C.F. and L.P. have no conflict of interests. M.H.A. is a scientist at BTI Biotechnology Institute (Vitoria, Spain).

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