Clinical Outcome of Inter-Proximal Papilla between a Tooth and a Single Implant Treated with CAD/CAM Abutments: a Cross-Sectional Study

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ABSTRACT

Objectives: The aim of this study was to assess the clinical outcomes achieved with Computer-Assisted Design/Computer-Assisted Manufacturing implant abutments in the anterior maxilla.
Material and Methods: Nineteen patients with a mean age of 41 (range form 26 to 63) years, treated with 21 single tooth implants and 21 Computer-Assisted Design/Computer-Assisted Manufacturing (CAD/CAM) abutments in the anterior maxillary region were included in this study. The patients followed 4 criteria of inclusion: (1) had a single-tooth implant in the anterior maxilla, (2) had a CAD/CAM abutment, (3) had a contralateral natural tooth, (4) the implant was restored and in function for at least 6 months up to 2 years. Cases without a contact point were excluded. Presence/absence of the interproximal papilla, inter tooth-implant distance (ITD) and distance from the base of the contact point to dental crest bone of adjacent tooth (CPB) were accessed.
Results: Forty interproximal spaces were evaluated, with an average mesial CPB of 5.65 (SD 1.65) mm and distal CPB of 4.65 (SD 1.98) mm. An average mesial ITD of 2.49 (SD 0.69) mm and an average distal ITD of 1.89 (SD 0.63) mm were achieved. Papilla was present in all the interproximal spaces accessed.
Conclusions: The restoration of dental implants using CAD/CAM abutments is a predictable treatment with improved aesthetic results. These type of abutments seem to help maintaining a regular papillary filling although the variations of the implant positioning or the restoration teeth relation.

Keywords: Computer-Assisted Design; Computer-Assisted Manufacturing; dental abutments; dental implants; outcomes assessment; dental esthetics.

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INTRODUCTION

Nowadays, there are several restorative treatments alternatives for replacing a missing tooth. Over recent years the rehabilitation of partially edentulous patients with dental implants has become a well-established treatment [1,2].

Replacement of missing teeth in the aesthetic zone presents a complex challenge for the clinicians, due to the difficulty in restore the natural appearing sulcular and papillae anatomy surrounding rehabilitated zones [3]. There are several studies that report similar success rates for implants rehabilitation in the anterior region compared to those placed in other parts of the jaws [4-6]. Cordioli et al. in 1994 [7], Engquist et al. in 1995 [8] and McMillan et al. [9] in 1998 reported a single-tooth implant restoration survival rate of 94.4%, 97.6% and 96% respectively.

The long-term unpredictable stability of the soft tissues is one of the problems of single-tooth implant rehabilitation for clinicians [10-11]. In past decades, the presence or absence of papillae between two teeth, a teeth and an implant and between adjacent implants has been a topic widely discussed and important in oral implants rehabilitations. Tarnow et al. [12-14] related the presence or absence of the interdental papilla to the distance of bone to the contact point between the teeth and between teeth and implants.

Dental implant abutment selection plays also an important role in achieving optimal aesthetic results [15]. The Computer-Assisted Design/Computer-Assisted Manufacturing (CAD/CAM) systems were incorporated in the production of implant abutments and frameworks in the early 1990s and first applied to titanium abutments [16-19]. CAD/CAM abutment technique consists in a computer program that reproduces the position of the implant and allows a correct abutment design with an ideal shape and tilt. This information is then transmitted to a device that machines the final abutment [20]. Vigolo et al. [21-22] assessed in their studies the precision at the implant-abutment interface of CAD/CAM abutments. For optimal mucogingival aesthetics, implant abutments should have the appropriate emergence profile needed to support the surrounding soft tissue and preferentially be made from tooth-coloured material to prevent the bluish translucency of the overlying mucosa [21-23]. The aim of this study was to assess the clinical outcomes achieved with Computer-Assisted Design/Computer-Assisted Manufacturing implant abutments in the anterior maxilla.

MATERIAL AND METHODS

Patient selection

Nineteen patients (8 females and 11 males) with a mean age of 41 years (range form 26 to 63) who had been treated with 21 single tooth implants and 21 CAD/CAM abutments in the anterior region of the maxilla were included in this study. The selection of the patients for the implant treatment included patients with teeth lost due to traumatic injury, endodontic failure or traditional fixed prostheses failure. The patients with edentulous sites due to periodontal disease were excluded from the study. After the treatment, the patients followed 4 criteria of inclusion: (1) had a single-tooth implant in the anterior maxilla, (2) had a CAD/CAM abutment, (3) had a contralateral natural tooth, (4) the implant was restored and was in function for at least 6 months up to 2 years. The cases where did not exist contact point between the implant and the teeth were excluded.

These patients were treated between January 2009 and January of 2010 in the Department of Oral Surgery and Implant Dentistry of Private Medical Centre in Bragança and all signed the consent form in accordance with the Helsinki Declaration of 1975, revised in 2000. The control group was absent.

Surgical and reconstructive treatment protocol

The implants (OsseoSpeed™, AstraTech Dental, Möhndal, Sweden) were placed over delayed extraction sites, with a time of healing 7 to 8 weeks, or immediate extraction sites were there no compromise of the buccal bone plate. All the implants were placed in the maxilla between teeth #14 - 24 area and left to heal for a period of 6 to 10 weeks, following a two-stage protocol (Figure 1). After this period osseointegration was confirmed. All implants were then restored with screw-retained resin provisional crowns (Protemp™ Plus Temporization Material, 3M ESPE, St. Paul, Minnesota, USA) during a period of 2 months.The implants were then rehabilitated with a CAD/CAM abutment system (Atlantis™, Atlantis Europe, Möhndal, Sweden) using zirconia and gold titanium abutments (Figure 2). The zirconia abutments were made of Yttria-stabilized tetragonal zirconia polycristals (Y-TZP) and the titanium abutments used were milled from titanium alloy 6Al-4V (grade 5) blank and then coated with thin layer of titanium nitride (TiN) that provides the gold shade. The peri-implant soft tissue anatomy was copied with the use of a light-curing composite resin added to fill the space between the soft tissue and the impression coping to prevent the tissues from collapsing while the impression was being

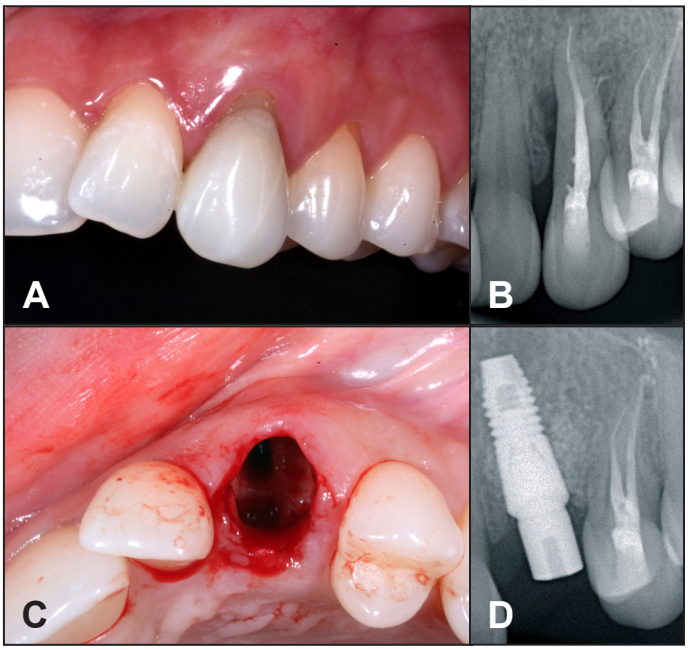

Figure 1. Surgical treatment protocol: A and B = clinical status and radiographical aspect of the tooth 23; C = post-extraction socket; D = implant placement in the fresh socket.

poured (Figure 2C). Then both the diagnostic model and master cast are scanned in order to initiate the milling process of the abutment. The virtual abutment design software accurately establishes the location, orientation, angle and depth of the implant (Figure 3). All the abutments were then restored with all ceramic crowns, with ceramic veneering in lithium disilicate (LS_2) (IPS e.max Ceram, Ivoclar Vivadent AG, Schaan, Principality of Liechtenstein), placed over the CAD/CAM abutments.

Follow-up evaluation protocol

After a two-year period of the implant rehabilitation the 19 patients were recalled as part of their recall program. One patient was excluded of the study group since it had no contact points between the implant restoration and the adjacent teeth. Standard clinical and radiographic examinations were made, regarding the implants situation in terms of survival and success.

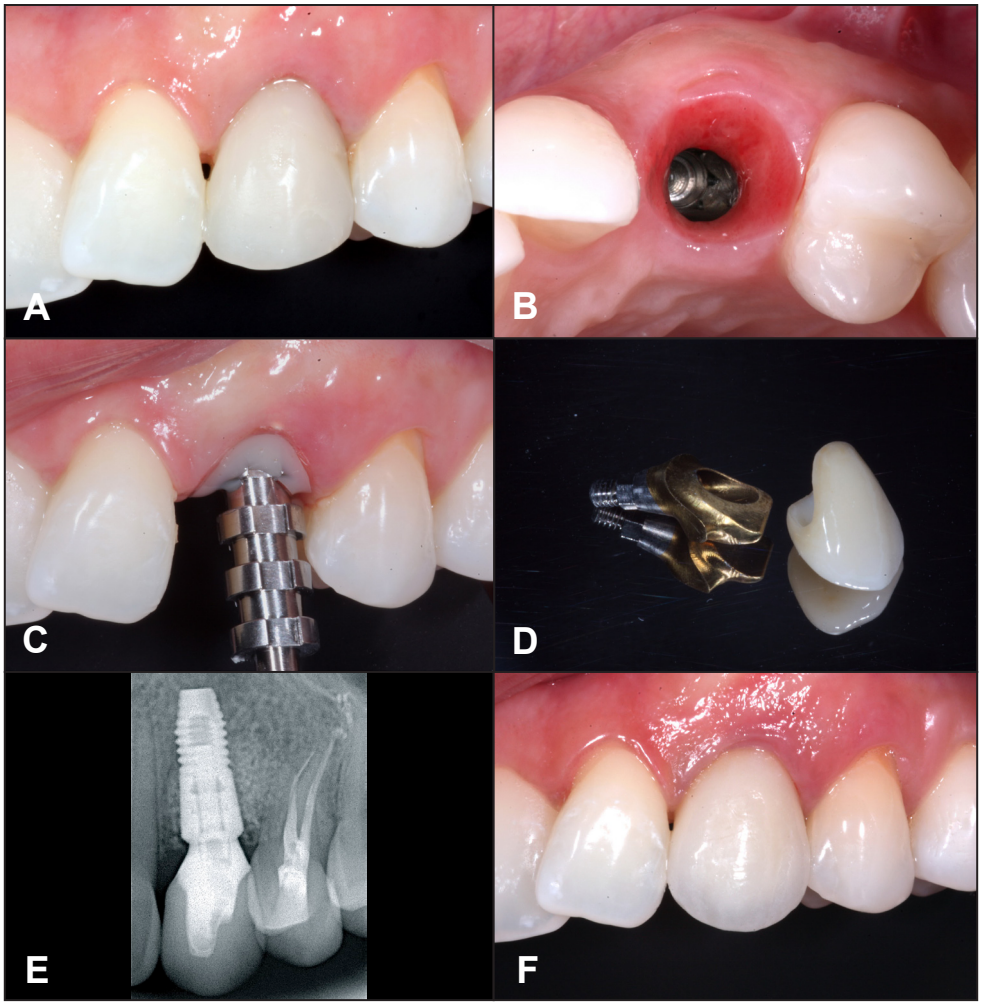

Figure 2. Prosthetic treatment protocol: A = screw-retained resin provisional crown; B = soft tissue emergency profile after 10 weeks with provisional restoration; C = implant-level impression; D = CAD/CAM gold titanium abutment; E and F = ceramic restoration.

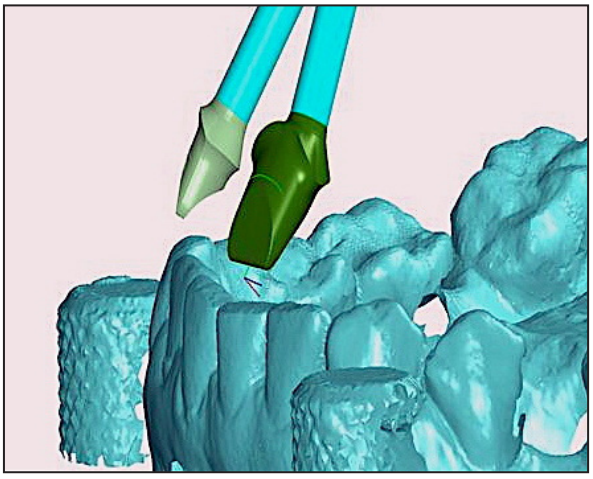

Figure 3. Computer aided design of the abutments.

Selected parameters

The following parameters were evaluated: (1) presence/absence of the interproximal papilla, (2) inter tooth-implant distance (ITD) and (3) distance from the base of the contact point to dental crest bone of adjacent tooth (CPB).

Interproximal papilla evaluation

The presence/absence of the interproximal papilla was based in the pink aesthetic score parameters for mesial and distal papilla [24] (Table 1). The inter-proximal papilla was diagnosed as present if it filled up the entire proximal space and was in good harmony with the adjacent papillae; half-present if the proximal space was half filled with the papilla and if less than half of the papilla was present the diagnosis was absent papilla. All implant crowns were captured with a digital SLR camera (Canon EOS 450D, Canon, Tokyo, Japan. Em 140 DG Macro Flash, Sigma, Kanagawa, Japan. Sigma 105 mm DG Macro Lens, Sigma, Kanagawa, Japan). The contralateral tooth was also completely and symmetrically represented. Standardized clinical photographs (magnification x1) were taken at each implant site and the contralateral tooth. The analyses were performed by one experienced prosthodontist who had not been involved in the prosthetic treatment of any patients represented in this study. After 2 weeks a second set of ITD and CPB measurements was performed to evaluate the intra-observer variability. The mean difference between the first and the second assessment was negligible.

Radiographic assessment

Peri-apical radiographs were taken 24 months after definitive implant restoration with the parallelism technique using intra-oral X-ray device (Heliodent Plus, Sirona Dental Systems Inc., NY, USA. XIOS Intra-oral Sensor System, Sirona Dental Systems Inc., NY, USA). A computerizing analysis were performed, using commercially available software Adobe® Photoshop® CS5 (Adobe Systems Inc., CA, USA) to determine inter-implant-tooth distance (ITD) and the distance between the contact point to the inter-dental bone (CPB) values (Figure 4). The parameter chosen to set the measurement system was the distance between the implant neck and the most apical point of each fixture, along an ideal line running parallel to the long fixture axis [25,26]. If in the periapical radiographs were found an overlapping zone with the adjacent tooth and the crown of the restored implant, we accepted the medium point in the overlapping zone for effects of measurement of CPB values.

Table 1. Papilla pink aesthetic scores

Parameter	Absent	Incomplete	Complete
Mesial papilla	0	1	2
Distal papilla	0	1	2

Statistical Analysis

A statistical analysis was performed using computer software SPSS™, Statistical Package for the Social Sciences, version 17.1 (IBM Corporation, Armonk, NY, USA). Data distribution was characterized by mean value and standard deviation (SD).

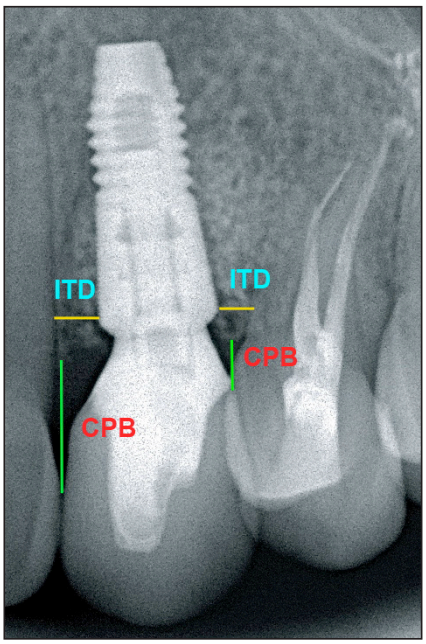

Figure 4. Computerized analysis performed to determine values of the inter-implant–tooth distance (ITD) and the distance from the base of the contact point to the inter-dental bone (CPB) after converting the periapical radiograph to a digitalized image.

RESULTS

All the selected eighteen patients were present at this stage recall. Twenty implants placed in the anterior maxilla (four in the site of 22, seven in the site of 21, five in the site of 12, one in the site of 11 and three in the site of 23), were evaluated. Forty interproximal sites, between tooth and implant were assessed, regarding the papilla presence, ITD and CPB values. No implant failures were reported in the two-year evaluation stage, resulting in a 100% implant success rate. Clinical and radiographic parameters which were assessed are shown in Table 2.

Interproximal papilla evaluation

An average mesial papilla score of 1.75 (SD 0.44) mm and a distal papilla score of 1.7 (SD 0.47) mm were achieved. At the mesial side, the papilla filled the interproximal space completely at 75% of the sites and at the distal side the papilla filled the interproximal space completely at 70% of the sites. An overall completely papilla filing was found in 72.5% of the sites and in 100% of the sites the papilla was either completely or half present.

Radiographic assessment

A mesial ITD average of 2.49 (SD 0.69) mm and a distal ITD average of 1.89 (SD 0.63) mm were achieved. An overall CPB average of 5.11 (SD 1.86) mm was determined, with a mesial CPB average of 5.65 (SD 1.65) mm and distal CPB of 4.65 (SD 1.98) mm (Table 2).

DISCUSSION

This study comprised a retrospective analysis of 20 dental implants, placed in the maxillary anterior region, restored with CAD/CAM abutments. Although the surgeon skills and local anatomy play a major role in the peri-implant tissue stability, clinical reports of the literature also tells us that custom abutments seem to provide better results than stock abutments for ideal crown contours and peri-implant soft tissue support [24]. To minimize the impact that the surgical skills might had in the final aesthetic result, all the surgical procedures were carried out by an experienced implant surgeon (TB) and were only included in the study group patients that received dental implants with no associated extensive regeneration procedures. A review on the management of inter-dental/inter-implant papilla by Zetu and Wang [27] addressed factors that may influence its appearance; these mainly included the dimension of the inter-proximal space, the horizontal distance between a tooth and an implant, adequate bone volume, the presence of adjacent tooth attachment and a proper soft tissue thickness.

Table 2. Clinical papilla radiographic assessments

Implant	Tooth	Papilla presence		CPB (mm)		ITD (mm)		Abutment
		Mesial	Distal	Mesial	Distal	Mesial	Distal	
1	22	2	2	4.9	2.8	2.64	1.29	Gold Ti
2	12	1	1	3.5	2.55	1.63	1.05	Gold Ti
3	12	2	2	5.22	2.89	2.26	1.13	Gold Ti
4	12	2	2	5.8	2.56	1.5	1.35	Gold Ti
5	21	2	2	4.05	6.21	2.7	2.13	Gold Ti
6	22	1	2	4.75	4.81	1.2	2.72	ZIRCONIA
7	12	2	2	6.67	5.56	2.08	2.24	Gold Ti
8	21	2	2	5.56	4.17	3.09	1.81	Gold Ti
9	22	1	1	9.72	7.09	1.87	2.04	Gold Ti
10	21	2	2	7.91	5.66	2.99	1.6	ZIRCONIA
11	11	2	1	4.93	5.33	3.4	1.55	GOLD Ti
12	21	2	1	5.45	2.89	2.76	1.95	ZIRCONIA
13	21	1	1	3.92	6.5	3.19	2.24	Gold Ti
14	12	2	2	4.29	2.64	2.24	1.14	Gold Ti
15	21	2	2	6.11	3.93	4.07	2.53	Gold Ti
16	21	1	1	8.17	9.2	2.93	1.5	Gold Ti
17	23	2	2	4.33	2.6	2.35	2.93	Gold Ti
18	23	2	2	5.19	5.66	2.28	3.16	Gold Ti
19	22	2	2	5.98	2.7	2.25	1.28	Gold Ti
20	23	2	2	5.67	2.88	2.53	2.28	Gold Ti

The parameters that affected the incidence of inter-proximal papilla between a tooth and an implant were also examined by Gastaldo et al. [28] in 48 patients (80 inter-proximal sites). These authors compared different parameters like the distance from the base of the contact point to the bone crest (D1), the distance between a tooth and an implant or between two implants (D2) and the distance from the base of the contact point to the tip of the papilla (D3) and stated that when D2 was 3, 3.5 or 4 mm, the papilla was present most of the time and when D2 was 2 or 2.5 mm the papilla was absent 100% of the time. When the distance between the contact point and the bone crest (D1) was 3, 3.5, 4 mm the papilla was present 100%. When the distance was 6 mm the interdental papilla filled this space about 55% of the time and at 7 mm the interdental space was completely filled about 25% of the time [27].

The results reported in the present study on the apico-coronal dimension of the inter-proximal area are not confirmed by the investigation of Gastaldo et al. [28]. In fact, for an overall CPB > 5 mm we assessed an overall 72.5% completely papilla presence and at least half-presence of the papilla in all the interproximal spaces assessed (Table 3). Also, from the data collected we can report a papilla presence in all the nine sites with an ITD between 1 - 1.5 mm (Table 4) and completely papilla presence on 86.7% of the fifteen (15) sites with a CPB ranging 5.0 - 7.0 mm (Table 3).

The results reported in the present study are also distant from the investigation by Choquet et al. [10]. Although these authors established that the papilla level around single-tooth implant restorations is mostly related to the bone level adjacent to the teeth and more specifically to the bone crest, they stated that the papillae regeneration after a single implant treatment was successful with a distance of 5 mm between the contact point and the bony crest. Above 5 mm the occurrence of papilla regeneration was at least 50% but with no predictability [10].

Grunder [29] showed in his study that when an implant is placed adjacent to a tooth, if a distance between the contact point and the crest of bone was < 5 mm, results in a similar outcome in order to presence or absence of papilla to that between two adjacent teeth. This author presented ten case reports of single-tooth rehabilitation and referred that all the papillae were presented after crowns were placed. The presence of healthy bone on adjacent tooth and the location of the contact point at a distance of 5 mm or less were determinant factors in Grunder's study. Although the differences established by different authors regarding the papilla position, its clear that a missing contact point, the implant-to-tooth distance and the distance of the bone peak to the contact point address as important predictors in terms of papilla recession, plus the surgical approach or flap design [30].

Since the present evaluation was a retrospective analysis we must take notice of the absence of a control group, and the lack of parameters that were not considered like the type of surgical flap or the execution of some regeneration procedures. The attempt to correlate different parameters like ITD and CPB and a papilla score, that relates to a direct comparison between the implant restoration and the soft tissue status around the natural control tooth seems to be an acceptable protocol to evaluate aesthetic outcomes [31]. In future studies it would be interesting to relate this type of implant abutment restoration with other abutment options for the anterior maxillary region, considering also different timings of implant placement and related surgical procedures.

Table 3. Presence of inter-proximal papilla according to contact point to bone crest distance (CPB)

CPB (mm)	N	Papilla present	%	Papilla half-present	%
2.0 - 3.0	9	8	89	1	11
3.0 - 5.0	11	8	72.7	3	27.3
5.0 - 7.0	15	13	86.7	2	13.3
> 7	5	1	20	4	80

N = number of interproximal spaces evaluated.

Table 4. Presence of inter-proximal papilla according to implant–tooth distance (ITD)

ITD (mm)	N	Papilla present	%	Papilla half-present	%
1 - 1.5	9	6	66.7	3	33.3
1.5 - 3	26	19	73	7	27
> 3	5	4	80	1	20

N = number of interproximal spaces evaluated.

CONCLUSIONS

The restoration of dental implants using Computer-Assisted Design/Computer-Assisted Manufacturing abutments appears to be a predictable treatment with improved aesthetic results in anterior maxilla. Properly placement of the implant and correct prosthetic considerations play a major role in the inter-proximal papilla management. The restoration of dental implants using Computer-Assisted Design/Computer-Assisted Manufacturing abutments seems to improve the papilla presence between tooth and implant.

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The authors declare that they have no conflict of interests.

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