Research

# Evaluation of clinical and radiographic outcome of friction fit conical abutment system in implant-supported dental prostheses: An *in vivo* study

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## Abstract

**Aim:** The purpose of this clinical study was to analyze the clinical feasibility of friction fit conical abutment system in implant-supported fixed dental prostheses as an alternative to cement and screw retention.

**Settings and Design:** This was an *in vivo* longitudinal study.

**Materials and Methods:** A total of 10 prostheses were designed as 3- or 4-unit fixed dental prostheses supported by two implants. All the subjects selected were evaluated for pocket probing depth (PPD) and marginal bone loss at the time of implant placement (T1), at the time of placement of friction fit prostheses (T2), and 12 months after placement of friction fit prostheses (T3). Marginal bone loss at T2 and T3 was measured with respect to bone levels at T1 and T2, respectively. The patient satisfaction was assessed at T2 and T3 using FDI clinical criteria and scoring system (modified by Monaco *et al*.).

**Statistical Analysis Used:** Shapiro–Wilk test was employed to test the normality of data. Paired sample t-test was performed for quantitative variables.

**Results:** A total of twenty implants were inserted in ten partially edentulous spaces; the average patient age was 50.2 years. No significant difference was seen between T2 and T3 for PPD. Comparison of marginal bone loss using paired *t*-test showed a statistically highly significant difference at T2 and T3 with higher value at T2. No prostheses were dislodged during postprosthetic follow-up. The survival rate was 100% for both the abutments and implants. No change in surface luster was observed 12 months following prosthetic rehabilitation in any case. No prostheses or framework fracture was reported and all patients were satisfied with the prosthesis received.

**Conclusions:** Friction fit conical abutment system can act as a novel approach for the retention of implant-supported fixed dental prostheses.

**Keywords:** Alternate retention, computer-aided design and computer-aided manufacturing, friction fit

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## INTRODUCTION

The longevity of restoration is the key objective of a successful treatment plan and so it is with implant-supported prosthetic rehabilitation. A successful treatment plan demands meticulous adherence to established protocols. The implant and prostheses are technique and material sensitive. One of the areas of concern is the abutment-prosthesis junction.[1] Implant-supported prosthetic reconstructions can either be screw retained or cement retained or a combination of both.[2,3] Although there are many advantages to either approach, inherent risks and drawbacks which negatively affect the long-term success of the implant-supported prosthesis become predominant.[4]

Screw-retained implant prostheses have an inherent lack of esthetics with a channel cast in metal or a compromised strength of the superstructure around the access hole. In addition, the problems of screw loosening and plastic deformation arise due to biomechanical overload. Subsequently, the restoration becomes mobile as the screw loosens, leading to an inflammatory reaction or a screw fracture.[5,6] Cement-retained implant prostheses are associated with peri-implantitis attributed to residual excess cement.[7,8] Residual excess cement can be eliminated by using a screw-retained cemented prosthesis or a combination implant crown in which screw access hole is on the occlusal surface of prosthetic crown which is extraorally cemented to abutment allowing removal of excess cement. Thereafter, the assembly is retained through screw. Although this technique allows the elimination of residual cement, it leaves the occlusal, usually functional cusp/fossa area to be restored with a composite that is more susceptible to wear and abrasion, thereby compromising occlusal contacts. Moreover, with multiple units, this technique becomes more difficult.[9]

To overcome the aforementioned shortcomings of the screw- or cement-retained implant prosthesis, friction fit implant-supported dental prosthesis that uses a tapered cone design to retain the coping on the abutment by surface friction can be designed. The conical coping is retained on conical abutment by surface contact. Tapered cone design creates friction when the prosthesis is completely seated over the abutment. The tapered attachment design ensures complete seating of the prosthesis as the diameter of the coping is greater than the diameter of the abutment.[10-12]

The aim of this clinical study was to analyze the clinical feasibility of friction fit conical abutment system in implant-supported fixed dental prostheses as an alternative to cement and screw retention. The objective is to analyze the clinical outcome by evaluating the health of peri-implant tissues over time by assessing the pocket probing depth (PPD), clinical parameters, and complications in terms of esthetic and functional properties[13] and radiographic outcome by evaluating the peri-implant bone changes (marginal bone loss) to demonstrate the feasibility of the friction fit conical abutment system as a novel approach for the retention of the prostheses.

## MATERIALS AND METHODS

The study was approved by the Institutional Ethical Committee (RUHS-CDS/EC/2017/Proposal/001). All partially edentulous patients registered in the Department of Prosthodontics were assessed for implant-supported prostheses. Ten partially edentulous cases were selected following the inclusion criteria. All sites had opposing natural dentition. A total of ten prostheses supported by two implants were designed. All the subjects selected were evaluated at the time of implant placement (T1), at the time of placement of friction fit prostheses (T2), and 12 months after placement of friction fit prostheses (T3). The implant system used in the study was NobelReplace Conical Connection Implant System (Nobel Biocare).

The study included healthy subjects of 18 years and above with no temporomandibular joint pathosis, normal maxillomandibular relationship, sufficient interarch space, sufficient bone volume, and physically or psychologically fit for implant-supported fixed dental prostheses. Subjects with recent myocardial infarction, bleeding disorder, psychiatric disorder, undergoing intravenous bisphosphonate treatment, uncontrolled diabetes, pregnant women, and chronic smokers were excluded from the study. Prior to the study, the approval of the Institutional Ethical Committee (RUHS-CDS/EC/2017/Proposal/001) and informed consent of each participant were obtained. The participant data were formulated and used for research purposes.

### Surgical phase

Surgery was performed by one experienced operator. All patients were operated under local anesthesia (2% lignocaine with 1:100,000 adrenaline). The osteotomy site was prepared as recommended by Branemark to minimize trauma to the bone and thereby prevent necrosis of the bone.[14] Cover screws were placed and flaps were approximated to achieve complete closure using simple interrupted and/or simple mattress lock sutures using a 3-0 braided nonresorbable silk suture. The patients were called for the postoperative checkup after 24 h and then

after 10 days of surgery for suture removal. Delayed loading protocol was followed for the study. After completion of the requisite period of 6 months for the bone to implant integration, second-stage surgery was performed and per-mucosal attachments were placed for the formation of the gingival collar.

### Prosthetic phase

Irreversible hydrocolloid impression material (Zelgan 2002 Alginate; Dentsply) was used to make primary impressions. Impressions were poured immediately with Type 3 Dental Stone (Kalstone; Kalabhai Karson Pt Ltd.) to obtain primary cast for custom tray fabrication. A minimum window (1.5 $cm^2$) was prepared over the area of the implant to allow clearance for manipulation of the impression coping in the custom tray. Implant-level open-tray impression was made with polyvinyl siloxane impression material (Photosil; DPI) [Figure 1]. A master cast with implant analogs was created. A vinyl polysiloxane (GI-MASK Automix; Coltene/Whaledent Private Ltd.) was used to simulate soft tissues. After try-in of implant verification jig [Figure 2], the master cast with embedded implant analogs was sent for scanning, designing, and milling of abutment and superstructure/coping.

Three consecutive phases are involved in computer-aided design and computer-aided manufacturing (CAD/CAM) production: scanning, designing, and milling. Scanning: the master cast with implant analogs was digitally scanned by an extraoral scanner (Identica T500; MEDIT). Designing [Figure 3]: 2° conical titanium abutments were designed using CAD software (DentalCAD; Exocad GmbH) and were made parallel to each other. The abutments were allowed a uniform 2° axial taper to allow for complete seating and yet provide sufficient resistance form. The custom abutments were designed to be parallel and had the desired subgingival emergence profiles and heights. Milling: the customized implant abutments were created by the CAM device (ME-300HP; TDS Biotechnology Co. Ltd.) in accordance with the virtual design.

After milling, abutment try-in was done to ensure a complete fit of customized abutments over implants [Figure 4]. Thereafter, customized titanium abutments were completely seated on the master cast and digitally scanned with Extraoral Scanner (Identica T500; MEDIT) for designing the prosthesis [Figure 5]. Superstructure/prosthesis was designed directly over abutments [Figures 6 and 7]. It was ensured that to achieve friction fit, zero cement space was left after milling (the outer diameter of the abutment was the same as the internal diameter of the superstructure),

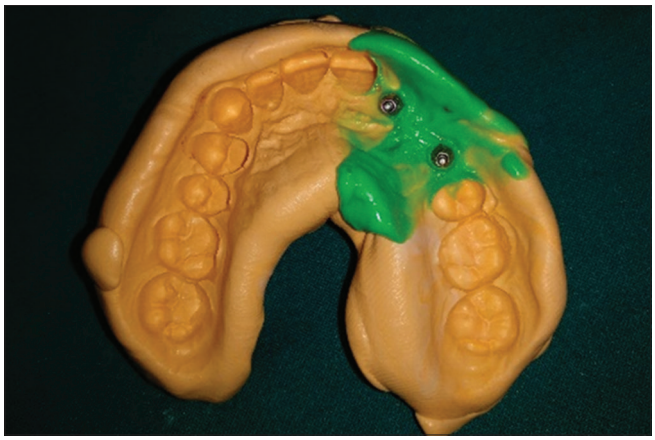

**Figure 1:** Implant-level open-tray impression

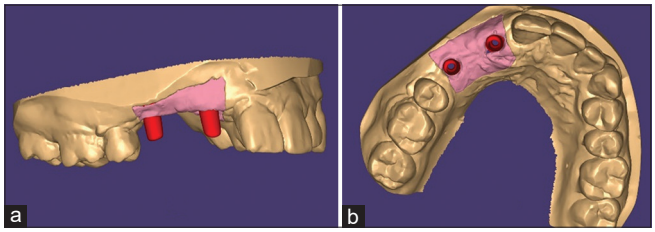


**Figure 3:** Abutment design using exocad DentalCAD software abutment design. (a) Lateral view, (b) occlusal view

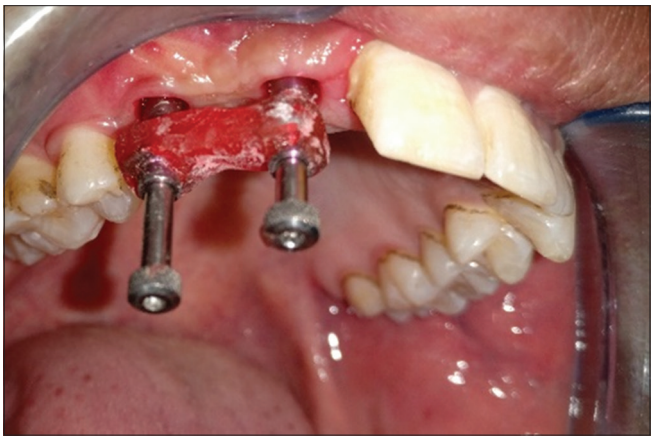

**Figure 2:** Try-in of implant verification jig

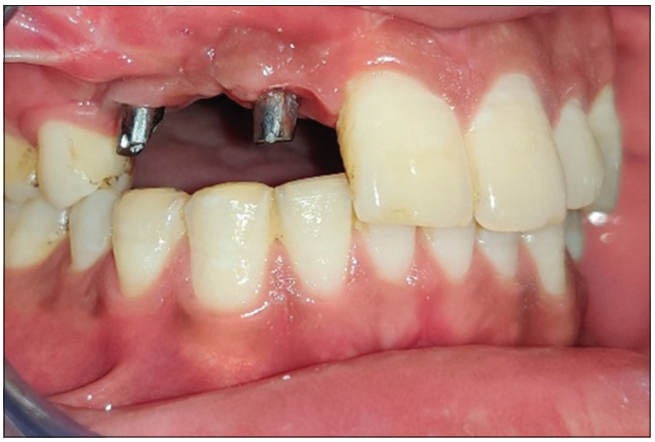

**Figure 4:** Customized milled abutment *in situ*

and a 2° axial taper was given. Thereafter, the superstructure was milled (ME-300HP; TDS Biotechnology Co. Ltd.). The abutments were tightened with a torque ratchet and superstructure was placed over abutments. Activation of friction fit attachment was achieved by biting force in posteriors and by gentle tapping with the handle of mouth mirror in case of anteriors. Implant-protected occlusion was ensured for all prostheses. Lateral tipping using a wood stick or lateral rocking of the prosthesis using forceps with silicon coating could be used for retrieving the prosthesis.[15,16]

## Examination

### *Clinical parameters*

PPD was evaluated at the time of prosthesis placement (T2) and 12 months after prosthesis placement (T3) using plastic instruments to avoid scarring and/or damage to the implant surface. Peri-implant PPD was measured using a plastic periodontal probe from the gingival margin to the bottom of the pocket at mesial, distal, facial, and lingual/palatal side with a pressure calibration stop of 0.25 N (TPS probe; Ivoclar Vivadent AG).[17,18]

### *Radiographic parameters*

Radiographic analysis of the peri-implant bone was done by the cone-beam computed tomography (CBCT) (CS3D-9000; Carestream Dental LLC). CBCT radiographs were taken for measurements of the quality and quantity of bone in the peri-implant area, immediately following implant placement (T1), at prosthesis placement (T2), and 12 months after prosthesis placement (T3). The analysis was done using a measuring tool inbuilt in the CS3D-9000 CBCT machine software.

Change in the crestal bone level (linear measurements of bone loss around the implant) was measured in millimeters using CBCT. Navigation was done on the multiplanar screen to show the precise reformatted panoramic and sagittal view of the implant. The bone loss around the implant was assessed by a line drawn on the mesial, distal, buccal, and palatal image on the collar margin of the implant to the alveolar crest, using software tools [Figures 8-11].[19] Mean marginal bone loss was obtained by dividing the sum of marginal bone loss of mesial, distal, buccal, and palatal sides by four.

Data obtained were compiled on a spreadsheet (MS Office Excel 2010; Microsoft Corp.). Data were subjected to statistical analysis using the statistical software program (IBM SPSS Statistics, v20.0; IBM Corp.). Descriptive statistics such as mean and standard deviation for numerical data have been depicted. Paired sample *t*-test was performed for quantitative variables. For all the statistical tests, $P < 0.05$ was considered to be statistically significant, keeping $\alpha$ error at 5% and $\beta$ error at 20%, thus giving a power to the study as 80%.

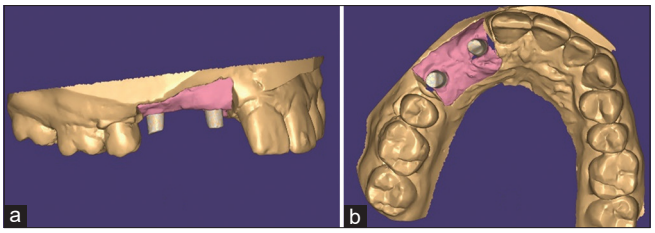


**Figure 5:** Scanned image of milled abutment. (a) Lateral view, (b) occlusal view

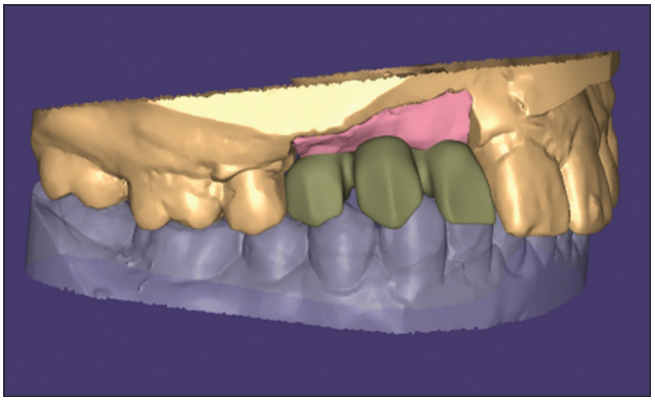

**Figure 6:** Prosthesis design using exocad DentalCAD software

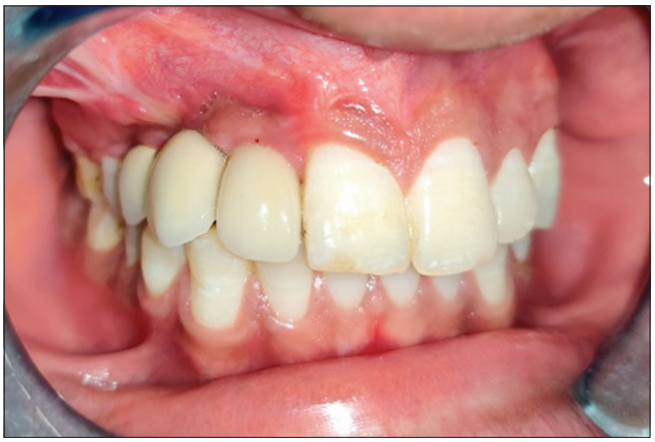

**Figure 7:** Milled superstructure with layered porcelain *in situ*

## RESULTS

## Clinical evaluation

### *Pocket probing depth*

The mean value of PPD was 1.66 mm with a standard deviation of 0.20 at T2 and 1.69 mm with a standard deviation of 0.23 at T3. Results showed no significant difference between T2 and T3. Furthermore, the surface-wise result showed a statistically nonsignificant

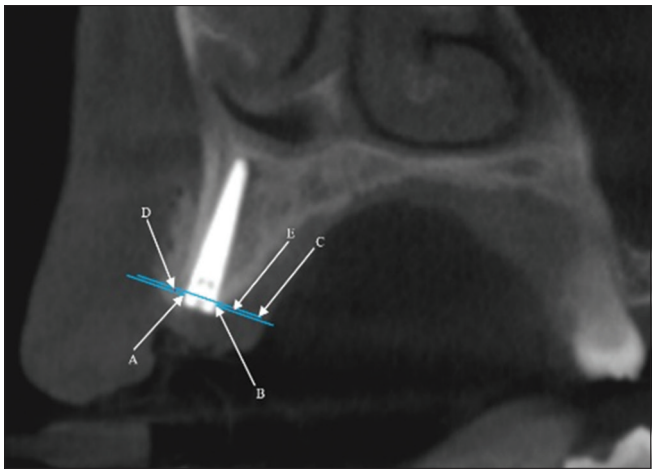


**Figure 8:** CBCT MARGINAL bone-level determination. (A) Bone crest buccally, (B) bone crest lingually, (C) line passing through implant shoulder buccolingually, (D) vertical distance between A and C, (E) vertical distance between B and C

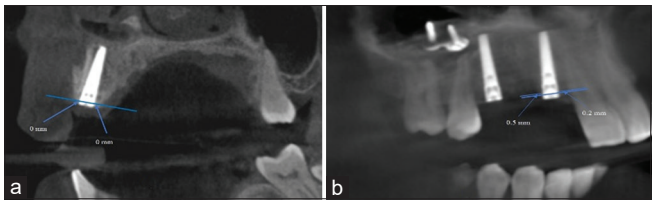


**Figure 10:** Marginal bone level at T2. (a) Faciolingual, (b) mesiodistal

**Table 1: Statistical comparison of pocket probing depth (paired *t*-test)**

| | Mean | *n* | SD | SEM | Mean difference | SD of difference | *T* | *P* of paired *t*-test |
|---|---|---|---|---|---|---|---|---|
| Mesial T2 | 2.35 | 20 | 0.59 | 0.13 | −0.10 | 0.31 | −1.45 | 0.163# |
| Mesial T3 | 2.45 | 20 | 0.60 | 0.13 | | | | |
| Distal T2 | 2.25 | 20 | 0.44 | 0.1 | −0.15 | 0.37 | −1.83 | 0.083# |
| Distal T3 | 2.40 | 20 | 0.50 | 0.11 | | | | |
| Facial T2 | 1.00[a] | 20 | 0.00 | 0.00 | - | - | - | - |
| Facial T3 | 1.00[a] | 20 | 0.00 | 0.00 | | | | |
| Lingual T2 | 1.05 | 20 | 0.22 | 0.05 | −0.05 | 0.22 | −1.00 | 0.330# |
| Lingual T3 | 1.10 | 20 | 0.31 | 0.07 | | | | |
| Average T2 | 1.66 | 20 | 0.20 | 0.05 | −0.02 | 0.08 | −1.45 | 0.163# |
| Average T3 | 1.69 | 20 | 0.23 | 0.05 | | | | |

*All values are non significant. SD: Standard deviation, SEM: Standard error of mean

difference between T2 and T3 with a higher value at T3 [Table 1].

### *Radiographic evaluation*

#### Marginal bone loss

Mean marginal bone loss was assessed before and after functional loading. Mean marginal bone loss at T2 represents bone loss before loading (between T1 and T2), while the mean marginal bone loss at T3 represents bone loss after functional loading (between T2 and T3). The mean values of marginal bone loss were 0.26 mm with a standard deviation of 0.08 at T2 and 0.12 mm

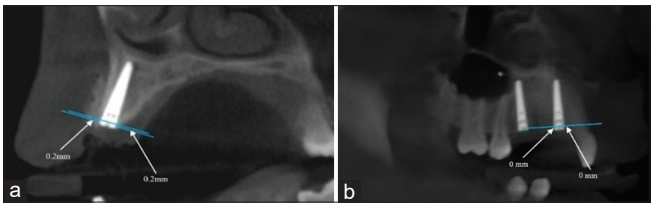


**Figure 9:** Marginal bone level at T1. (a) Faciolingual, (b) mesiodistal

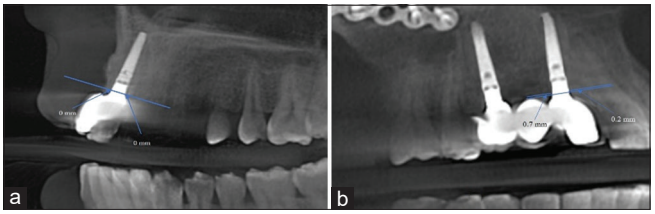


**Figure 11:** Marginal bone level at T3. (a) Faciolingual, (b) mesiodistal

with a standard deviation of 0.05 at T3. Comparison of marginal bone loss using paired *t*-test showed a statistically highly significant difference at T2 and T3 with higher value at T2 (0.26 mm ± 0.08). The above comparison indicates the marginal bone loss that occurred before functional loading was significantly higher than after loading [Tables 2 and 3]. Comparison of mesiodistal and faciolingual bone loss using paired *t*-test showed a highly significant ($P = 0.000$) difference at T2 and T3 with higher value at the mesiodistal surface [Table 4].

### *Prosthetic evaluation*

No prostheses were dislodged during postprosthetic follow-up. Clinical parameters and complications were evaluated in terms of esthetic and functional properties according to FDI clinical criteria and scoring system modified by Monaco *et al.* [Table 5].[13,20] No change in surface luster was observed in any cases at T3 (12 months after placement of friction fit prostheses). No prostheses and framework fractures were reported and all patients were satisfied with the prosthesis received.

## DISCUSSION

The friction fit abutment system achieves retention by principles of transition fit. The transition fit is used where accuracy is important, but where a small amount of clearance or a small amount of interference is acceptable and it results in size to size fit.[21-27] A friction fit is dependent on the accuracy at the prosthesis abutment interface and increases as the area of contact increases. Friction is maximum when the coping is fully seated on the abutment.[10-12,28]

This is, to the best of our knowledge, the first protocol that investigated the performance of friction

**Table 2: Marginal bone level at T1, T2, and T3**

| Subjects | Implants (location wise) | Marginal bone level (mm) | | |
|---|---|---|---|---|
| | | At the time of implant placement (T1) | At prosthesis placement (T2) | 12 months after prosthesis placement (T3) |
| 1 | 12 | +0.1 | −0.175 | −0.225 |
| | 14 | +0.1 | −0.15 | −0.2 |
| 2 | 12 | +0.075 | −0.25 | −0.35 |
| | 21 | +0.25 | 0 | −0.125 |
| 3 | 36 | +0.25 | 0 | 0 |
| | 38 | +0.175 | 0 | −0.05 |
| 4 | 46 | +0.125 | 0 | −0.15 |
| | 48 | −0.5 | −0.875 | −0.95 |
| 5 | 12 | +0 | −0.325 | −0.45 |
| | 22 | +0.3 | −0.025 | −0.125 |
| 6 | 32 | +0.3 | +0.025 | −0.075 |
| | 42 | +0.325 | +0.025 | −0.125 |
| 7 | 16 | +0.9 | +0.7 | +0.525 |
| | 18 | −0.175 | −0.35 | −0.45 |
| 8 | 34 | −0.075 | −0.425 | −0.5 |
| | 36 | +0.15 | −0.225 | −0.325 |
| 9 | 26 | +1 | +0.7 | +0.575 |
| | 28 | +0.25 | −0.075 | −0.25 |
| 10 | 45 | +1.6 | +1.325 | +1.15 |
| | 47 | +0.325 | +0.075 | −0.075 |

+: Alveolar crest above collar margin of implant, −: Alveolar crest below collar margin of implant

**Table 3: Statistical comparison of marginal bone loss (paired *t*-test)**

| | Mean | *n* | SD | SEM | Mean difference | SD of difference | *T* | *P* of paired *t*-test |
|---|---|---|---|---|---|---|---|---|
| T2 | 0.26 | 20 | 0.08 | 0.02 | 0.14 | 0.09 | 7.28 | 0.000** |
| T3 | 0.12 | 20 | 0.05 | 0.01 | | | | |

**Highly significant. SD: Standard deviation, SEM: Standard error of mean

**Table 4: Statistical comparison of marginal bone loss (paired *t*-test) (mesiodistal vs. faciolingual)**

| | Site | *n* | Mean±SD | SEM | *T* | *P* of paired *t*-test |
|---|---|---|---|---|---|---|
| T2 | MD | 20 | 0.35±0.09 | 0.02 | 6.83 | 0.000** |
| | FL | 20 | 0.17±0.07 | 0.02 | | |
| T3 | MD | 20 | 0.20±0.07 | 0.02 | 8.93 | 0.000** |
| | FL | 20 | 0.04±0.04 | 0.01 | | |

**Both values are highly significant. SD: Standard deviation, SEM: Standard error of mean, MD: Mesiodistal, FL: Faciolingual

fit conical abutment system in 3- or 4-unit fixed dental prosthesis supported by two implants. The present study was developed and carried out using methods that had been used in previous studies that examined the friction fit retention but with notable changes. Previous studies comprised three components (abutment-coping-superstructure) prosthetic assembly, where friction fit connection exists between abutment and coping and coping was then luted to the superstructure, while the present study design comprised two-component (abutment-superstructure) prosthetic assembly, where coping is an inherent part of the superstructure and friction fit connection exists between abutment and superstructure. In the present study, CAD-CAM-milled 3- or 4-unit metal-ceramic fixed dental prostheses were fabricated directly over the paralleled customized abutments instead of prefabricated abutment and coping, which were utilized in previous studies [Figure 12].[10,29-31] This eliminates the need for the dentist to choose prefabricated stock abutments and make them parallel intraorally. CAD-CAM abutments, on the other hand, are already parallel to each other with optimized height and emergence profile.[16]

In the present study, customized titanium abutments with 2° axial tapers were designed using CAD software (DentalCAD; Exocad GmbH) and were made parallel to each other. In one of our cases, abutment angle correction was >30 and it was compensated by using a multiunit abutment. This was done as retention of friction fit conical abutment system depends on the area covered. The more the area, the more will be retention.[28] Implant placement parallel to each other keeps the screw access hole occlusally and utilizes all axial surfaces for retention [Figure 13]. If the implants are not placed parallel to each other, it will result in shifting of screw access gingivally, thereby reducing the axial wall and thus the area covered by the superstructure [Figure 14].

Nardi *et al*. found the retention of friction fit prostheses to be directly proportional to the height and diameter of the abutment. The retentive strength of friction fit prostheses was found to be comparable with values reported for commonly used cement.[28] One advantage of the friction fit abutment system is the ease with which the clinician may retrieve the prosthesis to assess periodontal health and conveniently execute professional oral care.[16,32] In the present study, the prostheses were found to be acceptable

**Table 5: Clinical parameters and complications in terms of esthetic and functional properties (as modified by Monaco *et al.*)**

| Properties | Parameters | T2 | T3 |
|---|---|---|---|
| Esthetic properties | | | |
| Surface luster | | | |
| 1 | Surface luster comparable to enamel | 10 | 10 |
| 2 | Slightly dull, not noticeable if covered with film of saliva | | |
| 3 | Dull, cannot be masked by saliva film | | |
| 4 | Rough surface, unacceptable plaque retentive surface | | |
| Functional properties | | | |
| Framework fracture | | | |
| 1 | No | 10 | 10 |
| 4 | Yes | | |
| Veneer fracture | | | |
| 1 | No | 10 | 10 |
| 2 | Yes, color wear in the occlusal portion (Grade 1: Polishable) | | |
| 3 | Yes, chipping (Grade 2: Repairable) | | |
| 4 | Yes, severe chipping/delamination (Grade 3: Replacement) | | |
| Patient response | | | |
| 1 | Entirely satisfied | 10 | 9 |
| 2 | Satisfied | | 1 |
| 3 | Minor criticism of esthetics; no adverse effect | | |
| 4 | Completely dissatisfied and/or adverse effect, including pain | | |

1: Clinically excellent/very good, 2: Clinically good, 3: Clinically sufficient/satisfactory, 4: Clinically unsatisfactory

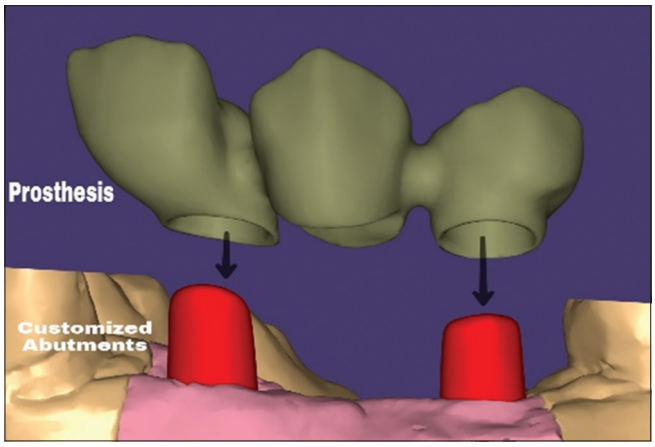


**Figure 12:** Two-component prosthetic assembly

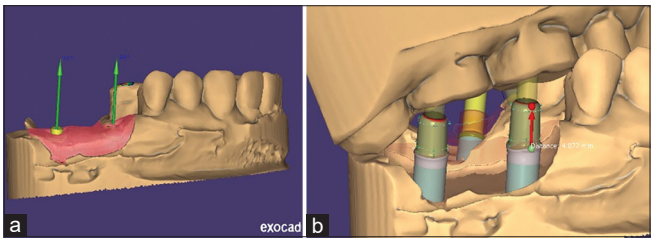


**Figure 13:** Implant placement parallel to each other keeps the screw access hole occlusally and utilizes all axial surfaces for retention. (a) Implant placed nearly parallel to each other, (b) occlusal screw access hole

on clinical parameters with 100% patient satisfaction in terms of retention and soft-tissue response.

Radiographic evaluation of marginal bone loss was done using CBCT. The amount of marginal bone loss was measured buccally, lingually, mesially, and distally using the inbuilt software of CBCT machine (CS3D-9000; Carestream Dental LLC) as conventional radiographs (periapical and panoramic) are two-dimensional and give no information about the alveolar bone quality and quantity.[33,34] Marginal bone loss assessment has been regarded as a critical criterion to assess implant success. The accepted implant success criteria are 1–1.5 mm of bone loss during the 1st year of loading and <0.2 mm annually thereafter.[35-37] Comparison of marginal bone loss using paired *t*-test showed a statistically highly significant difference at T2 (0.26 mm ± 0.08) and T3 (0.12 mm ± 0.05) with a higher value at T2. This can be attributed to surgical crestal bone trauma at the time of implant placement. These findings were in agreement with the study by Chou *et al.*[38] and Kline *et al.*[39] Marginal bone loss in the present study was 0.12 ± 0.05 mm during the 1st year of loading, which is less than the threshold specified in the success criteria.

In clinical parameter, PPD was recorded in the present study. The PPD results of the present study were in concordance with the results of the studies conducted by Degidi and Bressan, which also reported a nonsignificant difference in PPD at postprosthetic follow-up.[10,30]

The survival rate was 100% for both the abutments and implants. The frictional fit was viable, and even after 12 months of loading, a 100% prosthesis survival rate was achieved without prosthetic complications. These results were in concordance with the study conducted by Degidi *et al.*, which also reported similar results.[10] No change in surface luster was observed 12 months following prosthetic rehabilitation in any case. No prostheses or framework fracture was

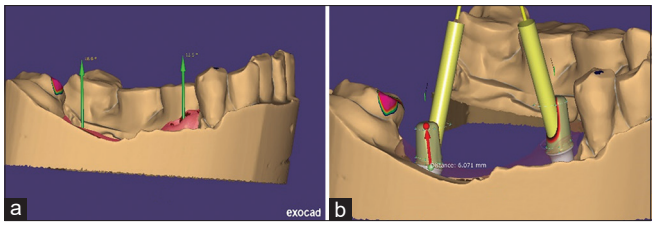


**Figure 14:** Implants placed nonparallel to each other will result in shifting of screw access gingivally, thereby reducing the axial wall and thus the area covered by the superstructure. (a) Implants placed nonparallel to each other, (b) shifting of screw access hole gingivally

reported and all patients were satisfied with the prosthesis received. No prostheses were dislodged during postprosthetic follow-up. However, to validate these findings, further long-term studies with a larger sample size are required.

## CONCLUSIONS

Within the limitation of the present study, the friction fit abutment-prosthesis connection showed a 100% survival with encouraging data of PPD and marginal bone loss endorsing the reliability of friction-retained prosthesis without compromising the periodontal status. Thus, the friction fit conical abutment system can act as a novel approach for the retention of implant-supported fixed dental prostheses.

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### Conflicts of interest.

There are no conflicts of interest.

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