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EFFECT OF VENTED AND CLOSED ABUTMENTS ON PERI-IMPLANT SOFT AND HARD TISSUES - CLINICAL AND RADIOGRAPHIC ASSESSMENT

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ABSTRACT

Excess cement found on tooth-retained restorations with healthy periodontal tissues present few if any problems. The cement-retained implant restoration may be more vulnerable to the effects of cement entering the soft tissues and residual excess cement on the implant restoration when compared to a tooth. It has been hypothesized that an open/hollow abutment may provide an internal reservoir for cement.

Materials and methods: The patients included in the study were divided into two groups according to the abutment design that was used after implant placement; closed abutment group (CA) where 7 crowns were cemented on closed abutments vented abutment group (VA) where 7 crowns were cemented on vented abutments. |Re-examination was scheduled 3, 6 and 12 months after crown cementation. Periodontal assessment included Bleeding Index (BI) and Probing depth (PD). Bone height measurements were performed using cone beam computed tomography to measure the marginal bone loss.

Results: Considering different intervals of the follow-up period, the differences in BI and PD between tested groups (vented and closed abutments) were statistically non-significant ($p>0.05$), but there was a statistically significant increase in PD for comparison between PD at different time periods in each group after 6 months as well as from 6 months to 12 months.

After 3, 6 as well as 12 months, Group CA showed statistically significantly higher mean amounts of bone loss than Group VA.

Conclusions: (1) Vented abutments exhibit better soft tissue response and less marginal bone loss when compared to closed abutments through one year follow up. (2) Soft tissue response and marginal bone loss associated with both abutment designs were within the normal health limits after one year follow up period of the study.

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INTRODUCTION

Using single implant crown to prosthetically restore the function and esthetics is a practical solution for missing single tooth; this treatment modality had an evidence based success. (Henry et al., 1996)

The coronal restoration over dental implants must fulfill certain criteria arising from special demands of function, which include biocompatibility, adequate mechanical strength, and transmission of functional forces within physiological limits.(Albrektsson, Jansson, & Lekholm, 1986)

Abutment preparations for cemented restorations commonly have a finish line that is supra-gingival wherever possible; the only sites that are frequently sub-gingival are in aesthetic areas. Excess cement found on tooth-retained restorations with healthy periodontal tissues present few if any problems. This is different for implant-retained restorations, even when the implant has been considered integrated clinically and radiographically.(Sadan, Blatz, Bellerino, & Block, 2004)

Increased tissue depths around implants present problems when cleaning excess cement and a study found that implant crown margins placed any distance sub-gingivally will result in remnants of excess cement. (Linkevicius, Vindasiute, Puisys, & Peciuliene, 2011)

The cement-retained implant restoration may be more vulnerable to the effects of cement entering the soft tissues and residual excess cement on the implant restoration when compared to a tooth. (C. P. K. Wadhwani & Pi??eyro, 2012)Although there are tens of thousands of articles written on cements, highlighting compressive, tensile, and shear strengths, their properties, and clinical applications, very little is reported about the way in which cements flow during the cementation process, how to optimize their application, or the amount of cement required to achieve the ideal cementation results.

A positive correlation between surface roughness and the rate of accumulation of micro-organisms has been observed in many in vivo studies. However, if the implant surfaces become colonized by pathogenic bacteria, the plaque-induced inflammation around the implants may cause peri-implant tissue destruction.(Khammissa, Feller, Meyerov, & Lemmer, 2012)

It has been hypothesized that an open/hollow abutment may provide an internal reservoir for cement. The flow of cement into the space provided maybe further affected by auxiliary venting in the form of two round holes 180 degrees apart placed in the axial walls of the abutment. (Emms, Tredwin, Setchell, & Moles, 2007)

AIM OF THE STUDY

This research studied the effect of changing the abutment design trying to decrease the amount of excess extruded cement on the peri-implant soft tissue by using two implant abutment modifications:

A) Closed abutment.

B) Vent abutment.

MATERIALS AND METHODS

This study was a randomized, double-blinded clinical trial with an equal allocation rate. Both the patient and the evaluator who assessed the soft tissue changes were blinded to the group assignment.

The present study was conducted on a series of 14 two pieces titanium endosseous threaded implants which were placed in 14 patients in upper premolar area.

Grouping:

The patients were divided according to treatment protocol into two groups according to the abutment design:

Group (CA): 7 crowns cemented on closed abutments. (figure 1, a)

Group (VA): 7 crowns cemented on vented abutments. (figure 1, b)

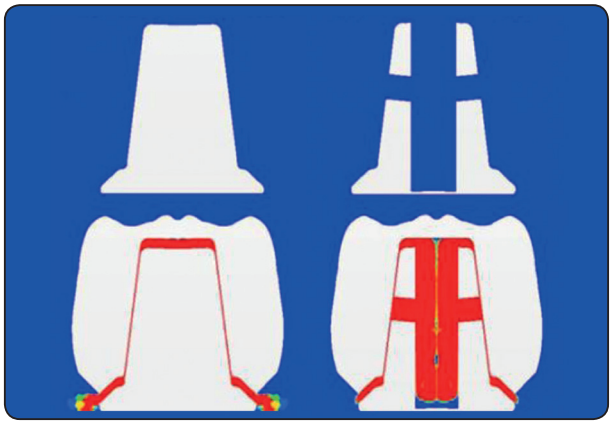

Fig. (1) a. closed abutment – b. vented abutment

Study population

I- Approval of ethics committee:

This study obtained ethics approval no. 45 from faculty of dentistry Ain Shams University ethics committee FDASU-REC. on 18-2-2015.

II- Patient's Selection:

The patients were selected from the outpatient clinic of Crown and Bridge department, Faculty of Dentistry, Ain Shams University, with no sex predilection, the patients' ages ranged from 20 to 40 years.

Inclusion Criteria

1. Patients between the age of 25 and 40.
2. Missing upper premolar bounded by a natural tooth anteriorly and posteriorly.
3. Sufficient bone width and height to receive an implant of minimum Diameter of 3.5 mm in width and length of 13 mm.
4. Bone quality either D2 or D3, as assessed by CBCT.
5. Systemically healthy patients.
6. Normal jaw relation and canine guided normal occlusion

Exclusion Criteria

1. Patients with uncontrolled diabetes, metabolic bone disorders, a history of renal failure or a history of radiation treatment to the head and neck area and patients on current chemotherapy.
2. Pregnancy.
3. Poor oral hygiene patients.
4. Heavy smoking.
5. Presence of parafunctional habits such as bruxism.

II- Patient education and approval

All patients have been subjected to sessions of patient education about implant importance, advantages, maintenance and care. They were informed of the whole surgical and prosthetic procedures and follow up consultations and were required to sign a consent form to participate in this clinical study and follow the recommendations and instructions.

III- Preoperative Preparations

To fulfill the predetermined criteria, a thorough diagnosis, clinical and radiographic examination as well as digital photographs were carried out for all patients.

Diagnostic cast evaluation:

Alginate impressions had been taken and poured to obtain diagnostic casts for the maxillary and mandibular ridges.

The diagnostic casts were mounted on mean value articulator and observed to detect the presence of an adequate inter-arch distance and to asses alignment of teeth, horizontal and vertical jaw relationships.

Clinical photographs:

Clinical photographs were taken for each patient using a digital camera including the implant site

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and at least one adjacent tooth on each side, the reference teeth should be visible well enough to ensure comparability.

Radiographic examination:

Standardized CBCT scanning procedures were done for all patients to detect the presence of any pathological lesions. Scanning was performed by the same radiologist operating a CBCT machine (PLANMECA ProMax)*

Implant planning:

Exposure was performed; image reconstruction was performed. The long axis was made in the center of the implant & perpendicular to it in both coronal & sagittal cuts to form corrected coronal & corrected sagittal cuts. Lines were drawn in mesial, distal, buccal & lingual aspects of the implant & parallel to it & the average bone density was recorded.

Surgical guide designing and fabrication:

3D Computer Simulation

Primary impressions with elastomeric impression material was taken for the arch of interest for each patient. Models were poured in extra hard stone. Scanning of the model using a CBCT machine. The obtained DICOM data was processed to obtain an STL file for each model. The CT data for each patient was imported to the planning software (Blue Sky Bio software) to simulate implant placement on the 3D model. Then a curve was drawn around the area which should be covered by the surgical guide.

The surgical guide was fully digitally designed in the software by using the automatic brush. After the treatment plan is finalized the guides were fabricated based on the scanned model. The completed surgical template was exported as an STL file ready for printing in 3D printer.

A rapid prototyping machine using the principle of stereolithography was used to fabricate the SLA models and guides (preform software)*

The angulation, mesiodistal and buccolingual positioning of each implant as planned using 3D computer simulation software was transferred to the SLA surgical guide.*

The study design included three stages:

Stage 1: Surgical Stage:

This stage included placement of implants.** The length and the diameter of each implant was measured and selected by the software of the Con Beam CT. The surgical guide was placed in position and the drilling was then done through the guide.

In the Labiolingual dimension, all the implants were placed such that the implant shoulder was positioned palatal to the point of emergence of adjacent teeth. In the mesiodistal dimension, the distance between the implant shoulder and the adjacent teeth was at least 1.5 mm.

A post operative CBCT was made for the patient to ensure correct implant placement in relation to the surrounding structures and correct mesiodistal and labioligual position in relation adjacent teeth and to the buccal and palatal bone plates. (figure 2)

Implant impression copings (transfer copings/ impression posts) were screwed over the implants for final impression.Rigid impression tray of suitable size was selected for one-step impression technique (open tray impression technique).

The internal hex of the implant was irrigated and the healing cap was luted with antibiotic gel and then screwed inside the implant.

Patients have been instructed to follow a post-surgical medication, oral hygiene measures and instructions.

* Formlabs Inc., Somerville USA
** Neobiotech

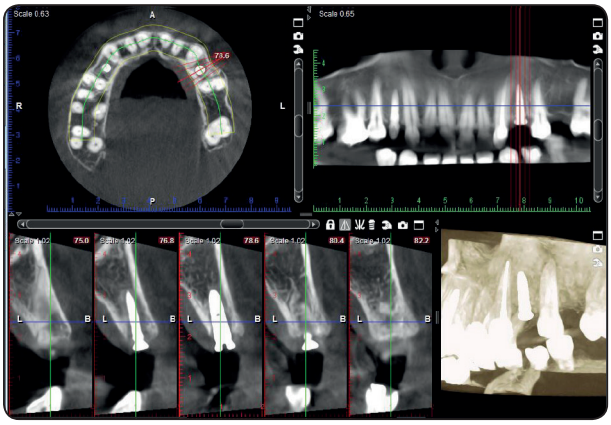

Fig. (2) Post operative CBCT

Stage 2: Prosthetic Stage:

This stage was done 48 hours after implant placement; it included placement of abutments with PMMA temporary crowns out of occlusion.

The Neobiotech abutments were prepared with occlusal clearance 2mm to receive the Vipiblock PMMA crowns.

Seven abutments were modified by placing vent holes internally. 2 holes, 180° apart a mark approximately 3 mm below the occlusal surface was done then the holes prepared using round bur size 2 with head diameter 1mm.

The PMMA crowns were constructed using CAD/CAM to match (As much as possible) the contours and contact areas of their contra lateral counter parts allowing the soft tissues to adapt to optimal contours. Scanning of the poured casts was done using Identica blue hybrid scanner*. Designing of the crowns was done using Exocad 2016 software.** All crowns were designed with nonfunctional occlusion with the opposing teeth. A 80µm cement gap was created starting 1mm above the margin. The crowns were milled using Vhf S1 five axis milling machine***.

After the fabrication of the restoration, the healing caps were removed from the patient's mouth and the final abutments (closed or vented) were removed from the cast and tightened over the implants with the hex driver, then the restorations were placed over the corresponding abutments and checked for contact, occlusion and shade.

A long-term temporary cement (Dentotemp)****, was used in this study to cement the PMMA crowns over the abutments. The abutment screw access was closed before the crown is cemented in the closed abutment group while a Teflon tape was used to cover the screw head keeping the screw access hole opened in the vented abutment group.

The restoration margin was carefully checked, and excess cement was removed and dental floss was used for checking of cement removal.

Stage 3: Post-restoration follow-up implant evaluation stage:

lRe-examination was scheduled 3, 6 and 12 months after crown cementation. All follow up assessments were made by two well trained blinded observers different from the prosthodontist and the mean of their scores was recorded. Before the start of the study, the observers were well trained to adequate levels of accuracy and reproducibility for the various measurements and indices to be used. All assessments were done by directly assessing the patients. The observers were blinded regarding the patient's group to avoid any bias.

1st: Periodontal assessments:

The following periodontal parameters was assessed at the mesial, buccal, distal and lingual aspects of each implant

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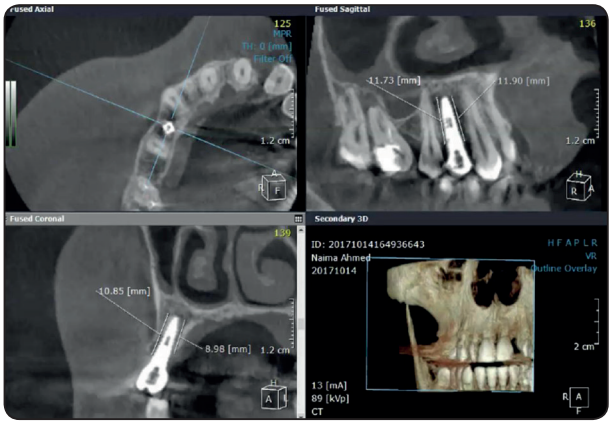

Fig. (3) Buccal, palatal, mesial and distal CBCT measurements at baseline

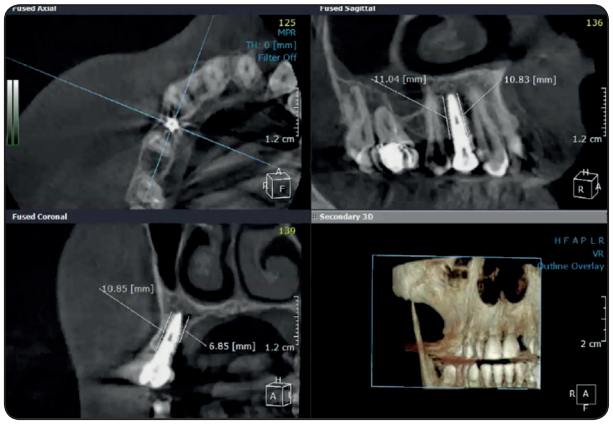

Fig. (4) Buccal, palatal, mesial, and distal CBCT measurements at 12 months

1- Sulcus Bleeding Index (bleeding on probing) (BI)

2- Probing depth (PD)

2nd: Bone height measurements:

Three CBCT's were taken at three months, six months, and one year after crown cementation.

These CBCT's were compared to the base-line CBCT taken immediate post-operative to measure the marginal bone loss. Comparison of marginal bone loss was performed by superimposition of the CBCT's and measuring the amount of bone loss. The measurements were taken from the crest of the ridge until the apex of the implant. (Figure 3 & 4)

Statistical analysis:

Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests). All data showed non-parametric distribution except for Peri-implant Probing Depth data which, showed parametric distribution.

Data were presented as mean, standard deviation (SD).

For parametric data; repeated measures ANOVA test was used to compare between the two groups as well as to study the changes by time within each group.

For non-parametric data, Mann-Whitney U test was used to compare between two groups. Friedman's test was used to study the changes by time in each group. The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

RESULTS

Bleeding Index (BI)

Frequency (N) and percentage (%) for BI for different tested groups presented in table (1)

Probing Depth (mm)

Mean and standard deviation (SD) for PD (mm) for different tested groups presented in table (3)

Considering different intervals of the follow-up period, the difference in probing depth between tested groups (vented and closed abutments) was statistically non-significant ($p>0.05$).

For comparison between PD at different time periods in each group, there was a statistically significant increase in PD for comparison between PD at different time periods in each group after 6 months as well as from 6 months to 12 months as presented in table (4).

Bone loss

Mean and standard deviation (SD) for bone loss for different tested groups presented in table (5).

After 3, 6 as well as 12 months, Group CA showed statistically significantly higher mean amounts of bone loss than Group VA as presented in table (5)

As presented in table (6), there was a statistically significant increase in bone loss, in Group CA after 6 months. From 6 to 12 months, there was no statistically significant change in mean bone loss. The amount of bone loss after 12 months showed statistically significantly higher mean value than 3 months.

In Group VA, there was no statistically significant change in bone loss after 6 months. From 6 to 12 months, there was a statistically significant increase in mean bone loss. The amount of bone loss after 12 months showed statistically significantly higher mean value than 3 months.

TABLE (1) Frequency (N) and percentage (%) for Bleeding Index (BI) for different tested groups

		CA		VA	
		N	%	N	%
3 months	.00	1	14.3	1	14.3
	1.00	3	42.9	5	71.4
	2.00	3	42.9	1	14.3
	3.00	0	0.0	0	0.0
	Rank	a		a	
6 months	.00	1	14.3	1	14.3
	1.00	2	28.6	6	85.7
	2.00	3	42.9	0	0.0
	3.00	1	14.3	0	0.0
	Rank	a		a	
12 months	.00	2	28.6	3	42.9
	1.00	3	42.9	4	57.1
	2.00	1	14.3	0	0.0
	3.00	1	14.3	0	0.0
	Rank	a		a	

TABLE (2) Mean and standard deviation (SD) for Bleeding index for different tested groups

		CA		VA		P-value
		M	SD	M	SD	
Bleeding index	3 months	1.26	0.76	1	0.58	0.4422
	6 months	1.75	0.98	0.86	0.38	0.0961
	12 months	1.14	1.07	0.57	0.53	0.2299

TABLE (3) Mean and standard deviation (SD) for Probing Depth (mm) for different tested groups.

		CA		VA		P -value
		M	SD	M	SD	
Probing depth	3 months	2.33	0.60	2.27	0.43	0.738
	6 months	2.58	0.53	2.54	0.49	0.822
	12 months	2.77	0.61	2.73	0.56	0.850

: Significant at P ≤ 0.05

TABLE (4) The mean, standard deviation (SD) values for comparison between PD at different time periods in each group

Group	3 months		6 months		12 months		P- value
	M	SD	M	SD	M	SD	
CA	2.33^{C}	0.60	2.58^{B}	0.53	2.77^{A}	0.61	<0.001*
VA	2.27^{C}	0.43	2.54^{B}	0.49	2.73^{A}	0.56	<0.001*

: Significant at P ≤ 0.05, Different superscripts in the same row are statistically significantly different

TABLE (5) Mean and standard deviation (SD) for Bone Loss for different tested groups.

		CA		VA		P value
		M	SD	M	SD	
Bone loss	3 months	0.95	0.38	0.58	0.25	0.014*
	6 months	1.30	0.45	0.75	0.29	0.003*
	12 months	1.63	0.55	1.00	0.30	0.004*

: Significant at P ≤ 0.05

TABLE (6) The mean, standard deviation (SD) values for comparison between Bone Loss at different time periods in each group

Group	3 months		6 months		12 months		P- value
	M	SD	M	SD	M	SD	
CA	0.95^{B}	0.38	1.30^{A}	0.45	1.63^{A}	0.55	<0.001*
VA	0.58^{B}	0.25	0.75^{B}	0.29	1.00^{A}	0.30	<0.001*

: Significant at P ≤ 0.05, Different superscripts in the same row are statistically significantly different

DISCUSSION

The current study was conducted to evaluate the influence of venting the abutment on variable biological & marginal bone loss around single tooth implants.

This study was conducted on medically free patients with the same age range and with standardized inclusion & exclusion criteria.

Implants of all subjects included in the study were randomly assigned to one of the treatment protocols to avoid bias among different treatment protocols.

Computer-assisted drilling guides have been used to provide ideal implant placement angulation and minimally invasive approaches.(Becker, Goldstein, Becker, & Sennerby, 2005)

Flapless technique and surgical guides were used in our study to facilitate the establishment of favorable forces on the implant and the prosthetic component and to preserve the soft tissue as well as ensure an aesthetic outcome.(D. et al., 2005)

All implants used in the study were two-piece implants used with temporary crown placement immediately within first 48 hours as the process of biological width formation begins immediately following exposure of implant to the oral environment.(Lazzara & Porter, 2006)

A nonfunctional CAD/CAM temporary crowns were designed with a cement gap 80μm and constructed out of occlusion to avoid the effect of the occlusal forces on the implant and peri-implant condition.(Hoang, Thompson, Cho, Berzins, & Ahn, 2015)

Long term temporary cementation is also used in our study because retrievability of implant prosthetic components is a significant safety factor. (Michalakis, Pissiotis, & Hirayama, 2000)

Standardization of factors that can influence the results such as: age range, bone quality, implant type, surgical technique and loading periods was achieved throughout the study. Moreover, all patients received the same treatment protocol performed by a team of the same implantologist, periodontist, prosthodontist and laboratory technician.

In the present study, classical periodontal parameters in terms of PD and BI were measured for clinical monitoring of implant soft tissue health.

When measuring the effect of the abutment design (vented and closed) on the peri-implant tissues it was found that there was no statistically significant difference between groups regarding all periodontal parameters though more acceptable outcomes were observed in vented abutment design group than those observed in closed abutment design group.

Peri–implant probing depth provides an important indication of the presence of peri –implant disease. (Mombelli, Mühle, Brägger, Lang, & Bürgin, 1997) In this study, both group A (2.77mm) and group B (2.73mm) were in accordance with previous studies after one year with no statistically significant difference between groups, indicating healthy peri – implant tissue. Within group comparison showed a statistically significant increase at 6 months and 12 months for both groups.

This observation may merit a longer follow-up period to assess whether the increase in pocket depth by time will continue or whether it will stabilize after the first year.

This better biologic behavior seems to be strongly correlated to the less excessive cement extruded in this group and there for less microbial retention and better soft tissue health was recorded.

This outcome was supported by a study done by chung et al in which thirty-six abutments were tested and the weight of the removed excess cement was measured finding out that modifying the internal configuration of the screw access channel of implant abutment affected the amount of extruded cement. (C. Wadhwani & Chung, 2014)

Cone Beam Computed Tomography was used to analyze marginal bone loss in this study. Measurement of buccal bone loss is extremely important especially in the esthetic zone. Loss of a substantial amount of buccal bone may lead to exposure of the metallic implant which will result in a greyish halo effect with an unaesthetic appearance which is unacceptable.(Kamburoğlu et al., 2014) (Ritter et al., 2014)

Four CBCT's were taken for each patient over a one-year period because according to literature, the largest amount of bone loss occurs during the first year of implant placement.(Linetskiy, Demenko, Linetska, & Yefremov, 2017)

CBCT software was than capable of super – imposing the different 3D images to provide an accurate measurement of the amount of bone loss throughout the one year follow up period. (Sennerby et al., 2015)

In this study, between groups comparison showed a statistically significant higher amount of bone loss in closed abutment group (0.95mm at 3 months,1.30mm at 6 months, and 1.63mm at 12 months) when compared to vented abutment group (0.58mm at 3 months, 0.75mm at 6 months, and 1.00mm at 12 months) at 3, 6 and 12 months respectively.

Both groups showed a statistically significant higher value of bone loss from 3 months to one year but both groups were within the range of acceptable bone loss values according to previous literature. Mean marginal bone loss for closed abutment group was 1.63mm and for vented abutment group was 1mm, which is between the range of 1-2mm established by previous literature. (Laurell & Lundgren, 2011) (Papaspyridakos, Chen, Singh, Weber, & Gallucci, 2012)

Limited number of patients, accurate observation of patient inclusion/exclusion criteria, conservative surgical technique, strict periodontal and prosthetic monitoring and short observation period, could be considered important co-factors for a high short-term successful rate observed in the study groups.

In conclusion and within the limitations of this study, it was demonstrated that implants restored using vented abutment protocol seem to behave better than implants restored with closed abutments, regarding soft tissue health and marginal bone loss

Finally, because of controversy still existing regarding cementation techniques and different abutment designs, the present study can be considered as a part of a series of ongoing more accurate long-term studies of the potential differences among different cementation techniques and abutment designs may increase our understanding in this field.

CONCLUSIONS

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

1. Vented abutments exhibit less excess cement extrusion, better soft tissue response and less marginal bone loss when compared to closed abutments through one year follow up.
2. Soft tissue response and marginal bone loss associated with both abutment designs were within the normal health limits after one year follow up period of the study.

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