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ASSESSMENT OF PERI-IMPLANT TISSUE BEHAVIOR AND ESTHETIC OUTCOMES OF BIOLOGICALLY ORIENTED PREPARATION TECHNIQUE (BOPT) IMPLANT-SUPPORTED CROWNS: A RANDOMIZED CLINICAL STUDY

Kholoud Mohamed Mahmoud Soliman*, Ossama Saleh Abd El Ghany, Mona Hossam Eldin Mandour

Crowns and Bridges Department, Faculty of Dental Medicine for Girls Al-Azhar University, Cairo, Egypt.

***Corresponding Author: Kholoud Mohamed Mahmoud Soliman**

Crowns and Bridges Department, Faculty of Dental Medicine for Girls Al-Azhar University, Cairo, Egypt.

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ABSTRACT

Aim: to compare peri-implant tissue behavior, marginal bone level and Pink Esthetic Score (PES), associated with custom zirconia implant abutments fabricated according to the Biologically Oriented Preparation Technique (BOPT) and conventional shoulder-finish-line zirconia abutments. **Materials and Methods:** Sixteen patients presenting with a single missing tooth in the esthetic zone were enrolled in this randomized clinical study and equally allocated into two groups. Group I received custom zirconia shoulder abutments on titanium bases, whereas Group II received custom zirconia BOPT abutments on titanium bases. All implants were placed using a two-stage delayed-loading protocol and restored through a fully digital workflow. Clinical and radiographic evaluations were performed at crown delivery, 3 months, and 6 months. Outcome measures included soft tissue thickness, marginal bone level, marginal bone loss, Pink Esthetic Score (PES. **Results:** Both groups demonstrated successful clinical outcomes throughout the follow-up period. Group II showed significantly better preservation of marginal bone levels than Group I at both 3 and 6 months ($P < 0.0001$). Overall marginal bone loss was significantly lower in the BOPT group (0.22 ± 0.05 mm) compared with the shoulder-abutment group (0.42 ± 0.12 mm). The percentage reduction in bone level was also significantly lower in Group II ($-1.92 \pm 0.39\%$) than in Group I ($-3.89 \pm 1.28\%$). Soft tissue behavior and esthetic outcomes favored the BOPT group. **Conclusions:** Within the limitations of this study, BOPT zirconia abutments demonstrated superior preservation of peri-implant hard and soft tissues and improved esthetic outcomes compared with conventional shoulder zirconia abutments.

KEYWORDS: Dental implants; BOPT; zirconia abutment; Pink Esthetic Score; marginal bone loss.

INTRODUCTION

Replacement of missing teeth through rehabilitation with dental implants has become a predictable treatment option, with long-term success rates exceeding 90%. However, implant therapy in the esthetic zone continues to be one of the most challenging clinical procedures, as the quality and stability of peri-implant soft and hard tissues are now as important as osseointegration in determining the success of treatment.[1]

Maintenance of peri-implant soft tissue architecture is critical for achieving harmonious integration of implant-supported restorations with adjacent dentition. Soft tissue stability contributes not only to esthetic outcomes but also to preservation of crestal bone and long-term implant success. Marginal bone loss has been associated with multiple factors including peri-implant mucosal thickness, implant-abutment design, implant positioning, and prosthetic emergence profile.[2]

The biologically oriented preparation technique (BOPT), which was initially introduced by Loi, is predicated on a vertical preparation concept that lacks a defined finish line. The technique allows peri-implant soft tissues to adapt to the prosthetic profile rather than being constrained by a fixed horizontal margin.[3] This concept has been proposed to enhance soft tissue conditioning, emergence profile stability, and peri-implant esthetics.[4]

Moreover, BOPT presents a promising alternative to traditional divergent collar designs, offering improvements in both peri-implant health and esthetics without the need for more advanced hard and soft tissue regeneration procedures.[5]

From a health perspective, placing the implant-abutment junction in a supracrestal position—away from the bone level—minimizes bacterial infiltration into the bone and surrounding connective tissue that reduces the likelihood of inflammation associated with microbial contamination at the critical bone-implant interface.[6]

The biological width surrounding dental implants is established through soft tissue healing by secondary intention, a process that is facilitated by the contraction of myofibroblasts. This is an aesthetic consideration. This contraction, particularly around a coronally convergent abutment, encourages coronal migration of the connective tissue attachment and leads to increased soft tissue thickness, enhancing the visual outcome.[7]

Although BOPT has demonstrated promising results regarding soft tissue behavior and esthetic outcomes, evidence regarding its effect on peri-implant tissue stability and esthetic outcomes remains limited. Therefore, the present randomized clinical study was conducted to assess peri-implant soft tissue thickness, marginal bone behavior and pink esthetic score associated with BOPT implant-supported crowns compared with conventional shoulder zirconia abutments.

MATERIALS AND METHODS

Study Design and Ethical Considerations

This randomized controlled clinical study was conducted at the Department of Crowns and Bridges, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt. The study was designed to compare peri-implant tissue behavior, esthetic outcomes, patient satisfaction, and marginal accuracy of implant-supported restorations fabricated utilizing the biologically oriented preparation technique (BOPT) versus conventional shoulder-finish-line zirconia abutments.

The study protocol was reviewed and approved by the Research Ethics Committee of the Faculty of Dental Medicine for Girls, Al-Azhar University (Approval No. P-CR-22-06). Before enrolling, all participants were notified of the study's objectives, treatment procedures, potential risks, and benefits. Prior to the commencement of treatment, all participants provided written informed consent. The study was conducted in accordance with the principles outlined in the Declaration of Helsinki for research involving human subjects.

Sample Size Calculation

Sample size calculation was performed utilizing G*Power software (Version 3.1.9.7, Heinrich Heine University, Düsseldorf, Germany). Based on previously published data evaluating peri-implant tissue changes associated with different restorative designs, a large effect size ($d = 1.4$), significance level ($\alpha = 0.05$), and statistical power of 80% were selected. The minimum required sample size was calculated to be 16 patients, with 8 patients allocated to each group.

A total of sixteen patients requiring replacement of a single missing tooth in the esthetic zone were recruited from the outpatient clinic of the Department of Crowns and Bridges.

A computer-generated randomization sequence was employed to randomly assign eligible patients to two equal groups. Utilizing sealed opaque envelopes that were opened during the planning of prosthetic treatment, allocation concealmentwas achieved.

Group I: Patients received customized zirconia implant abutments with a conventional horizontal shoulder finish line cemented onto titanium bases (Ti-bases).

Group II: Patients received customized zirconia implant abutments fabricated according to the biologically oriented preparation technique (BOPT) and connected to titanium bases.

Surgical Procedures

The same operator conducted all surgical procedures under local anesthesia, utilizing a standardized two-stage implant placement protocol.

Following clinical and radiographic examination, implant sites were prepared according to the manufacturer's drilling sequence. MODE Implants were inserted with adequate primary stability and cover screws were placed. The mucoperiosteal flaps were repositioned and sutured using interrupted sutures.

Patients received postoperative instructions and medications including antibiotics, analgesics, and chlorhexidine mouth rinse. Sutures were removed after one week.

To facilitate osseointegration prior to the commencement of the prosthetic phase, an approximate three-month healing period was observed.

Prosthetic Procedures

Second-Stage Surgery and Digital Impression

Following confirmation of osseointegration, second-stage surgery was performed and healing abutments were connected.

After soft tissue healing, digital impressions were obtained using Medit I 500 intraoral scanner. Scan bodies were attached to the implants, and digital implant positions were recorded.

The acquired digital data were exported as STL files and transferred to Exocad software for prosthetic design.

Design and Fabrication of Custom Abutments
Custom zirconia abutments were designed using Exocad software.
Group I: DD cube ONE ML (4Y-TZP) multilayered zirconia abutments were designed with a conventional horizontal shoulder finish line located at the peri-implant mucosal margin. Standard emergence profiles were developed according to restorative requirements.
Group II: DD cube ONE ML (4Y-TZP) multilayered zirconia abutments were designed according to BOPT principles. The abutments exhibited a vertical preparation design without a horizontal finish line and featured a convergent transmucosal profile to facilitate soft tissue adaptation and conditioning.

All zirconia abutments were milled from pre-sintered zirconia blocks and subsequently sintered according to manufacturer instructions. The zirconia components were then bonded to titanium bases using dual-cure resin cement under standardized conditions.

Provisional Restoration Phase
Temporary polymethyl methacrylate PMMA crowns were fabricated and delivered to condition peri-implant soft tissues.

In the BOPT group, the provisional restorations were used to progressively modify and shape the peri-implant soft tissue profile through controlled emergence profile adjustments.

Patients were monitored periodically to evaluate tissue maturation and contour development.

Definitive Crown Fabrication
Following soft tissue stabilization, definitive screw-retained multilayered DD cube Y HL (5Y\3Y) zirconia crowns were designed using CAD software.
For Group I, crowns were fabricated over conventional shoulder-finish-line abutments.
For Group II, crowns were fabricated over BOPT abutments while maintaining the established vertical emergence profile.

The internal surfaces of the zirconia crowns were airborne-particle abraded using aluminum oxide particles under standardized conditions prior to cementation onto the titanium bases.

The definitive restorations were inserted and occlusion was carefully adjusted to eliminate premature contacts and occlusal interferences.

Outcome Assessment
All measurements were recorded at crown delivery (baseline), 3 months, and 6 months after loading.

1. Soft Tissue Thickness Assessment
Peri-implant soft tissue thickness was evaluated using a digital superimposition technique.

Standardized intraoral scans were obtained at each follow-up interval. The digital models were imported into the Medit design software for three-dimensional analysis, and they were superimposed using stable adjacent tooth structures as reference landmarks.

Linear measurements were performed at standardized reference points that were established to ensure reproducibility of measurements. Two sagittal reference points were chosen: Buccal groove's most coronal point and palatal (or lingual) groove's most coronal point. A horizontal reference line was drawn connecting these two points, and the soft tissue dimension was measured in millimeters relative to this line. Predetermined reference points to calculate changes in peri-implant soft tissue thickness over time.

2. Marginal Bone Level and bone loss Assessment
In order to guarantee reproducibility, standardized digital periapical radiographs were acquired using the paralleling technique positioning device to evaluate marginal bone levels.

Radiographs were analyzed using image Vistascan software. Measurements were made from a fixed implant reference point to the first bone-to-implant contact on both mesial and distal surfaces. Statistical analysis was conducted by calculating the average of the mesial and distal measurements.

Marginal bone loss was calculated as the difference in bone level measurements between baseline and subsequent follow-up periods.

Bone level changes were calculated for: Baseline to 3 months, 3 months to 6 months and Baseline to 6 months. Percentage changes in bone level were also calculated.

3. Pink Esthetic Score (PES)
Peri-implant esthetic outcomes were assessed utilizing the Pink Esthetic Score described by Belser et al.[9] High-quality facial-view photographs were obtained utilizing a digital single-lens reflex (DSLR) Nikon camera equipped with a macro lens (approximately 100 mm) and ring flash to ensure uniform illumination and to eliminate shadows. Images were captured at a consistent magnification, with the patient in an upright position and the camera oriented perpendicular to the implant site. The same photographic parameters, angulation, and distance were maintained at baseline and follow-up visits to ensure reproducibility. Seven variables were evaluated: Distal papilla, Mesial papilla, Soft tissue level, Alveolar process deficiency, Soft tissue contour, Soft tissue texture and Soft tissue color. Each parameter was scored from 0 to 2, resulting in a maximum score of 14.The photographs were independently assessed by blinded evaluators.

Statistical Analysis

Data were collected, tabulated, and statistically analyzed utilizing GraphPad Prism software (Version 10.0, GraphPad Software Inc., San Diego, CA, USA).Quantitative variables were tested for normality using the Shapiro-Wilk test. Data were presented as mean ± standard deviation (SD), median, minimum, and maximum values. For intergroup comparisons, the Mann-Whitney U test was used. For intragroup comparisons among different time points, Friedman's test was applied followed by Dunn's multiple comparison post hoc test. Effect sizes were calculated using Cohen's d. The significance level was set at **P ≤ 0.05** for all statistical analyses.

RESULTS

Soft Tissue Thickness

Both groups exhibited significant increases in peri-implant soft tissue thickness throughout the follow-up period (P<0.001). However, no significant differences were detected between groups at any time point. At 6 months, mean soft tissue thickness reached 9.27±2.31 mm in Group I and 9.58±1.95 mm in Group II. Table (1), Figure (1)

Table 1: Descriptive statistics of soft tissue thickness (mm) and comparison between groups (independent t-test) and within the same group (repeated measures ANOVA).

Time point	Group 1 Mean ± SD	Group 2 Mean ± SD	Difference				t value	p-value	Eta squared
			Mean	Std Dev	95% C.I upper	95% C.I lower			
Month0	8.92 ± 2.14	8.73 ± 1.79	.188	.988	-1.931	2.306	**.190**	0.852 ns	.003
Month3	9.19 ± 2.25	9.39 ± 1.96	-.203	1.055	-2.465	2.060	-.192	0.850 ns	.003
Month6	9.27 ± 2.31	9.58 ± 1.95	-.313	1.068	-2.604	1.979	-.293	0.774 ns	.006
P value within group	.000*	.000*							

Significance level p ≤0.05, *significant, ns=non-significant

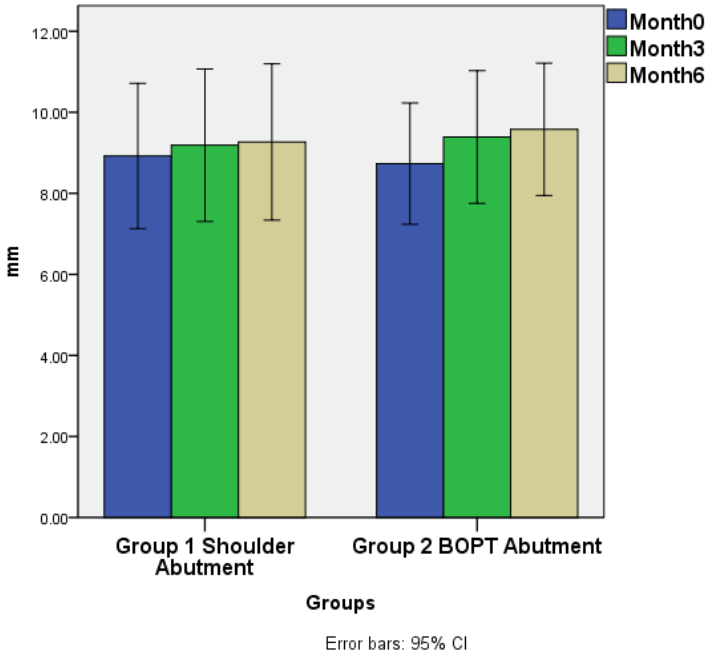

Figure 1: Bar chart illustrating mean value of soft tissue thickness (mm) in group 1 (shoulder abutment) and group 2 (BOPT abutment).

Marginal Bone Level

At baseline, no statistically significant difference was observed between the groups (P=0.11). However, Group II demonstrated significantly higher bone levels at both 3 months and 6 months (P<0.0001). The percentage reduction in bone level was significantly lower in Group II (−1.92±0.39%) than in Group I (−3.89±1.28%). Table (2)

Table 2: Comparison between group I and Group II regarding bone level at baseline, after 3 months and after 6 months and percentage of change.

Time Point	Group I		Group II		Mean Difference	Std. Error Difference	P value	Cohen's d
	Mean ± SD	Min / Max (Median)	Mean ± SD	Min / Max (Median)				
Baseline	11.08 ± 0.62	10.43 / 11.69 (11.11)	11.65 ± 0.06	11.55 / 11.73 (11.65)	0.57	0.22	0.11	0.44
3 months	10.81 ± 0.64	10.15 / 11.45 (10.81)	11.53 ± 0.03	11.48 / 11.58 (11.53)	0.73	0.23	<0.0001*	0.45
6 months	10.66 ± 0.73	9.93 / 11.37 (10.67)	11.43 ± 0.05	11.36 / 11.51 (11.44)	0.77	0.26	<0.0001*	0.52
% of Change	-3.89 ± 1.28	-5.70 / -2.66 (-3.40)	-1.92 ± 0.39	-2.35 / -1.34 (-1.97)	1.97	0.47	<0.0001*	0.95

*Significant difference as P <0.05.

Marginal Bone Loss (bone level changes)

Bone loss was significantly greater in Group I during the first 3 months and over the entire 6-month period. Total bone loss reached 0.42±0.12 mm in Group I compared with 0.22±0.05 mm in Group II. Table (3)

Table 3: Comparison between bone levels changes at baseline – 3months, after 3 months - after 6 months, and baseline – 6 months within each group.

Time Point	Group I		Group II	
	Mean ± SD	Min / Max (Median)	Mean ± SD	Min / Max (Median)
Baseline – 3 months	-0.28 ± 0.06 ab	-0.37 / -0.20 (-0.29)	-0.12 ± 0.03 ab	-0.16 / -0.07 (-0.12)
3 months – 6 months	-0.15 ± 0.10 a	-0.28 / -0.03 (-0.15)	-0.10 ± 0.02 a	-0.13 / -0.06 (-0.10)
Baseline – 6 months	-0.42 ± 0.12 b	-0.60 / -0.31 (-0.37)	-0.22 ± 0.05 b	-0.28 / -0.15 (-0.23)
P value	<0.0001*		0.0009*	

**Significant difference as P <0.05.*

Means with different superscript letters were significantly different as P <0.05.

Pink Esthetic Score

Both groups showed significant improvement in PES over time. At 6 months, the BOPT group achieved significantly higher PES values (13.5±0.53), indicating superior peri-implant esthetic outcomes. Table (4)

Table 4: Descriptive statistics of Pink esthetic Scores (PES) and comparison between groups (independent t-test) and within the same group (paired t test).

Time point	Group 1 (Mean ± SD)	Group 2 (Mean ± SD)	Difference				t value	P value	Eta Squared
			Mean	Std Dev	95% C.I upper	95% C.I lower			
0 Month	10.5 ± 0.53	10.5 ± 0.53	0	0	0	0	0.00	1.000 ns	.000
3 Month	12.75 ± 0.71	13.5 ± 0.53	-.750	.313	-1.422	-.078	2.39	**0.031***	.290

Significance level p ≤0.05, *significant, ns=non-significant

DISCUSSION

The present randomized clinical study was conducted to evaluate the influence of custom zirconia abutment design on peri-implant tissue behavior, esthetic outcomes, patient satisfaction, and marginal adaptation in single implant-supported restorations placed in the esthetic zone. The findings demonstrated that both treatment modalities achieved favorable clinical outcomes; however, restorations supported by BOPT custom zirconia abutments exhibited superior preservation of peri-implant hard tissues and improved esthetic outcomes compared with conventional shoulder-finish-line zirconia abutments. These findings support the hypothesis that modification of the transmucosal abutment profile may significantly influence peri-implant tissue stability and esthetic integration.

The growing emphasis on esthetic implant dentistry has shifted clinical attention beyond implant survival toward preservation of peri-implant soft and hard tissues. Long-term success of implant-supported restorations in the esthetic zone depends largely on maintaining harmonious gingival architecture and stable crestal bone levels. Previous studies have demonstrated that marginal bone loss may adversely affect soft tissue contours, papillary height, and overall esthetic outcomes, making preservation of peri-implant bone a critical determinant of treatment success.[10,11]

The digitalization of dentistry has introduced new possibilities at each of the prosthetic stages, which is why a fully digital workflow was implemented in the current study: intraoral scanning, computer-aided design

(CAD), additive or subtractive manufacturing (CAM) of models and restorations, and enhanced communication between the laboratory and the clinic. Several studies have demonstrated that digital impressions can generate restorations with a marginal fit that is comparable to that achieved with conventional techniques for single crowns and more extensive prostheses, while still falling within the range of misfit that is considered clinically acceptable.[12,13]

A fully digital workflow has been described in the specific field of the BOPT, which replicates the classical steps performed on the stone model. Before printing the prototype, the clinician scans the intraoral situation, digitally defines the desired cervical contour, and the technician designs the "reduction" around the implant or abutment on the virtual model. This resin model, which features removable analogues, enables the verification of the path of insertion and contact points of the crowns in a manner similar to the gypsum model. However, it offers improved control over the initial design, more precise communication, and a slight reduction in overall treatment time when contrasted with the Analog workflow.[12] After taking the scan, the healing abutment was immediately screwed to the implant to prevent soft tissue collapse over the implant.[14]

Multiple methods were applied to assess the gingival thickness, though the invasive transgingival probing. In spite of the easiness of this technique, patient discomfort and the requirement of local anesthesia that may increase the soft tissue volume are the common adverse effects of this technique. On the other hand, CBCT has been broadly used in the maxillofacial, dental regions and periodontal soft tissue but difficulty in distinguishing the fine soft tissue structures because of the overlapping between lips and gingiva and the frequent x ray exposure to the patients are considered significant disadvantages of using CBCT in oral soft tissue assessments.[15]

Therefore, The soft tissue volumetric changes were digitally measured in our study using intraoral scanners that generate 3D images at various moments in a highly reproducible and completely noninvasive manner.[10]

The digital periapical radiograph was employed to quantify the marginal bone loss at the distal and mesial sites of the implants in this study. In spite of the apparent limitations of two-dimensional radiographs, it was feasible to ascertain the distinction between the impact of prefabricated and custom abutments on marginal bone levels. Periapical radiographs are unequivocally not the gold standard for marginal bone assessment, and they may serve as one of the primary constraints of the current investigation. Nevertheless, it has been determined that digital periapical radiographs are a reliable method for assessing bone height when regional distortion rates and standardization are maintained. Additionally, the use of periapical radiographs reduces the patient's exposure to radiation during follow-up periods.[16]

The results of the present study revealed that there was significant increase in soft tissue thickness over time in both groups. However, although the BOPT group demonstrated greater mean soft tissue thickness values at 3 and 6 months, the intergroup differences were not statistically significant.

The greater increase observed in the BOPT group may be explained by the biologically oriented preparation concept itself. The BOPT philosophy is based on a vertical preparation approach with a convergent emergence profile that allows the peri-implant soft tissues to adapt and mature around the prosthetic contour. This design promotes tissue thickening and stabilization by supporting the peri-implant mucosa and enhancing soft tissue remodeling.

The present study's results are consistent with those of Mandilo et al[10] that found the soft tissue volume surrounding convergent morphology implants appears to be significantly increased by the design of biologically guided crowns.

Furthermore, the establishment of biologic width around the implant-abutment interface may be linked to the increase in soft tissue thickness observed in both groups. Previous studies[11,17] have shown that soft tissue maturation continues during the first months after prosthetic loading, leading to gradual tissue thickening and stabilization.

The absence of statistically significant intergroup differences may be related to the relatively short follow-up period and limited sample size. A longer follow-up period might reveal more pronounced differences in tissue maturation and peri-implant mucosal stability.

The present study demonstrated that although no significant difference in marginal bone level was observed between the two groups at baseline ($P = 0.11$), Group II (BOPT abutments) exhibited significantly greater bone levels at both 3 and 6 months and significantly less overall bone loss than Group I. These results indicate that the BOPT concept may contribute to enhanced preservation of peri-implant hard tissues during the early post-loading period.

The absence of significant baseline differences confirms that both groups were comparable before prosthetic loading, allowing subsequent changes to be attributed primarily to differences in abutment design and peri-implant tissue response rather than pre-existing anatomical variations. This supports the internal validity of the study design.

The superior bone preservation observed in the BOPT group may be explained by the biological principles

underlying the vertical preparation concept. BOPT aims to create a convergent transmucosal profile that allows soft tissues to adapt and stabilize around the prosthetic emergence profile, thereby promoting formation of a stable peri-implant mucosal seal and reducing crestal bone remodeling. This concept was first described by Loi and Di Felice[18] and later adapted to implant-supported restorations.

The findings of the present study are in agreement with those reported by Canullo[19] and colleagues, who demonstrated that implant-supported restorations using a vertical preparation approach were associated with stable peri-implant tissues and limited crestal bone remodeling.

Also, it is in agreement with the clinical trial by Agustín-Panadero et al.[20] reported that implant restorations fabricated according to the BOPT concept maintained stable peri-implant hard tissues over a 3-year follow-up period and demonstrated favorable marginal bone behavior compared with conventional restorative designs. The authors concluded that prosthetic emergence profile design plays an important role in maintaining peri-implant tissue stability.

The present findings are further supported by Agustín-Panadero et al[21]., who demonstrated a direct relationship between peri-implant soft tissue stability and preservation of underlying crestal bone. The authors suggested that a stable soft tissue collar may prevent apical migration of the junctional epithelium and consequently reduce marginal bone resorption.

The significantly lower percentage reduction in bone level observed in Group II (−1.92%) compared with Group I (−3.89%) further supports the concept that prosthetic contouring influences peri-implant tissue behavior. In the present study, the large effect size (Cohen's d = 0.95) suggests that the difference was not only statistically significant but also clinically meaningful.

The overall marginal bone loss recorded in both groups remained within the limits generally accepted for successful implant therapy. In accordance with the criteria proposed by Albrektsson et al.[8], successful implants may exhibit up to approximately 1.5 mm of bone loss during the first year of function, followed by less than 0.2 mm annually thereafter. In the present study, cumulative bone loss after 6 months was only 0.42 mm in Group I and 0.22 mm in Group II, indicating favorable peri-implant tissue health in both groups despite the superiority of the BOPT design.

In the present study BOPT abutments recorded a significantly higher value (13.5 ± 0.53) for the pink esthetic score at the 6 months follow up. This may be related to the ability of the convergent abutment design to support soft tissue architecture and guide tissue healing. The vertical preparation concept allows the peri-implant tissues to adapt dynamically to the restoration contours, leading to improved gingival contour and papillary formation.

This result agreed with Barwacz et al[22] who showed that implant-abutment configuration significantly affects peri-implant esthetic outcomes at the time frame between prosthesis delivery and 6 months.

Also, the results agreed with Canellu[19] et al who found that good esthetic results were achieved and stable soft and hard peri-implant tissues were maintained by the use of the BOPT protocol to restore tissue-level implants with a convergent collar.

Within the limitations of the present study, custom zirconia abutments fabricated according to the biologically oriented preparation technique demonstrated superior preservation of peri-implant hard tissues and improved esthetic outcomes compared with conventional shoulder-finish-line zirconia abutments. The benefits were particularly evident during the early healing and tissue maturation period, suggesting that the prosthetic emergence profile plays a critical role in peri-implant tissue stability. These findings support the incorporation of BOPT principles into implant prosthodontic treatment protocols when optimal esthetic and biologic outcomes are desired. Nevertheless, the relatively small sample size and short follow-up period should be considered when interpreting the results. Further randomized clinical studies with larger sample sizes and longer follow-up periods are recommended to validate the long-term effectiveness of the BOPT approach.

CONCLUSION

BOPT zirconia abutments demonstrated superior preservation of peri-implant hard tissues, reduced marginal bone loss, and improved esthetic outcomes compared with conventional shoulder-finish-line zirconia abutments. The findings suggest that the BOPT concept may represent a predictable prosthetic approach for enhancing peri-implant tissue stability and esthetic integration in implant-supported restorations within the esthetic zone.

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