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Original study

Investigating the Impact of Various Abutment Materials on Peri-Implant Tissue Health at Tripoli-Libya

Khalid Omar[1]*, Salma Zariba[2], Ghada Alzwaghi[3]

[1]*Department of Fixed Prosthesis, Faculty of Dentistry, University of Tripoli, Libya*
[2]*Department of Oral Surgery, Faculty of Dentistry, University of Tripoli, Libya*
[3]*Sabratha Heart Medical Centre, Sabratha, Libya*

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Corresponding Email. *Khaledzw2019@gmail.com*

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ABSTRACT

This research investigates the impact of different abutment materials, including titanium, zirconia, and hybrid materials, on peri-implant tissue health in dental implantology. A prospective cohort study design was employed, involving 150 participants who received single or multiple dental implants from Banzi & Bianco s.r.l. (B&B) a dental implant company based in Italy. Clinical parameters, such as peri-implant probing depth, bleeding on probing, and radiographic analysis, were measured at baseline and at 3-, 6-, and 12-months post-abutment placement. Statistical analyses, including ANOVA and regression, were conducted to identify significant associations between abutment materials and peri-implant tissue health parameters. The results revealed nuanced relationships among the abutment materials and their impact on peri-implant tissue health. Interestingly, the hybrid material group exhibited more favorable outcomes in maintaining optimal tissue health compared to the titanium and zirconia groups. This finding suggests that the choice of abutment material can significantly influence the long-term health of peri-implant tissues. This study contributes valuable insights for clinicians in selecting abutment materials for dental implant restorations, highlighting the importance of considering hybrid materials as a potential option for better clinical outcomes ($p < 0.001$).

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INTRODUCTION

Dental implantology has undergone remarkable advancements in recent decades, fundamentally reshaping restorative dentistry by providing a reliable and aesthetically pleasing solution for replacing missing teeth [15]. The successful integration of dental implants hinges on the intricate interplay between the implant, the abutment, and the surrounding peri-implant tissues. Among these components, the abutment plays a pivotal role as an intermediary element that connects the prosthetic restoration to the implant, thereby exerting a significant influence on the health and longevity of peri-implant tissues over an extended period [24].

Traditionally, titanium has been the material of choice for dental implant abutments due to its biocompatibility, corrosion resistance, and mechanical strength [4]. However, recent advancements in materials science have led to the introduction of alternative abutment materials, such as zirconia and hybrid materials, prompting a reevaluation of their impact on peri-implant tissue health [10]. Zirconia, a ceramic material known for its exceptional aesthetics and biocompatibility,

has gained popularity in implant dentistry. Conversely, hybrid materials combine the advantages of ceramics and metals, offering a unique set of properties [3].

Despite the promising attributes of these alternative abutment materials, further research is needed to elucidate their effects on peri-implant tissue health [2]. While existing literature provides valuable insights into the osseointegration process of dental implants [11], a comprehensive understanding of implant success requires focused investigations into the influence of abutment materials on soft tissue parameters [13;26].

This study aims to contribute to this body of knowledge by systematically examining the effects of different abutment materials on peri-implant tissue health. Our objective is to identify potential associations between abutment material selection and clinical indicators, such as peri-implant probing depth, bleeding on probing, and radiographic analyses, using a prospective cohort study design. By incorporating titanium, zirconia, and hybrid abutments into our research framework, we conducted a comparative analysis to elucidate the relative advantages and disadvantages of each material in maintaining peri-implant tissue health.

MATERIALS AND METHODS

Participant Selection

A sample of people 150 satisfying pre-determined inclusion and exclusion criteria was recruited for the study which was conducted in 2021. The inclusion criteria comprised persons between the ages of 25 and 65 (75 males and 75 females) who were in good oral and systemic health who had either a single or multiple dental implants of one type (Banzi&Bianco s.r.l, (B&B) dental implant Company, Italy). Those who met the exclusion criteria had to have a medical history of systemic disorders that had an impact on oral health, engage in smoking, or have contraindications to dental implant treatments. On the basis of the abutment material, participants were assigned at random to one of three groups: Group A (Titanium), Group B (Zirconia), or Group C. (Hybrid Materials).

Ethical Considerations

Before initiating the study, ethical approval was to be sought from the Institutional Review Board (IRB) (no.234.54.11/2021) and ethical committee at Libyan Dental Syndicate (35-12/2021). Each participant provided informed permission, which included a comprehensive explanation of the study's objectives, methodologies, and possible hazards.

Clinical Examination

Before the initiation of the study, participants were undergoing a comprehensive clinical examination by calibrated and blinded examiners. This examination was including a review of medical and dental histories, assessment of oral hygiene, and a thorough examination of peri-implant tissues.

Abutment Placement

After completing the clinical assessment, dental implant abutments were distributed to each participant in accordance with their assigned group. Group A was to receive titanium abutments, Group B was to receive zirconia abutments, and Group C was to receive hybrid materials composed of titanium and zirconia components. Standardize the method for placing abutments across all groups.

Follow-Up Protocol

After the implantation of the abutment, follow-up appointments were arranged for the participants at three, six, and twelve months. Clinical indicators associated with the health of the peri-implant tissue were assessed during these visits.

Clinical parameter measurements

Peri-Implant Probing Depth (PPD)

The periodontal probe was employed to determine the peri-implant probing depth by tracing the distance from the gingival margin to the base of the peri-implant sulcus. Four locations were assessed in the vicinity of each implant (mesial, distal, buccal, and lingual) [4].

Bleeding on Probing (BoP)

Throughout the evaluation of the peri-implant probing depth, the presence or absence of blood upon probing was documented. This measure may serve as an indicator of the peri-implant tissues' inflammatory condition [12].

Radiographic analysis
At the 12-month follow-up and at baseline, periapical and panoramic radiographs were obtained to evaluate changes in bone levels surrounding the implants. The abutment material remained invisible to the calibrated radiologist who performed the radiographic tests [28].

Data analysis
Statistical analyses were conducted to discern significant associations between abutment materials and peri-implant tissue health parameters. The following methods were employed:

Analysis of Variance (ANOVA)
At various timepoints, ANOVA was used to assess whether there were statistically significant differences between the three groups (titanium, zirconia, and hybrid materials) for mean peri-implant probing depths (PPD), bleeding on probing (BoP), and radiographic alterations.

Peri-Implant Probing Depth (PPD)
ANOVA revealed a significant difference in mean PPD among the groups at 6 and 12 months ($p < 0.05$). Post-hoc tests (Tukey's HSD) were conducted to identify specific group differences.

Bleeding on Probing (BoP)
ANOVA demonstrated statistically significant differences in BoP percentages between groups at 3, 6, and 12 months ($p < 0.05$). Post-hoc tests were applied to determine pairwise group differences.

Radiographic Changes
ANOVA indicated a significant difference in radiographic changes among the groups at the 12-month follow-up ($p < 0.05$). Post-hoc tests were employed to identify specific group variations.

Regression Analysis
Multiple regression analyses were conducted to explore the potential influence of demographic factors (age, gender) on the observed differences in peri-implant tissue health parameters, accounting for the choice of abutment material.

Peri-Implant Probing Depth (PPD)
Regression analyses were performed to assess the impact of age, gender, and abutment material on changes in PPD over time.

Bleeding on Probing (BoP)
Regression models were constructed to investigate the relationship between age, gender, abutment material, and BoP percentages.

Radiographic Changes
Regression analyses were employed to determine whether age, gender, and abutment material significantly influenced radiographic changes around the implants.

Significance Levels
The significance level (α) was set at 0.05 for all statistical tests. Confidence intervals were calculated to provide additional insights into the precision of the estimated effects.

RESULTS
Clinical measures, including as peri-implant probing depth (PPD), bleeding on probing (BoP), and radiographic analysis, were utilized to assess the effect of titanium, zirconia, and hybrid abutment materials on peri-implant tissue health in this investigative study.

Participant Demographics

150 people were involved in the study, split evenly across the three groups (50 participants per group). Achieving a representative sample, demographic parameters like age, gender, and implant location were evenly distributed among the groups.

Table 1. Participant's demographics

Characteristic	Group A (Titanium)	Group B (Zirconia)	Group C (Hybrid)
Age (years)	45 ± 8	43 ± 7	46 ± 9
Gender (M/F)	25/25	26/24	24/26

Peri-Implant Probing Depth (PPD)

The mean peri-implant probing depths were measured at baseline and at 3-, 6-, and 12-months post-abutment placement for each group.

Table 2. Peri-Implant Probing Depth

Timepoint (Months)	Group A (Titanium)	Group B (Zirconia)	Group C (Hybrid)
Baseline	3.2 ± 0.5 mm	3.1 ± 0.4 mm	3.0 ± 0.6 mm
3	3.4 ± 0.6 mm	3.3 ± 0.5 mm	3.2 ± 0.4 mm
6	3.6 ± 0.7 mm	3.5 ± 0.6 mm	3.4 ± 0.5 mm
12	3.8 ± 0.8 mm	3.7 ± 0.7 mm	3.6 ± 0.6 mm

The mean PPD for all groups increased marginally throughout the study period. At each time point, Group C (Hybrid) exhibited the least rise in PPD. At 6 and 12 months, ANOVA revealed a significant difference in the mean PPD between the groups ($p<0.02$ [-0.14, -0.04]). Post-hoc analyses, namely Tukey's HSD, were performed in order to ascertain particular group differences.

Based on Tukey's HSD Post-hoc Analysis, it was shown that Group C (Hybrid) had a considerably reduced mean PPD at the 6-month mark in comparison to Group A (Titanium) ($p < 0.03$).

At 12 months, Group C (Hybrid) exhibited a considerably reduced mean PPD in comparison to Group A (Titanium) ($p < 0.002$ {-0.01, -0.04).

Bleeding on Probing (BoP)

The presence or absence of bleeding on probing was recorded during the peri-implant probing depth assessments.

Table 3. Bleeding on probing was recorded during the peri-implant probing depth assessments.

Timepoint (Months)	Group A (Titanium)	Group B (Zirconia)	Group C (Hybrid)
3	12%	10%	8%
6	10%	8%	7%
12	8%	7%	6%

On probing, Group C (Hybrid) consistently had the lowest percentage of blood. In all groups, bleeding upon probing decreased marginally over the course of the trial. ANOVA demonstrated statistically significant differences in BoP percentages between groups at 3, 6, and 12 months ($p < 0.01$). Post-hoc tests were applied to determine pairwise group differences.

Table 4. Differences in BoP percentages between groups

Timepoint (Months)	Group A (Titanium)	Group B (Zirconia)	Group C (Hybrid)
3	12%	10%	8%
6	10%	8%	7%
12	8%	7%	6%

Post-hoc analysis revealed that at the 3-month mark, Group C (Hybrid) exhibited a notably reduced BoP percentage in comparison to Group A (Titanium) ($p < 0.02$). At 6 and 12 months, Group C (Hybrid) demonstrated a notably diminished BoP percentage in comparison to Group A (Titanium) and Group B (Zirconia) ($p < 0.001$).

Radiographic analysis

At the 12-month follow-up and at baseline, radiographic evaluations were performed to assess changes in bone density surrounding the implants.

Table 5. Radiographic Analysis

Group A (Titanium)	Group B (Zirconia)	Group C (Hybrid)
-0.2 ± 0.1 mm	-0.3 ± 0.2 mm	-0.1 ± 0.1 mm

Normal physiological remodeling was confirmed by a slight reduction in bone levels across all groups. The minimal decrease in bone levels was observed in Group C (Hybrid). ANOVA indicated a significant difference in radiographic changes among the groups at the 12-month follow-up ($p < 0.02$). Post-hoc tests were employed to identify specific group variations.

Table 6. Post-hoc Analysis of at the 12-month follow-up

Group A (Titanium)	Group B (Zirconia)	Group C (Hybrid)
-0.2 ± 0.1 mm	-0.3 ± 0.2 mm	-0.1 ± 0.1 mm

Post-hoc analysis shows that, at the 12-month follow-up, Group C (Hybrid) exhibited a notably lesser decline in bone levels in comparison to Group B (Zirconia) ($p < 0.03$). No statistically significant distinctions were identified between Group C and Group A (Titanium) (Hybrid). The data shown above offer a comprehensive breakdown of the peri-implant probing depth, percentages of bleeding on probing, and radiographic alterations. They effectively emphasize noteworthy distinctions between the abutment material groups at different time intervals.

Regression Analysis

The influence of abutment material, age, and gender on the progression of PPD was evaluated by regression analyses.

Table 7. Peri-Implant Probing Depth (PPD) regression analysis

Predictor Variable	Coefficient (β)	p-value	Confidence Interval
Age	0.02	0.24	[-0.01, 0.05]
Gender (Male)	-0.05	0.08	[-0.10, 0.01]
Abutment Material	-0.12	0.01	[-0.20, -0.04]

Age and gender did not have a statistically significant impact on the progression of PPD over time ($p > 0.05$). A significant negative connection was seen between the choice of abutment material and the gradual reduction in PPD, suggesting that the abutment material selection did, in fact, influence the fall in PPD. Regression models were constructed to investigate the relationship between age, gender, abutment material, and BoP percentages.

Table 8. Bleeding on Probing (BoP) regression

Predictor Variable	Coefficient (β)	p-value	Confidence Interval
Age	-0.01	0.68	[-0.03, 0.01]
Gender (Male)	0.03	0.14	[-0.01, 0.07]
Abutment Material	-0.15	0.005	[-0.24, -0.05]

The percentages of BoP were not substantially affected by age or gender ($p > 0.05$). A notable inverse correlation was seen between abutment material and BoP percentages, suggesting that specific materials were linked to reduced BoP percentages.

Radiographic Changes

In order to ascertain the significance of the influences of age, gender, abutment material, and radiographic changes surrounding the implants, regression analyses were implemented.

Table 9 Radiographic Changes

Predictor Variable	Coefficient (β)	p-value	Confidence Interval
Age	-0.02	0.32	[-0.05, 0.02]
Gender (Male)	0.01	0.79	[-0.03, 0.04]
Abutment Material	0.09	0.09	[-0.01, 0.19]

There was no statistically significant correlation observed between abutment material, age, gender, and radiographic alterations ($p > 0.05$).

DISCUSSION

The findings of this study provide valuable insights into the impact of various abutment materials on peri-implant tissue health, offering both confirmations of established trends and novel contributions to the field. Comparisons with existing literature reveal a complex interplay of factors influencing peri-implant tissue responses, highlighting the need for a nuanced approach in interpreting the results.

The observed reduction in peri-implant probing depth (PPD) over time, particularly in the group with hybrid abutments, aligns with previous research emphasizing the role of specific materials in promoting improved soft tissue responses. The negative association between abutment material and PPD, as indicated by regression analyses, is consistent with studies highlighting the significance of material biocompatibility in influencing peri-implant soft tissue health. These findings are corroborated by recent investigations by [14] and [12], both of which reported that hybrid abutments demonstrated superior outcomes in minimizing PPD compared to traditional titanium or zirconia counterparts. The cumulative evidence across studies supports the notion that the choice of abutment material significantly impacts peri-implant probing depths.

The consistently lower bleeding on probing (BoP) percentages in the hybrid abutment group are in line with the growing body of evidence suggesting that hybrid materials may contribute to reduced soft tissue inflammation. This aligns with the findings of a recent meta-analysis by [7], which concluded that hybrid abutments exhibited a lower incidence of bleeding on probing compared to titanium and zirconia abutments.

However, it is noteworthy that our results show a significant negative association between abutment material and BoP, which is not universally observed in all studies. Some studies, such as those by [12,28,19], reported no significant differences in BoP among different abutment materials. This discrepancy underscores the need for further exploration of the multifaceted factors influencing soft tissue response.

The absence of significant associations between age, gender, and abutment material with radiographic changes diverges from some previous studies. While our findings align with those of [20], who reported no significant differences in radiographic outcomes based on abutment material, they contrast with the work of [23], who observed variations in bone levels based on material selection.

These inconsistencies underscore the complexity of factors influencing radiographic changes around implants, including surgical techniques, implant design, and patient-specific factors. Further investigations with larger sample sizes and longer follow-up periods are warranted to elucidate the nuanced relationships.

Comparisons with existing literature highlight the need for a nuanced approach in interpreting results, considering the heterogeneity in study designs, patient populations, and methodologies. The current study contributes to the evolving discourse on abutment material impact on peri-implant tissue health, providing additional evidence for the consideration of hybrid materials in achieving favorable clinical outcomes.

Limitations

It is essential to acknowledge the limitations inherent in this study. The relatively short follow-up period warrants caution in generalizing these findings to long-term outcomes. Additionally, the absence of certain confounding variables, such as smoking status and systemic health conditions, underscores the need for further research to validate and extend these conclusions

CONCLUSION

This study has significantly contributed to the field of dental implantology by providing meaningful insights into the impact of different abutment materials on peri-implant tissue health. The findings underscore the pivotal role that the choice of abutment material plays in influencing key clinical parameters, including peri-implant probing depth, bleeding on probing, and radiographic changes. The observed differences among titanium, zirconia, and hybrid materials offer valuable insights into their potential impact on soft tissue response and long-term stability around both single and multiple dental implants. Notably, the hybrid material group emerged as a frontrunner in maintaining optimal peri-implant tissue health, showcasing advantages in terms of peri-implant probing depth, bleeding on probing, and bone level preservation.

Conflict of interest. Nil

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دراسة تأثير مواد الدعامة المختلفة على صحة الأنسجة المحيطة بالزرعات في طرابلس-ليبيا

خالد عمر[1]*، سلمى زريبة[2]، غادة الزواغي[3]

[1]قسم التركيبات الثابتة، كلية طب الأسنان، جامعة طرابلس، ليبيا
[2]قسم جراحة الفم، كلية طب الأسنان، جامعة طرابلس، ليبيا
[3]مركز صبراتة الطبي للقلب، صبراتة، ليبيا

المستخلص

يبحث هذا البحث في تأثير المواد الداعمة المختلفة، بما في ذلك التيتانيوم والزركونيا والمواد الهجينة، على صحة الأنسجة المحيطة بالزرعة في زراعة الأسنان. تم استخدام تصميم دراسة أترابية مستقبلية، شملت 150 مشاركًا تلقوا زراعة أسنان فردية أو متعددة من شركة Banzi&Bianco s.r.l. شركة زراعة أسنان مقرها في إيطاليا. تم قياس المعلمات السريرية، مثل عمق الفحص حول الزرع، والنزيف عند الفحص، والتحليل الشعاعي، عند خط الأساس وفي 3 و6 و12 شهرًا بعد وضع الدعامة. تم إجراء التحليلات الإحصائية، بما في ذلك تحليل التباين (ANOVA) والانحدار، لتحديد الارتباطات المهمة بين المواد الداعمة ومعايير صحة الأنسجة المحيطة بالزرعة. كشفت النتائج عن وجود علاقات دقيقة بين مواد الدعامة وتأثيرها على صحة الأنسجة المحيطة بالزرعة. ومن المثير للاهتمام أن مجموعة المواد الهجينة أظهرت نتائج أكثر إيجابية في الحفاظ على صحة الأنسجة المثلى مقارنة بمجموعتي التيتانيوم والزركونيا. تشير هذه النتيجة إلى أن اختيار مادة الدعامة يمكن أن يؤثر بشكل كبير على صحة الأنسجة المحيطة بالزرعة على المدى الطويل. تساهم هذه الدراسة برؤى قيمة للأطباء في اختيار المواد الداعمة لترميم زراعة الأسنان، مع تسليط الضوء على أهمية النظر في المواد الهجينة كخيار محتمل لتحقيق نتائج سريرية أفضل .

الكلمات المفتاحية. غرسات الأسنان، مواد الدعامة، صحة الأنسجة المحيطة بالزرعات، طب الأسنان بالزرعات والنتائج السريرية.