Clinical and Experimental
Health Sciences

Assessment of Micro-Gap in Hybrid Abutment-Crowns Fabricated with Different Materials

Tuğçe Çetin[1], Yılmaz Umut Aslan[2]

[1] Department of Prosthodontics, Faculty of Dentistry, Marmara University, İstanbul, Türkiye.
[2] Department of Prosthodontics, Faculty of Dentistry, Marmara University, İstanbul, Türkiye.

Correspondence Author: Tuğçe Çetin
E-mail: tugcecetin@icloud.com
Received: 06.12.2022 **Accepted:** 13.02.2023

ABSTRACT

Objective: The aim of this in vitro study is to evaluate the micro-gap changes in three dimensions after thermodynamic loading between hybrid abutment crowns made of different materials and implants with internal conical connection.

Methods: A total of 10 morse cone connection implants (Straumann Bone Level Implant, Institut Straumann AG, Basel, Switzerland) were used. In this study, two study groups were formed using lithium disilicate glass-ceramic (LD) and polymethyl methacrylate (PMMA) in hybrid abutment-crown production (n=5). Hybrid abutment-crowns were fabricated by CAD/CAM system. Hybrid abutment crowns were designed and manufactured digitally. A 4-month of clinical cycle was applied to the samples in the chewing simulator. The micro-gap at the implant-abutment interface was visualized with micro-CT before and after thermodynamic loading. Micro-gap change was determined using these obtained images. For comparisons, independent t-test was used.

Results: When comparing the micro-gap volumes before and after aging, no significant difference was observed between the LD and PMMA groups. The micro-gap increase after loading was 0.68 ±0.209 in the LD group and 0.45 ±0.373 in the PMMA group. Although the increase was higher in the LD group, there is no statistically significant difference between two groups.

Conclusion: he micro-gap in the interface of implants and hybrid abutment crowns increased after aging. Hybrid abutment-crown material affected the micro-gap increase, but it was not statistically significant.

Keywords: Micro-gap, hybrid abutment-crown, implant-abutment connection.

1. INTRODUCTION

The implant-abutment connection (IAC) is the transition point from surgery to the prosthetic stage and it is the primary determinant of the success and stability of the implant-supported prosthesis (1). It has been stated that the implant-abutment connection is an important factor that determines the long-term prognosis of the treatment (2). Mismatch at the implant-abutment attachment interface can cause increased stress at the connection part, leading to screw loosening, screw breakage, and implant overloading (3,4). This situation can also lead to peri-implant pathology by causing microleakage and bacterial colonization (5,6,7). Various connection types have been developed to eliminate micro-gap caused by incompatibility between the implant and abutment. Currently, the use of conical connections is most recommended to avoid micro-gaps (8,9).

In addition to the implant abutment connection, the choice of abutment and material used in restoration production is important for the long-term success of the treatment (10,11). With the development of CAD/CAM systems, hybrid restorations prepared by fixing the restoration on the original titanium abutment of the implant system have become popular (12). Hybrid restorations produced as a combination of titanium abutments and various materials are very advantageous in terms of low cost and easy application (13) (14). In addition, soft tissue modeling can be performed during healing using hybrid restorations in immediate loading applications (15,16). Hybrid restorations used in the immediate loading protocol can be fabricated from ceramics such as lithium disilicate (LD) or from different materials such as hybrid ceramics, composites and polymethylmethacrylate (PMMA) (17,18,19). Many studies have been conducted to evaluate the effect of abutment production techniques and restoration materials on the implant-abutment connection (11,20). However, more studies are needed to evaluate the effects of all-ceramic and polymer materials, which are

DOI: 10.33808/clinexphealthsci.1215298

increasingly used in fabricating hybrid restorations, on the implant-abutment connection. The aim of this study is to evaluate the micro-gap volume between internal morse cone implants and hybrid abutment-crowns manufactured from two different materials before and after dynamic loading.

2. METHODS

2.1. Design of Study

After thermodynamic loading, the effect of different restoration materials on the micro-gap change between the implant and abutment was evaluated. In this present study, these steps were followed to evaluate the micro-gap changes: production of monolithic hybrid abutment-crowns from LD blocks and PMMA blocks with a digital system for implants, cementation of the produced restorations on titanium bases, loading of the prepared hybrid abutment crowns on the implants, three dimensionally (3D) evaluation before aging, aging equal to 4-month oral use with a chewing simulator, after aging 3D evaluation, 3D superimposition of the obtained images, determination of micro gap change and statistical analysis of the results were performed respectively.

Hybrid abutment crowns with LD blocks (IPS E-max CAD, Ivoclar Vivadent, Schaan, Liechtenstein) and PMMA blocks (Telio CAD, Ivoclar Vivadent, Schaan, Liechtenstein) were prepared for the Straumann Bone Level Implants (Institut Straumann AG, Basel, Switzerland). The Straumann bone level implant-abutment connection is morse-conical. This connection has a 15º tapered structure and four slots. Ten implants with a diameter of 4.1mm and a length of 10mm were included in this study. Two study groups were formed for LD and PMMA materials. Five hybrid abutment crowns were fabricated from each material (n=5). Study groups and sample numbers are given in Table 1.

2.2 Preparation of Samples

For the fabrication of the crowns, a ti-base abutment (TiBase S BL 4.1 L, Sirona, Bensheim, Germany) was placed on the implant. Scan post (ScanPost, Sirona, Bensheim, Germany) were placed on the ti-base abutment, and digital impressions were taken with a Cerec Omnicam intraoral camera (Sirona, Bensheim, Germany). After the optical impression process, STL data obtained with CEREC SW 4.5.1 software (Sirona, Bensheim, Germany) on a portable computer were transferred to CEREC inLab 4.5.1 program (Sirona, Bensheim, Germany). A first premolar crown compatible with the ti-base was designed by paying attention to anatomical details. The designed crown data were saved as STL data and transferred to CEREC SW 4.5.1 (Sirona, Bensheim, Germany) software. Production of the crown was completed with the CAM unit CEREC MCX (Dentsply-Sirona Dental Systems, Bensheim, Germany). All processes to complete the crystallization and polishing of the restoration were performed with a Programat P 310 porcelain furnace (Ivoclar Vivadent, Schaan, Liechtenstein). After checking the compatibility of the restoration with the ti-base abutment, the other LD crowns were produced with the same steps. The same design and milling processes were applied for PMMA (Telio CAD, Ivoclar Vivadent, Schaan, Liechtenstein) crowns. Polishing of PMMA crowns was finished with brush bur.

According to company instructions, all restorations were cemented onto ti-base abutments with Multilink Hybrid Abutment Cement (Ivoclar Vivadent, Schaan, Liechtenstein).

The implants were embedded in acrylic using a silicone index. The prepared hybrid abutment crowns were loaded onto the implants with a torque wrench. A load of 35 N was applied with a torque wrench.

Table 1. *Sample distribution of the study groups according to tested materials. (LD= Lithium disilicate ceramic; PMMA=Polymethyl methacrylate)*

Group	Materials (Product name, manufacturing company)	N
LD	Lithiumdisilicate ceramic (IPS e.max CAD, Ivoclar Vivadent, Schaan, Liechtenstein)	**5**
PMMA	Polymethyl methacrylate (Telio CAD, Ivoclar Vivadent, Schaan, Liechtenstein)	**5**

2.3. Determination of the Initial Micro-gap

Before aging, all samples were scanned with the micro-tomography device (Skyscan 1174, Skyscan, Kontich Belgium) to determine the initial micro-gap volume. After finishing the scanning process, 3D images were obtained by rendering the radiographic image sequences taken during 180° rotation. CTan (Bruker, Kontich, Belgium) software was used to determine the micro-gap volume, and CTVol (Bruker, Kontich, Belgium) software was used for the 3D analysis of the images.

Figure 1. *All samples prepared to place in the chewing simulator*

2.4. Aging of the Samples

Thermodynamic aging of the samples was performed on a dual-axle chewing simulator (SD Mechatronic Chewing Simulator CS-4.2, Willytech, Munich, Germany). Hybrid restoration-implant complexes were fixed in the sample holders of the device with acrylic (Figure 1). Metal parts of the device are fixed in the upper compartment for dynamic loading application. Samples were simulated 80,000 cycles of chewing, equivalent to approximately four months of clinical use. Dynamic loading was performed with 50 N at 5-55ºC.

2.5. Determination of Micro Gap Change After Loading

After loading, samples were scanned a second time with microtomography, and 3D radiographic images were obtained. 3D images of each sample before and after loading were superimposed on three axes (x, y, z). The superimposing process was performed with Skyscan Data Viewer (Bruker, Kontich, Belgium) software. The area to measure of micro-gap in the implant-abutment interface was determined on these superimposed images. In the determined areas, the change was determined by calculating the micro-gap volume before and after dynamic loading.

Table 2. *Comparison of micro-gap before and after aging*

Groups	LD	PMMA	P value
Micro-gap Before Aging (%) (Mean+SD)	2,65 ± 0,338	2,71 ± 0,59	0,863
Micro-gap After Aging (%) (Mean+SD)	3,33 ± 0,444	3,16 ± 0,719	0,663

Independent t test; Mean±Standart Deviation
LD= lithium disilicate ceramic; PMMA=polymethyl methacrylate

2.6. Statistical Analysis

The IBM SPSS (Statistical Package for Social Sciences) for Windows V22 (SPSS Inc, Chicago, USA) program was used to evaluate the findings obtained in this present study. Evaluations were done at 95% confidence interval and p<0.05 significance level. The assumption of normal distribution was checked with the Shapiro-Wilk test. Before and after aging micro-gap values and micro-gap changes after aging of the two groups using different restoration materials were evaluated. An Independent t-test was used as parametric test assumptions were provided in comparisons.

Table 3. *Comparison of micro-gap changes*

Groups	Mean+SD (%)	P value
1.LD	0.68 ±0.209	0,273
2.PMMA	0.45 ±0.373	

Independent t test; Mean±Standart Deviation
LD= lithium disilicate ceramic; PMMA=polymethyl methacrylate

3. RESULTS

Representative µCT images of implant-abutment junction surface before and after aging from both study groups are shown in Figure 2-3. In this study, comparisons between groups were achieved with percentage (%) values. Comparisons of the micro-gap before and after aging are given in Table 2. Micro-gap was observed in all samples regardless of condition. No significant difference was observed when the two groups' micro-gap volumes before and after aging were compared. (p= 0,663 and p>0,541). After loading in both groups, an increase in the micro-gap volume was determined. The mean micro-gap increase (%) was %0,68 ± 0.209 in the LD Group and %0,45 ± 0,37 in the PMMA Group. Although the increase was higher in the LD Group, no statistically significant difference was found (p= 0,273) (Table 3).

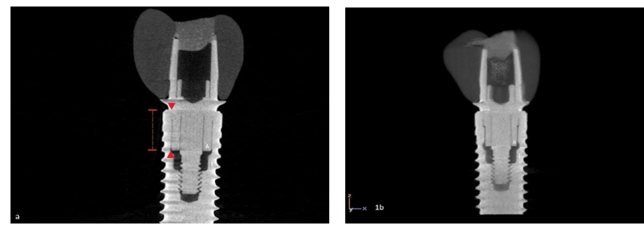

Figure 2. *Representative micro-CT images for LD group before (a) and after (b) aging. The dashed lines show the measured area (3.0x magnification). (I = Implant body, A = Abutment).*

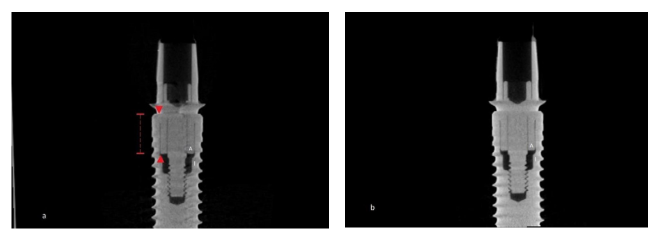

Figure 3. *Representative micro-CT images for PMMA group before (a) and after (b) aging. The dashed lines show the measured area (3.0x magnification). (I = Implant body, A = Abutment).*

4. DISCUSSION

Incompatibility, which creates micro-gaps and loss of stabilization between the implant and abutment, causes mechanical and biological problems. It has been reported that the increased mechanical stress on the connection components, the implant and the bone tissue surrounding the implant neck may cause preload loss or mechanical problems such as screw loosening/breakage (21,22,23,24). The micro-gap increase can cause bacterial leakage, micro-movements and wear between two components that will affect osseointegration (6,11,25). Rack et al. reported that the micro-gap increase occurred under cyclic loading in different internal conical joint systems, causing the micro-motion range to expand. They concluded that with an increasing mismatch between the two components in the implant abutment joint, the amount of microleakage increases and the mechanical properties of the joint weaken (26). In this present study, it was observed that the micro-gap between implant and abutment increased in short-term loading in both groups.

Many studies have been conducted to evaluate the abutment production technique and the effect of materials used in restoration production on mechanical stability in implant-supported restorations (11,20). However, there are still not enough studies to understand the mechanical behaviour of all materials and abutment types (27,28) Zordk et al. compared the torque loss of hybrid abutment crowns fabricated with zirconia, lithium disilicate and PEEK materials after thermal aging. And no statistically significant difference was found between these three groups (20). In this present study, micro-gap changes between the hybrid abutment crowns, which were produced by using two different materials, and implants after aging were investigated. However, this increase was similar in hybrid restorations prepared with the same production technique and different materials and fixed on identical titanium bases.

The elastic modulus of the materials that used implant-supported restorations affects the stress distribution from the occlusal face to the implant (29,30). Tribst et al. reported that hybrid restorations with low elastic modulus show better stress distribution (31). In a different study, it has been reported that materials with low elastic modulus have little effect on the micro-gap change (32). In this present study, although the elastic modulus of the restoration materials was different, there was no statistically significant difference between the changes. The micro-gap change was less in the Telio CAD (3.2 GPa) group with a low elastic modulus than in the lithium disilicate glass-ceramic (95 GPa) group with a higher elastic modulus.

5. CONCLUSION

Micro-gaps between implant-abutment existed in all conditions. The micro-gap volume at the interface of implants and hybrid abutment crowns increased after aging. Hybrid abutment-crown material affected the micro-gap increase, but it was not statistically significant.

Acknowledgement: *Thank you for supporting the participants in this study.*
Funding: *The author(s) received no financial support for the research.*
Conflicts of interest: *The authors declare that they have no conflict of interest.*
Peer-review: *Externally peer-reviewed.*
Author Contributions: İnitials only
Research idea:
Design of the study:
Acquisition of data for the study:
Analysis of data for the study:
Interpretation of data for the study:
Drafting the manuscript:
Revising it critically for important intellectual content:
Final approval of the version to be published:

REFERENCES

[1] Singla S, Kumar L, Rathee M. Know your implant connections. Afr J Oral Health. 2018;6(2): 1-7. DOI:10.4314/ajoh.v6i2.162380

[2] Goodacre CJ, Kan JY, Rungcharassaeng K. Clinical complications of osseointegrated implants. J Prosthet Dent. 1999;8(5): 537-552. DOI: 10.1016/s0022-3913(99)70208-8

[3] Sailer I, Sailer T, Stawarczyk B, Jung RE, Hämmerle CH. In vitro study of the influence of the type of connection on the fracture load of zirconia abutments with internal and external implant-abutment connections. Int J Oral Maxillofac Implants. 2009;24(5):850-858. DOI:10.5167/uzh-26251

[4] Gupta S, Gupta H, Tandan A. Technical complications of implant-causes and management: A comprehensive review. Natl J Maxillofac Surg. 2015;6(1):3-8. DOI: 10.4103/0975-5950.168233

[5] Koutouzis, T. Implant-abutment connection as contributing factor to peri-implant diseases. Periodontology. 2019;81(1):152–166. DOI: 10.1111/prd.12289

[6] Liu Y, Wang J. Influences of microgap and micromotion of implant-abutment interface on marginal bone loss around implant neck. Arch Oral Biol. 2017;83:153-160. DOI: 10.1016/j.archoralbio.2017.07.022

[7] Caricasulo R, Malchiodi L, Ghensi P, Fantozzi G, Cucchi A. The influence of implant-abutment connection to peri-implant bone loss: A systematic review and meta-analysis. Clin Implant Dent Relat Res. 2018;20(4):653-664. DOI: 10.1111/cid.12620

[8] Schmitt CM, Nogueira-Filho G, Tenenbaum HC, Lai JY, Brito C, Döring H, Nonhoff J. Performance of conical abutment (Morse Taper) connection implants: a systematic review. J Biomed Mater Res A. 2014;102(2):552-574. DOI: 10.1002/jbm.a.34709

[9] Canullo L, Penarrocha-Oltra D, Soldini C, Mazzocco F, Penarrocha M, Covani U. Microbiological assessment of the implant-abutment interface in different connections: cross-sectional study after 5 years of functional loading. Clin Oral Implants Res. 2015;26(4):426-434. DOI: 10.1111/clr.12383

[10] Priest G. A current perspective on screw-retained single-implant restorations: a review of pertinent literature. J Esthet Rest Dent. 2017;29(3):161-171. DOI: 10.1111/jerd.12283

[11] Huang Y, Wang J. Mechanism of and factors associated with the loosening of the implant abutment screw. J Ethet Restor Dent. 2019;31(4):338-345. DOI: 10.1111/jerd.12494

[12] Edelhoff D, Schweiger J, Prandtner O, Stimmelmayr M, Güth JF. Metal-free implant-supported single-tooth restorations. Part I: Abutments and cemented crowns. Quintessence Int. 2019;50(3):176-184. DOI: 10.3290/j.qi.a41906

[13] Edelhoff D, Schweiger J, Prandtner O, Stimmelmayr M, Güth JF. Metal-free implant-supported single-tooth restorations. Part II: Hybrid abutment crowns and material selection. Quintessence Int. 2019;50(4):260-269. DOI: 10.3290/j.qi.a42099

[14] Zembic A, Kim S, Zwahlen M, Kelly JR. Systematic review of the survival rate and incidence of biologic, technical, and esthetic complications of single implant abutments supporting fixed prostheses. Int J Oral Maxillofac Implants. 2014;29:99-116. DOI: 10.11607/jomi.2014suppl.g2.2

[15] Qutub OA, Basunbul GI, Binmahfooz AM. Influence of abutment material on the shade of dental implant restorations in the esthetic zone: a single case report. Clin Cosmet Investig Dent. 2019;11:73-80. DOI: 10.2147/CCIDE.S199635

[16] Tribst JPM, Dal Piva AMO, Özcan M, Borges ALS, Bottino MA. Influence of Ceramic Materials on Biomechanical Behavior of Implant Supported Fixed Prosthesis with Hybrid Abutment. Eur J Prosthodont Restor Dent. 2019;27(2):76-82. DOI: 10.1922/EJPRD_01829Tribst07

[17] Glauser R, Zembic A, Hämmerle CH. A systematic review of marginal soft tissue at implants subjected to immediate loading or immediate restoration. Clin Oral Implants Res. 2006;17(2):82-92. DOI: 10.1111/j.1600-0501.2006.01355.x

[18] Yazigi C, Kern M, Chaar MS, Libecki W, Elsayed A. The influence of the restorative material on the mechanical behavior of screw-retained hybrid-abutment-crowns. J Mech Behav Biomed Mater. 2020;111:103988. DOI: 10.1016/j.jmbbm.2020.103988

[19] Adolfi D, Tribst JPM, Adolfi M, Dal Piva AMO, Saavedra GSFA, Bottino MA. Lithium Disilicate Crown, Zirconia Hybrid Abutment and Platform Switching to Improve the Esthetics in Anterior Region: A Case Report. Clin Cosmet Investig Dent. 2020;12:31-40. DOI: 10.2147/CCIDE.S234980

[20] Al-Zordk W, Elmisery A, Ghazy M. Hybrid-abutment-restoration: effect of material type on torque maintenance and fracture resistance after thermal aging. Int J Implant Dent. 2020;6(1):24. DOI: 10.1186/s40729.020.00220-y

[21] Oh TJ, Yoon J, Misch CE,Wang HL. The causes of early implant bone loss: myth or science. J Periodontol. 2002;73(3):322-333. DOI: 10.1902/jop.2002.73.3.322

[22] Broggini N, McManus LM, Hermann JS, Medina R, Schenk RK, Buser D. Peri-implant inflammation defined by the implant-abutment interface. J Dent Res. 2006;85(5):473-478. DOI: 10.1177/154.405.910608500515

[23] Coelho AL, Suzuki M, Dibart S, DA Silva N, Coelho PG. Cross-sectional analysis of the implant-abutment interface. J Oral Rehabil. 2007;34(7):508-16. DOI: 10.1111/j.1365-2842.2007.01714.x

[24] Ricomini Filho AP, FernandesFS, Straioto FG, da Silva WJ, Del BelCury AA. Preload loss and bacterial penetration on different implant-abutment connection systems. Braz Dent J. 2010;21(2):123-129. DOI: 10.1590/s0103.644.0201000.020.0006

[25] Blum K, Wiest W, Fella C, Balles A, Dittmann J, Rack A, Maier D, Thomann R, Spies BC, Kohal RJ, Zabler S, Nelson K. Fatigue induced changes in conical implant-abutment connections. Dent Mater. 2015;31(11):1415-1426. DOI: 10.1016/j.dental.2015.09.004

[26] Rack T, Zabler S, Rack A, Riesemeier H, Nelson K. An in vitro pilot study of abutment stability during loading in new and fatigue-loaded conical dental implants using synchrotron-based radiography. Int J Oral Maxillofac Implants. 2013;28(1):44-50. DOI: 10.11607/jomi.2748

[27] Elsayed A, Wille S, Al-Akhali M, Kern M. Effect of fatigue loading on the fracture strength and failure mode of lithium disilicate and zirconia implant abutments. Clin Oral Implants Res. 2018;29(1):20-27. DOI: 10.1016/j.prosdent.2020.09.059

[28] Nouh I, Kern M, Sabet A, Aboelfadl A, Hamdy A, Chaar M. Mechanical behavior of posterior all-ceramic hybrid-abutment-crowns versus hybrid – abutments with separate crowns: a laboratory study. Clin Oral Impl Res. 2019;30(1):90-98. DOI: 10.1111/clr.13395

[29] Karl M, Graef F, Wichmann MG, Heckmann SM. The effect of load cycling on metal ceramic screw-retained implant restorations with unrestored and restored screw access holes. J Prosthet Dent. 2008;99(1):19-24. DOI: 10.1016/S0022-3913(08)60004-9

[30] Karl M, Kelly JR. Influence of loading frequency on implant failure under cyclic fatigue conditions. Dent Mater. 2009;25(11):1426-1432. DOI: 10.1016/j.dental.2009.06.015

[31] Tribst JPM, Piva AMDOD, Borges ALS, Bottino MA. Influence of crown and hybrid abutment ceramic materials on the stress distribution of implant-supported prosthesis. Rev Odontol UNESP. 2018;47(3):149–154. DOI:10.1590/1807-2577.04218

[32] Vahey BR, Sordi MB, Stanley K, Magini RS, Novaes de Oliveira AP, Fredel MC, Henriques B, Souza JCM. Mechanical integrity of cement – and screw-retained zirconium-lithium silicate glass-ceramic crowns to Morse taper implants. J Prosthet Dent. 2018;120(5):721-731. DOI: 10.1016/j.prosdent.2018.01.028

How to cite this article: Çetin T, Aslan YU. Assessment of Micro-Gap in Hybrid Abutment-Crowns Fabricated with Different Materials. Clin Exp Health Sci 2023; 13: 871-875. DOI: 10.33808/clinexphealthsci.1215298