The Effect of Splinted Implant-Supported Crowns on Marginal Bone in Partially Edentulous Ridge: A Retrospective Study

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THESIS
Submitted in partial satisfaction of the requirements for degree of
MASTER OF SCIENCE

in

Oral and Craniofacial Sciences

in the

GRADUATE DIVISION
of the
UNIVERSITY OF CALIFORNIA, SAN FRANCISCO

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Acknowledgments

I would like to acknowledge the following individuals for their support and contributions throughout this research project. Dr. Guo-Hao (Alex) Lin, for his unwavering mentorship, guidance, and dedication in making this project possible. Dr. Yvonne Kapila for her continued feedback and guidance throughout the past three years. Dr. Richard Kao for his mentorship and push towards excellence. Dr. Donald Curtis for his guidance, feedback, and mentorship. Ms. Karolina Brzyska for her assistance and dedication to this project. I would also like to acknowledge my family and friends for their constant encouragement and unconditional support throughout not only this project, but throughout all my academic endeavors. Lastly, I would like to acknowledge my co-residents, Dr. Hanna Brody and Dr. Raime Shah, who shared both the highs and lows throughout this journey and were there every step of the way.

Abstract: The Effect of Splinted Implant-Supported Crowns on Marginal Bone in Partially Edentulous Ridge: A Retrospective Study

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Objective: The aim of this retrospective study is to investigate the association between splinted implant-supported restorations and marginal bone levels in partially edentulous ridge.

Materials and Methods: Data from January 2000 to February 2021 was collected from the electronic charts of patients at the UCSF School of Dentistry with implant-supported prostheses and with radiographs at least twelve months after restoration. Five types of restorations were included: 1) two single adjacent crowns, 2) two splinted adjacent crowns, 3) 3-unit bridges, 4) three single adjacent crowns, and 5) three splinted adjacent crowns. Measurements included vertical distance between adjacent implant platforms, radiographic bone loss (RBL) around implants, and emergence angle of restorations. Odds ratios (ORs) and 95% confidence interval (95% CI) of implants with ≥1mm RBL between different type of restorations were calculated.

Results: When there was a vertical distance of ≥ 0.5 mm between adjacent implant platforms, the majority (66.67%) of three splinted crowns had at least one implant with ≥ 1 mm RBL, followed by two splinted crowns (58.97%), 3-unit bridges (25.93%), two single crowns (24.24%), and three single crowns (18.18%). When the vertical distance between adjacent implant platforms was ≥ 1 mm, there was a greater percentage of implants with ≥ 1 mm RBL. The highest group was three splinted adjacent crowns (70.00%), followed by two splinted crowns (61.11%), three single crowns (22.22%), and 3-unit bridges and two single implants (21.05%). Three splinted crowns were significantly associated with ≥ 1mm RBL when compared to three single crowns and 3-unit bridges (OR= 6.67, 95% CI= 1.14 to 38.83 and OR= 6.56, 95% CI= 1.59 to 27.07, respectively). Similarly, two splinted crowns were significantly associated with ≥ 1 mm RBL when compared to 2 single crowns (OR= 2.50, 95% CI= 1.08 to 5.79).

When the emergence angle of an implant restoration was >30°, the incidence of ≥ 1 mm RBL was 90.01% for three splinted implants. This was followed by two splinted crowns (62.07%), two single crowns (58.33%), 3-unit bridges (41.67%), and three single implants (40.00%). For these four categories,

RBL was only detected for bone-level implants. When an implant restoration had an emergence angle >30°, there was a significant association of ≥ 1 mm RBL for three splinted crowns when compared to 3-unit bridges and three single crowns (OR= 14.00, 95% CI= 1.33 to 147.43 and OR= 13.33, 95% CI= 1.05 to 169.56, respectively), and two splinted crowns when compared to two single crowns (OR= 4.40, 95% CI= 1.05 to 18.36).

Conclusion: Within the limitations of this study, two or three adjacent implants, when splinted together, are associated with higher incidence of RBL ≥ 1 mm than non-splinted restorations. In addition, a vertical distance of ≥ 0.5 mm between adjacent implant platforms or an emergence angle of >30° significantly increased the risk of peri-implant bone loss.

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Introduction

Dental implants have become a popular treatment modality for replacing missing teeth. A 2005-2006 survey conducted by the American Dental Association found that more than 2 million dental implants were placed in private practices around the United States.[1] Furthermore, there has been a large increase in the prevalence of dental implants, from 0.7% in 1999 to 2000 to 5.7% in 2015 to 2016, with dental implant prevalence projected go up to 23% by 2026.[2] With this upward trend of dental implants being placed, the prevalence of peri-implant diseases has largely increased.[3,4]

Peri-implant diseases are complex and multifactorial. Peri-implantitis is a plaque-associated pathological condition characterized by inflammation in the peri-implant mucosa and subsequent progressive loss of supporting bone.[5] There is strong evidence that there is an increased risk of developing peri-implantitis in patients with a history of chronic periodontitis, poor plaque control skills, and irregular maintenance care after implant therapy.[6] Iatrogenic factors that can contribute to peri-implant disease risk include poor implant positioning and inadequate hygiene access due to suprastructure design.[7]

Restoration contour is a critical component of the suprastructure design.[8,9] There are two specific terms for restoration contours: emergence angle and emergence profile. Emergence angle is defined as the angle of an implant restoration's transitional contour as determined by the relation of the surface of the abutment to the long axis of the implant fixture. Emergence profile is defined as the contour of a tooth or restoration, such as a crown on a natural tooth or dental implant abutment, as it relates to the adjacent tissues. An over-contoured restoration on a dental

implant may have a negative implant peri-implant health and increase the risk of developing peri-implantitis. In particular, an emergence angle of >30° has been found to be significant risk indicator for peri-implantitis, with a convex profile creating an additional risk.[8] Interestingly, this peri-implantitis risk was seen for bone-level implants, but not for tissue-level implants.

A recent study investigating the influence of prosthetic features on peri-implantitis risk also found a statistically greater prevalence of marginal bone loss if the emergence angle was ≥ 30°.[9] This same study reported that implants splinted to both mesial and distal adjacent implants have a higher risk of peri-implantitis. However, these findings were not in line with previous studies that found no significant differences in marginal bone loss between splinted and non-splinted implant restorations.[10,11] These contradicting results highlight the multifactorial nature of the marginal bone level around splinted implants. The aim of this retrospective study is to investigate the association between splinted implant-supported crowns in partially edentulous ridge and the marginal bone level.

Materials and Methods

Data from January 2000 to February 2021 was collected from the electronic charts of patients at the University of California San Francisco (UCSF) School of Dentistry with implant-supported prostheses. Inclusion criteria included two or three adjacent implants placed and restored at the UCSF School of Dentistry, baseline periapical or bitewing radiographs taken before implant loading, and at least one follow-up radiograph taken more than twelve months after prosthesis delivery. Exclusion criteria included implant-supported dental prostheses with more than three units, multi-unit splinted implant-supported prostheses with cantilevers, and lack of baseline or

follow-up radiographs. Patient information was protected according to the privacy regulations of the Federal Health Insurance Portability and Accountability Act of 1996 (HIPAA). The study protocol was approved by the UCSF Institutional Review Board (IRB number: 21-33265).

Five types of implant-supported restorations were included: 1) two single adjacent crowns, 2) two splinted adjacent crowns, 3) 3-unit bridges, 4) three single adjacent crowns, and 5) three splinted adjacent crowns. The following measurements were determined based on radiographs using a computer software (MiPACS, Medicor Imaging, Charlotte, NC, USA): vertical distance between adjacent implant platforms, radiographic bone loss (RBL) around implants, and emergence angle of restorations. Other implant-related data collected included the most apical implant, presence of platform switch, implant platform level (bone- vs. tissue-level), restoration type (cement- vs. screw-retained), and presence of restoration open margins. In addition to these implant-related factors, the patient's demographic data, including gender and age, diabetes status, history of smoking, use of anti-depressants, and history of periodontal disease, were also recorded.

Statistical Analysis

Descriptive analyses were performed to demonstrate the percentage of implants with RBL of ≥ 1 mm when there was a vertical distance of ≥ 0.5 mm or ≥ 1 mm between the adjacent implant platforms, or an emergence angle >30 degrees for one of the implant-supported crowns. Odds ratios (ORs) and the 95% confidence intervals (CIs) of the vertical distance between adjacent implant platforms and emergence angle >30 degrees for RBL among different types of the restorations were further calculated.

Statistical analyses were calculated using a computer program (SAS Institute Inc. 2011. Base SAS® 9.3 Procedures Guide, Cary, NC).

Results

Patient Demographics

After screening the 475 electronic dental records, 156 patients with 337 implants met the inclusion criteria for this study. Of these 156 patients, 52% were male and 48% were female. In addition, 29% of the patients had a smoking history, 13% had diabetes, 18% used anti-depressant medication, and 47% had a history of periodontitis.

Vertical Distance between Implant Platforms

When there was a vertical distance of ≥ 0.5mm between adjacent implant platforms, the majority (66.67%) of three splinted crowns had at least one implant with ≥1 mm RBL (Table 2), followed by two splinted crowns (58.97%), 3-unit bridge (25.93%), two single crowns (24.24%), and three single crowns (18.18%). When the vertical distance between adjacent implant platforms was ≥1mm, there was overall a greater percentage of implants with ≥ 1mm of RBL. The highest group was three splinted adjacent crowns (70.00%), followed by two splinted crowns (61.11%), three single crowns (22.22%), 3-unit bridges (21.05%), and two single implants (21.05%).

After adjusting for smoking, diabetes, anti-depressant use, and history of periodontitis, a significantly higher OR for ≥1 mm RBL was found for three splinted crowns when compared to

three single crowns (OR= 6.67, 95% CI= 1.14 to 38.83, Table 3). Three splinted crowns also had a significantly higher OR for ≥ 1mm RBL when compared to 3-unit bridges (OR= 6.56, 95% CI= 1.59 to 27.07). Similarly, a significantly higher OR for ≥ 1mm RBL was found for two splinted crowns when compared to two single crowns (OR= 2.50, 95% CI= 1.08 to 5.79).

Emergence Angle

When the emergence angle of an implant restoration was >30°, the incidence of ≥1 mm RBL was 90.01% for three splinted implants (Table 2). This was followed by two splinted crowns (62.07%), two single crowns (58.33%), 3-unit bridges (41.67%), and three single implants (40.00%). For these four categories, RBL was only detected for bone-level implants.

After adjusting for smoking, diabetes, anti-depressant use, and history of periodontitis, a significantly higher OR for ≥1mm RBL was found when an implant restoration had an emergence angle >30° for three splinted crowns when compared to 3-unit bridge and three single crowns (OR= 14.00, 95% CI= 1.33 to 147.43 and OR= 13.33, 95% CI= 1.05 to 169.56, respectively, Table 3). Similarly, a significantly higher OR for ≥1 mm RBL was found for two splinted crowns when compared to two single crowns (OR 4.40, 95% CI 1.05 to 18.36).

Discussion

The findings from this current study support previous studies on the association between over-contoured implants and peri-implantitis risk. In particular, an emergence angle of >30° is a

significant risk indicator for peri-implantitis,[8,9] and splinting adjacent implant-supported restorations could be a significant risk factor for peri-implantitis[9].

Peri-implantitis is a plaque-associated pathological condition that is thought to be caused by bacteria and a local host inflammatory response.[5,12,13] Poor oral hygiene and plaque control are associated with an increased risk of developing peri-implant bone loss.[6,14] One potential mechanism for the increased prevalence of peri-implant bone loss around splinted implants and implants with a wider emergence angle is compromised oral hygiene access and plaque accumulation.

A previous study comparing cemented single and splinted implants found that local factors such as accessibility for oral hygiene at the implant sites seems to be related to the presence or absence of peri-implantitis[15]. Peri-implant bone loss was associated with inadequate plaque control at implant sites. Furthermore, peri-implantitis was a rare finding around implants when proper plaque control was ensured. These results highlight the importance of proper prosthetic constructions that allow accessibility for oral hygiene around implants, as well as giving proper oral hygiene instructions to patients who are rehabilitated with dental implants.

A previous study compared the effects of simulated occlusal loading of three implants restored with cemented splinted and non-splinted crowns[16]. Single non-splinted restorations transfer significantly less stress in the implant neck. When several adjacent implant restored crowns are joined, there is a summation of inherent misfit inaccuracies, resulting in transfer of increased loads to the implants and supporting structures. This difference in stress transfer for splinted

implants may contribute to physiologic bone remodeling, which is another potential mechanism for the increased prevalence of peri-implant bone loss around splinted implants.

These two theories support the findings of the previous study that saw the prevalence of peri-implantitis of the splinted-middle group was 4.66-fold higher than the implant restored independently.[9] The splinted prosthesis may limit the access for proper plaque control and may transfer increased loads to the implants, contributing to the increased risk for peri-implant bone loss.

Once implants are uncovered, the implant-abutment interface is established and the bone typically resorbs 1.5-2.0mm apically. An inter-implant horizontal distance of at least 3mm is needed to minimize crestal bone loss[17]. However, the findings of the current study suggest that the minimal inter-implant horizontal distance may need to be greater if the implant platforms are at different vertical levels.

Two or three adjacent implants, when splinted together, are associated with higher incidence of marginal bone loss ≥1mm than non-splinted restorations. A vertical distance of ≥0.5mm between adjacent implant platforms significantly increased the risk of peri-implant bone loss. An emergence angle of >30° significantly increased the risk of peri-implant bone loss, especially for bone-level implants. These findings suggest that single-unit implant-supported crowns would be recommended when two or three adjacent implants are placed at different platform levels. Additionally, when two or three adjacent implants are restored with an emergence angle of >30°,

splinted crowns have higher risk for peri-implant bone loss than single-unit crowns or bridge prostheses, especially for bone-level implants.

There are several limitations for the current study. First, due to the retrospective nature of this study, some clinical parameters, i.e., oral hygiene status and occlusion, could not be assessed. Second, due to the structure of care within a dental school setting, there might be variability in patient care due to provider experiences. Third, for a study of this scope, a larger number of both patients and implants would have provided for a more robust data analysis.

Conclusion

Within the limitations of this study, two or three adjacent implants, when splinted together, are associated with higher incidence of marginal bone loss ≥1mm than non-splinted implant restorations. In addition, a vertical distance of ≥0.5mm between adjacent implant platforms or an emergence angle of >30° significantly increased the risk of peri-implant bone loss.

Table 1: Demographic data of the participants

	Two single crowns, adjacent	Two splinted crowns, adjacent	3-unit bridges	Three single crowns, adjacent	Three splinted crowns, adjacent
Bone level implants					
N patients	28	49	23	8	12
N implants	56	98	46	24	36
Male/Female	10/18	23/26	14/9	3/5	6/6
Mean age, range (SD)	58.75 (37-79)	62.59 (21-84)	64.35 (45-83)	68.75 (52-82)	66.17 (47-84)
Smoking (%)	7/28	19/49	3/23	2/8	4/12
Diabetes (%)	3/28	5/49	4/23	1/8	2/12
Anti-depressants (%)	3/28	11/49	5/23	1/8	2/12
History of periodontitis (%)	11/28	28/49	8/23	5/8	4/12
Cement retained implants	12/56	18/98	8/46	4/24	9/36
Screw retained implants	44/56	80/98	38/46	20/24	27/36
Platform switched design (implant level)	Open margin: 3/50 Fitted margin: 47/50	Open margin: 6/64 Fitted margin: 58/64	Open margin: 6/44 Fitted margin: 38/44	Open margin: 1/24 Fitted margin: 23/24	Open margin: 7/27 Fitted margin: 20/27
Straight platform design (implant level)	Open margin: 1/6 Fitted margin: 5/6	Open margin: 2/34 Fitted margin: 32/34	Open margin: 0 Fitted margin: 2/2	Open margin: 0/24 Fitted margin: 0/24	Open margin: 0/0 Fitted margin: 9/9
Tissue level implants					
N patients	14	11	6	3	2
N implants	28	22	12	9	6
Male/Female	8/6	9/2	5/1	2/1	1/1
Mean age, range (SD)	59.86 (37-74)	59.27 (38-86)	61.17 (55-66)	65.67 (62-68)	73.5 (70-77)
Smoking (%)	4/14	5/11	1/6	1/3	0/2
Diabetes (%)	2/14	1/11	1/6	1/3	1/2
Anti-depressants (%)	3/14	0/11	2/6	0/3	1/2
History of periodontitis (%)	7/14	6/11	3/6	0/3	1/2
Cement retained implants	8/28	10/22	8/12	9/9	3/6
Screw retained implants	20/28	12/22	4/12	0/9	3/6
Straight platform design (implant level)	Open margin: 4/28 Fitted margin: 24/28	Open margin: 6/22 Fitted margin: 16/22	Open margin: 4/12 Fitted margin: 8/12	Open margin: 0/9 Fitted margin: 0/9	Open margin: 0/6 Fitted margin: 6/6

Table 2: Incidence of at least one of the implants with bone loss ≥1mm for different type of restorations

	Two single crowns, adjacent	Two splinted crowns, adjacent	3-unit bridges	Three single crowns, adjacent	Three splinted crowns, adjacent
Vertical platform distance ≥ 0.5mm	24.24% (8/33)	58.97% (23/39)	25.93% (7/27)	18.18% (2/11)	66.67% (8/12)
Vertical platform distance ≥ 1mm	21.05% (4/19)	61.11% (11/18)	21.05% (4/19)	22.22% (2/9)	70% (7/10)
Emergence angle >30 degrees	58.33%, only for bone level implants	62.07%, only for bone level implants	41.67%, only for bone level implants	40%, only for bone level implants	90.91%, no matter they are bone level or tissue level implants

Table 3: Adjusted ORs and 95% CI of peri-implant bone loss ≥1mm on the adjacent implant between different types of restorations

	3-unit bridge vs. Three splinted crowns	3-unit bridge vs. Three single crowns	Three single crowns vs. Three splinted crowns	Two single crowns vs. Two splinted crowns
Overall	6.5625 95% CI: 1.5912 to 27.0660	1.7143 95% CI: 0.3024 to 9.7194	6.6667 95% CI: 1.1445 to 38.8331	2.5000 95% CI: 1.0801 to 5.7863
Vertical platform distance ≥ 0.5mm	5.7143 95% CI: 1.3048 to 25.0263	1.5750 95% CI: 0.2717 to 9.1307	9.0000 95% CI: 1.2852 to 63.0249	4.4922 95% CI: 1.6194 to 12.4611
Vertical platform distance ≥ 1mm	8.7500 95% CI: 1.5278 to 50.1117	1.0714 95% CI: 0.1571 to 7.3074	8.1667 95% CI: 1.0271 to 64.9365	5.8929 95% CI: 1.3766 to 25.2256
Emergence angle >30 degrees	14.0000 95% CI: 1.3295 to 147.4289	2.6250 95% CI: 0.2996 to 22.9982	13.3333 95% CI: 1.0485 to 169.5571	4.4000 95% CI: 1.0546 to 18.3578

* Adjusted for smoking, diabetes, use of anti-depressants and history of periodontitis.

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