The Effects of Disconnection and Reconnection of Definitive Abutments on Peri-implant Bone Levels Changes: A 1-Year Split-Mouth Randomized Controlled Clinical Study

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Abstract

Background: There is evidence suggesting non-removal of a definitive abutment on an implant from the day of surgery helps to preserve the peri-implant marginal bone levels. However, the limited literatures available still contains contradictory conclusions to this finding.

Objective: The aim of this prospective study was to evaluate the effects of definitive abutment connection at the time of implant placement on peri-implant bone levels and soft tissue changes in posterior maxilla and mandible regions.

Materials and Methods: A total of 38 implants were placed in 17 patients with at least 2 missing posterior teeth in the maxilla or the mandible for this study. Each patient received 2 or 4 implants. A definitive prefabricated abutment (test group) was randomly connected to one implant at implant placement (T0) and left undisturbed throughout the duration of the study. On the other implant, a healing abutment (control group) was connected and subjected to go through three disconnections and reconnections at 3 months (T3), 6 months (T6), and 12 months (T12) after the implant placement. Throughout the study period (1 year), all implants remained unrestored. Marginal bone level changes (MBLC) were assessed using standardized periapical radiographs taken at T0 and T12. Peri-implant soft tissue parameters including the keratinized mucosa width and lingual mucosa thickness were also recorded and evaluated.

Results: At the 1-year follow-up, the test group showed significantly less MBLC compared to the control group. The mean MBLC in the test group was 0.32 ± 0.47 mm, which was significantly lower than the 0.80 ± 0.92 mm observed in the control group (p=0.009). The test group also had a smaller reduction in keratinized mucosa width, with a mean reduction of 0.42 ± 0.42 mm compared to 0.90 ± 0.77 mm in the control group (p=0.049). Lingual mucosa thickness changes were 0.38 ± 0.26 mm in the test group and 0.71 ± 0.59 mm in the control

group, but this difference did not reach statistical significance (p=0.053). However, a significant correlation was identified between changes in keratinized mucosa width and MBLC in the test group (p=0.02).

Conclusion: The results of this study support the hypothesis that connecting a definitive abutment at the time of implant placement results in less MBLC compared to repeated abutment disconnections. Additionally, the test group demonstrated better preservation of peri-implant soft tissue compared to the control group. These findings suggest that the one-abutment-one-time protocol may contribute to improved peri-implant tissue stability.

Keywords: *abutment disconnection-reconnection, one-abutment one-time, definitive abutment, one-time abutment, marginal bone loss*

1. INTRODUCTION

The peri-implant mucosal barrier consists of two key components: (i) a junctional epithelium approximately 2 mm, and (ii) a connective tissue compartment about 1–1.7 mm.[1-3] During healing, it is hypothesized that the connective tissue adheres to the transmucosal implant components, forming a barrier that inhibits epithelial downgrowth and helps prevent peri-implant bone resorption due to bacterial and mechanical insults.[4-7] To preserve the marginal bone level around dental implants, it is important to improve the quality and stability of the connective tissue integration, in addition to utilizing a minimally invasive surgical technique.[2]

Several factors may influence the connective tissue-implant interface, including the type of implant, initial soft tissue thickness,[8] depth of implant placement,[9-12] and the stability of the implant-abutment connection.[10] Additional factors include the size of the microgap at the implant-abutment connection, the material and surface topography of the abutment,[13-15] abutment height,[16] and the abutment emergence profile.[17] The reaction of peri-implant soft tissue to repeated disturbance, such as disconnections and reconnections of the abutment, has also been shown to impact bone resorption.[18-20]

Abrahamsson et al[19] were the first to report, in an animal study, that repeated abutment disconnections and reconnections can compromise the mucosal barrier, resulting in approximately 0.7 mm of additional peri-implant bone loss and soft tissue recession. This finding led to the development of the "one-abutment-one-time" (OAOT) concept, which advocates placing a definitive abutment at the time of implant surgery to avoid disrupting connective tissue adaptation during restorative procedures. However, subsequent studies in both animals and humans have produced contradictory results regarding peri-implant bone changes.[21-23] Human studies by Degidi et al reported a significant reduction in horizontal bone remodeling around subcrestally placed tapered implants when a definitive abutment

was delivered at the time of surgery.[24,25] Similar studies arrived at the same conclusions for implants placed at both immediate post-extraction sites[20,26,27] and healed sites.[28-33] Other studies, however, demonstrated that peri-implant bone levels did not change significantly.[34-39] Several reviews and meta-analyses also found a lack of consensus on this topic.[18,40-42] Two meta-analysis concluded that multiple abutment disconnections significantly affect marginal bone level changes in partially edentulous patients.[43,44] The evidence on this concept remains controversial due to the wide variation in methodologies employed by the studies and the inclusion of confounding factors that may influence the results.[45-47]

Marginal bone changes are critical for the long-term assessment and maintenance of dental implants, as they form the basis for implant success criteria and help determine the progression of peri-implant pathology.[45,46] The present study aimed to evaluate peri-implant bone level changes one year after implant placement with a definitive abutment, before functional loading. The null hypothesis was that there would be no significant difference in peri-implant bone levels between implants with definitive abutments delivered at the time of surgery using the one-abutment-one-time protocol, and those subjected to multiple abutment disconnections and reconnections.

2. MATERIALS AND METHODS

2.1 Sample size

Power analysis was carried out to determine the sample size. A sample size of 38 implants was needed to achieve 80% power to detect a difference between the null proportion of 0.500 at a significance level of 0.05.

2.2 Patient selection

This study was designed as a single-center, prospective, randomized modified split-mouth

clinical trial. It was conducted at the Loma Linda University School of Dentistry (LLUSD) Center for Implant Dentistry, California, United States. The study followed guidelines established by the Loma Linda University Institutional Review Board (IRB No.#5190024) and was approved prior to initiation.

To be included in the study, patients had to meet the following criteria: (i) read, sign, and receive a copy of the informed consent form, including consent for photos; (ii) Male or female with at least 18 years of age with good oral hygiene and good general health; (iii) have a healed site with two or more missing teeth in the maxillary or mandibular posterior region (excluding third molars); (iv) have adequate bone width and height to accommodate at least a 4.3 mm diameter and 8 mm length implant at each site; (v) have at least 8 mm of interocclusal restorative space; and (vi) be willing to participate and attend the planned 1-year follow-up visits before starting the implant restoration procedures.

Patients were excluded if they had the following: (i) history of alcohol or drug dependency, or any medical, physical, or psychological factors that might affect the surgical or prosthodontic procedures and follow-up examinations; (ii) history of radiation therapy to the head and neck region; (iii) history or current habit of smoking; (iv) history or current habit of bruxism; (v) no opposing occluding dentition or prostheses; (vi) need for bone augmentation during implant placement; or (vii) implant insertion torque value <35 Ncm. Each patient received at least two implants in the posterior maxilla or mandible. At implant placement (T0), one implant was randomly selected to receive a definitive prefabricated abutment (test group), which was left undisturbed throughout the study. The other implant received a healing abutment (control group), which underwent three disconnections and reconnections at 3 months (T3), 6 months (T6), and 12 months (T12) after implant surgery. All implants were restored with individual screw-retained crowns after the 1-year study period.

2.3 Surgical procedures

At the time of implant surgery, patients were escorted to the operating room at the LLUSD Center for Implant Dentistry. They were instructed to rinse their mouths with 0.12% chlorhexidine gluconate solution for 3 minutes prior to surgery. After being seated, monitors were placed to record blood pressure, pulse rate, and oxygen saturation. The patient's circumoral area was sterilized with a Povidone-Iodine swab (Aplicare, Aplicare Inc., Branford, CT), and the area was then draped for a sterile protocol. Oxygen was provided to the patient through a nasal cannula at a minimum flow rate of 3 liters per minute.

Following the administration of local anesthetic (2% lidocaine with 1:100,000 epinephrine [Dentsply, York, PA, USA]), a surgical stent was used to determine the position of implant placement. Pre-operative keratinized mucosa width was measured and recorded at the center of the future implant placement site with a 1.0 mm marked periodontal probe (Hu-Friedy, Chicago, IL, USA). Crestal and intrasulcular incisions were made using a #15 blade (Miltex, Japan), and a buccal periosteal flap was reflected, leaving the lingual mucosal tissue undisturbed. Lingual mucosal tissue thickness was measured with a 1.0 mm marked periodontal probe from the bone crest at the center of the future implant placement. If indicated, lingual periosteal flap reflection and alveoloplasty were performed with a carbide bur (H21L, Komet, Rock Hill, SC) to level the alveolar ridge prior to implant placement. Osteotomy was performed following the manufacturer's recommendations, using the surgical stent as a guide.

The implants used in this study were 4.3 or 5.0 mm in diameter and at least 8 mm in length. They featured a tapered design with TiUnite surface, symmetric threads, and an internal conical connection (NobelReplace Conical Connection, Nobel Biocare, Yorba Linda, CA, USA). A one-stage implant surgery protocol was followed, and the implants were placed 1 mm subcrestally with a minimum insertion torque of 35 Ncm. The minimum distance

between the implant and the adjacent natural tooth was at least 1.5 mm, and between implants, at least 3 mm.

In the test group, definitive abutment (On1™ Base, Nobel Biocare, Yorba Linda, CA, USA) was randomly assigned to one of the implants, and were torqued to 35 Ncm as recommended by the manufacturer. A healing cap (On1™ Healing Cap, Nobel Biocare, Yorba Linda, CA, USA) was placed over the definitive abutment. In the control group, conventional healing abutment (Healing Abutment CC, Nobel Biocare, Yorba Linda, CA, USA) were hand-tightened onto another implant. The flaps were approximated to allow for non-submerged healing using resorbable polyglactin sutures (5-0 Vicryl Plus Antibacterial suture; Johnson & Johnson, Somerville, NJ, USA). Bite registration (Regisil, Dentsply Sirona Inc., Charlotte, NC, USA) mounted on a Rinn holder was used to create the custom jig for standardized radiographs. Baseline periapical radiographs were taken at implant placement.

Patients were advised to avoid functioning over the surgical sites for the first 3 weeks. A soft diet was recommended throughout the remaining healing period (16 weeks).

2.4 Data collection and outcome variables

All examinations and data collection were performed by three calibrated examiners (S.B, Y.C, Q.F). After implant placement, patients were recalled for follow-up appointments at 3 months, 6 months, and 12 months. During these follow-up visits, the healing caps (test group) and the healing abutments (control group) were disconnected and reconnected with hand torque. Clinical parameters and radiographic evaluations were performed and recorded at T0, and T12. The following parameters were recorded at the final follow-up appointment.

Implant success Rate

The overall implant success rate was assessed according to the 2017 classification criteria set by the American Academy of Periodontology (AAP). These criteria included factors such as the absence of pain, infection, mobility, and radiographic bone loss beyond acceptable

thresholds. Success was determined by the implant's ability to meet these clinical and radiographic standards over the course of the follow-up period.

Marginal bone loss (MBL) and marginal bone level changes (MBLC)

Standardized digital periapical radiographs (VistaScan, Durr Dental AG, Bietigheim-Bissingem, Germany) were taken at T0 and T12 using the long-cone paralleling technique and custom jig. The radiographs were exported as JPEG files and analyzed using ImageJ (ImageJ Imaging Software version 2.0, Bethesda, MD, USA). Mesial and distal MBL were assessed by measuring the distance between the implant platform and the first bone-to-implant contact at T0 and T12. The measurements were calibrated using the known implant length and were performed twice for each implant. MBLC was calculated as the difference in MBL measurements between T0 and T12. All measurements were performed by blinded and calibrated one examiner (S.B). Intra-examiner reproducibility was evaluated using double assessments on 10 randomly selected radiographs performed 2 months apart, with the intra-class correlation coefficient (ICC) indicating a strong correlation (ICC = 0.998).

Keratinized mucosa width

At implant surgery, after the connection of healing abutments in the control group and definitive abutments with healing caps in the test group, the flaps were approximated and sutured. The width of the keratinized mucosa was recorded from the mid-buccal aspect of the abutments using a 1.0 mm marked periodontal probe (PCP UNC-15, Hu-Friedy, Chicago, IL, USA). At the 1-year follow-up, measurements were taken at the same location before disconnection and reconnection of the healing abutments and healing caps.

Thickness of lingual mucosa

Lingual mucosa thickness was measured at implant surgery and at the 1-year follow-up appointment. The method used for evaluating lingual mucosa thickness was based on the technique described by Linkevicius et al.[49] At implant surgery, after crestal and intrasulcular

incisions, the buccal flap was raised while the lingual mucosa was not elevated to ensure direct visibility. Lingual mucosa thickness at each implant site was measured from the bone crest using a 1.0 mm marked periodontal probe (PCP UNC-15, Hu-Friedy, Chicago, IL, USA). At the 1-year follow-up, lingual mucosa thickness was measured from the definitive abutment platform and implant platform after disconnection of the healing cap and healing abutment, respectively.

Modified plaque index (mPLI)

Presence or absence of plaque was assessed and recorded at six sites around each implant (mesiobuccal, mid-buccal, distobuccal, mesiolingual, mid-lingual, and distolingual). Plaque assessment was performed with a periodontal probe following the criteria established by Mombelli et al.[48] Each site was assigned a score according to the following criteria:

- Score 0: No detection of plaque
- Score 1: Plaque only recognized by running a probe across the smooth marginal surface of the healing abutments or healing caps
- Score 2: Plaque visible to the naked eye
- Score 3: Abundance of soft matter

Modified sulcus bleeding index (mSBI)

The mSBI was evaluated and recorded at the same six sites as described for the mPLI assessment following the criteria established by Mombelli et al.[48] Each site was assigned a score according to the following criteria:

- Score 0: No bleeding observed when a periodontal probe is passed along the gingival margin
- Score 1: Isolated bleeding spots are visible
- Score 2: Blood forms a continuous red line along the gingival margin

- Score 3: Heavy or profuse bleeding is present

Surgical and prosthetic complications

Complications were recorded and included soft tissue issues, the incidence of peri-implantitis based on the 2017 classification criteria from the American Academy of Periodontology (AAP), and occurrences of prosthetic complications.

2.5 Statistical Analysis

Implant was considered the unit of analysis. MBLC at the mesial and distal aspect of the implant during 1-year follow-up was considered the primary outcome of this study. Descriptive statistics, including means and standard deviations, were calculated for mesial, distal, and overall MBLC, keratinized mucosa width changes, and lingual mucosa thickness changes across the test and control groups. The Shapiro-Wilk test was used to assess the normality of the data. When the assumption of normality was violated, non-parametric methods were utilized alongside traditional parametric tests. Specifically, paired samples t-tests were used to compare MBLC and soft tissue changes between the two groups. Wilcoxon signed-rank tests were conducted where normality assumptions were not met.

Correlation analyses were performed to explore relationships between all measured parameters, including MBLC, keratinized mucosa width changes, and lingual mucosa thickness changes. All statistical tests were two-tailed, with a significance level set at $p \leq 0.05$. Statistical analyses were conducted using R Statistics version 4.3.3 (The R Project for Statistical Computing, Vienna, Austria).

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