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ORIGINAL ARTICLE

Effect of the use of a ready-made plastic stent on the peri-implant soft tissue

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Abstract

Objective. This study compared the effect of the use of a ready-made plastic stent on the width of peri-implant keratinized mucosa with that of conventional methods and examined the effects of a plastic stent on peri-implant soft tissue. ***Materials and methods.*** Five young-adult beagle dogs were used. Forty titanium implants were placed in the mandibular alveolar ridge. Stage 2 surgery was performed 8 weeks after implant installation. Each dog received a full-thickness, apically positioned flap (fAPF) with a lingual crestal incision using a suture material in the control group ($n = 20$) and a ready-made plastic stent in the test group ($n = 20$). The keratinized mucosa width after stage 2 surgery was measured in each group. The pocket depth, length of connective-tissue contact and biological width were measured in the tissue samples. A student's *t*-test was used to test the differences between the groups (95% confidence level). ***Results.*** The width of the keratinized mucosa was significantly higher and the distance from the top of the implant platform to the mucogingival junction was significantly longer in the test group than the control group. Histometric observations revealed the pocket depth and biological width to be significantly lower in the test group than the control group. ***Conclusion.*** The use of a fAPF with a lingual crestal incision using a ready-made plastic stent can effectively preserve or enhance the width of the keratinized mucosa and might restore a more optimal biological environment at the early soft-tissue healing stage.

Key Words: *apically positioned flap, biologic width, dental implant, keratinized mucosa, ready-made plastic stent*

Introduction

The effects of oral keratinized mucosa on the implant survival rate are controversial. Several studies have reported no correlation between the long-term success rate of implants and the keratinized mucosa in peri-implant soft tissue [1–3], but other studies have reported that the keratinized mucosa affects the long-term success rate of implants [4,5]. This controversy has been attributed to the difficulty in conclusively defining the relationship between the keratinized mucosa and the long-term success rate of implants due to a range of confounding factors for the implant success rate [6]. Regardless of the aforementioned controversy, the presence and restoration of the peri-implant keratinized mucosa result in easier prosthetic procedures and improved esthetics [7,8]. Furthermore, many studies have suggested that keratinized mucosa and connective tissue attachment are essential for the successful management of peri-implantitis [4,9], resistance to gingival recession [1,10,11] and optimal plaque control [12–14]. For these reasons, a range of procedures have been used to increase the amount of keratinized mucosa upon implantation [15,16].

Apically or laterally positioned flap techniques are typical methods focusing on preserving the existing keratinized mucosa [17]. Free-gingival grafts might be used alternatively in cases of insufficient keratinized mucosa [18]. Occasionally, an apically positioned flap

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and free-gingival grafts are applied simultaneously in cases where there is a shallow oral vestibule and insufficient keratinized mucosa [19]. These methods, however, have the disadvantage of being too delicate for general dentists to perform.

To overcome these problems, a full-thickness, apically positioned flap (fAPF) with a lingual crestal incision was introduced to allow the apical positioning of the lingual keratinized mucosa as a pedicle in the buccal area [20]. This method has the advantage of being conducted easily by clinicians, but the disadvantage of it being difficult to obtain sufficient keratinized mucosa because the flap positioned at the buccal healing abutment is not fixed to the inferior and is displaced to the superior due to the tension of sutures along the flap. Therefore, many investigators have devised methods for moving the keratinized gingival flap from the lingual to the buccal and apical directions by fixing a ready-made plastic stent to the healing abutment.

To date, no clinical or histological evaluation has been conducted on the effect of the use of a stent fixed in the keratinized mucosa. In previous histology studies, the normal tissue biological width was reported to be 3–4 mm and the length of connective-tissue contact and mean pocket depth were reported to be 1–2 mm and 3 mm, respectively [10,12,21]. The use of a stent fixed in tissues is validated by observations of inflammatory cells, pocket depth and length of connective-tissue contact in tissue samples. In addition, few studies have examined methods using a stent, but no study has used animal experiments to validate the effects of a stent.

Therefore, this study compared the effects of the use of a ready-made plastic stent on the width of peri-implant keratinized mucosa with those of conventional methods. In addition, the effect of a plastic stent on peri-implant soft tissue was examined through histological observations.

Materials and methods

Design of the ready-made plastic stent

The stent used in our study, Louis Button, was produced by a domestic implant manufacturing firm (Louis Button®, Dentis Co., Daegu, South Korea). Figure 1 shows the type and specifications of the stent used in this study. The stent was made from polypropylene. The buccal and lingual wings pressing down the flap were 2 mm and 1 mm in size, respectively. The insertion part of the stent had a cylindrical form (diameter: 4.8 mm, height: 2 mm) that could hold the healing abutment by friction between the stent and healing abutment. Ready-made plastic stents were used in the test group and simple interrupted sutures were used in the control group. The results of both groups were compared (Figure 2).

Test animals

Five 1.5-year-old beagle dogs, weighing 12–15 kg and showing no evidence of periodontal diseases, were housed individually in cages under similar conditions. They were fed with commercially-available dog food (Hill's Pet Nutrition, Inc., Smyrna, TN) twice a day and given water *ad libitum*. Animal tests were conducted in accordance with the guidelines of the Institutional Animal Care and Use Committee (IACUC) at Chonnam National University (CNU IACUC-YB-R-2011-1).

Test and control group setting

In secondary implant surgery, 40 implants were placed in the five dogs using a procedure involving a fAPF with a lingual crestal incision. The stents were applied in the test group (20 implants), whereas simple interrupted sutures were applied to the control group (20 implants).

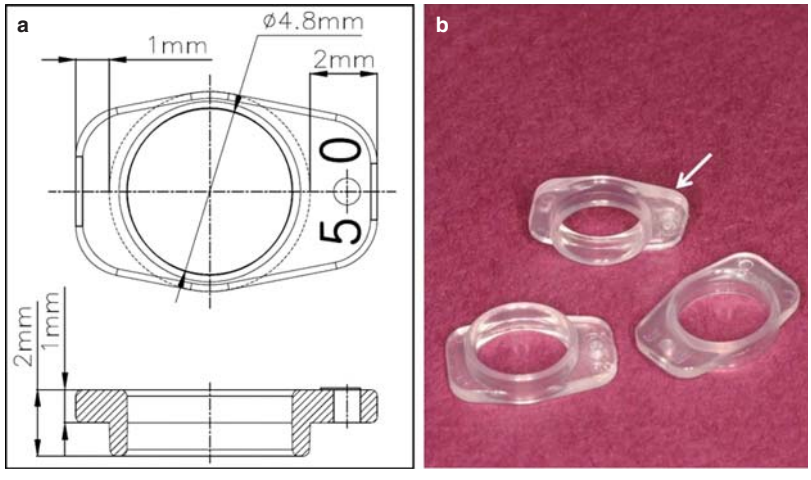

Figure 1. (a) Diagram of a ready-made plastic stent. (b) Photograph of a ready-made plastic stent. The body of the ready-made plastic stent holds the healing abutment, whereas the wing (white arrow) presses down the flap.

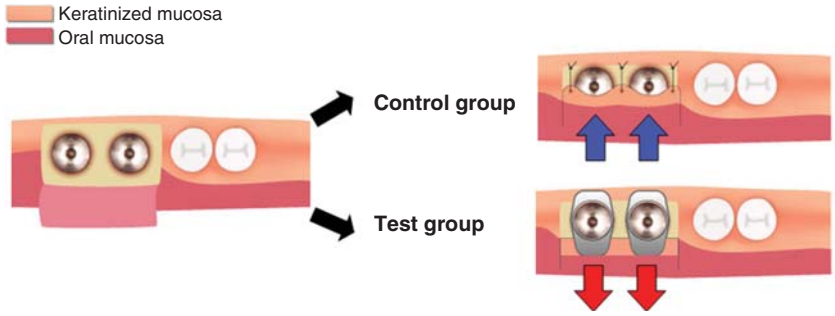

Figure 2. Comparison of both techniques. Control group: The labial flap has a tension due to the simple interrupted sutures in the fAPF with a lingual crestal incision. Therefore, the flap tends to extend coronally (blue arrow). Test group: Owing to the ready-made plastic stent in the fAPF with a lingual crestal incision, the dead space is eliminated and the mucogingival junction is displaced apically by the vertical pressure from the stent (red arrow).

Tooth extraction

For general anesthesia, medetomidine 48 μg/kg (Domitor®, Pfizer, Exton, Pennsylvania, USA), tiletamine/zolazepam 3 mg (Zoletil®, Virbac, Carros, France), and tramadol 5.4 mg/kg were injected intramuscularly for premedication, and 1–2% isoflurane (Aerane®, Ilsung Pharmaceutical Co., Seoul, South Korea) was used to maintain anesthesia. Cefazolin 20 mg/kg (Cefazolin®, Chongkundang Pharmaceuticals Co., Seoul, South Korea) was administered intravenously to prevent infection. The first, second, third and fourth mandibular premolars, first mandibular molar and first, second, third and fourth maxillary premolars were extracted. After local and infiltration anesthesia prior to extraction, the soft tissues around the teeth were dissected using a no. 15 surgical blade and the crown was cut with a high-speed handpiece. The teeth were extracted using an elevator and forceps. After tooth extraction, Carprofen (Rimadyl®, Pfizer) 2 mg/kg and amoxacilline 20 mg/kg were orally administered twice a day for 7 days and the oral cavity was disinfected with 0.12% chlorhexidine.

Stage 1 surgery

The soft and bone tissues healed completely 2 months after tooth extraction. Under general anesthesia, during tooth extraction, crestal incisions were made in both sides of the mandible and the implants were installed in the first, second, third and fourth premolar areas after elevating the fAPF. A total of eight tapered implants, 4.1 mm in diameter and 6 mm in length (batch no. 09J042, Dentis Co., Daegu, South Korea) were installed in the left and right regions (four implants for each region). Forty implants were installed in the five Beagle dogs. Each implant was connected using a cover screw and the flaps were sutured with 5-0 Gore-tex® (W. L. Gore & Associates, Inc., Flagstaff, AZ). Post-operative management was performed in the same manner as for tooth extraction.

Stage 2 surgery and the measurement of keratinized-mucosa width

Stage 2 surgery was conducted 8 weeks after stage 1 surgery. A crestal incision was made lingually, as far as possible, in the keratinized-mucosa region to obtain a more buccal keratinized mucosa. The cover screws were removed after the fAPF was formed and the healing abutments, 5 mm in diameter and 3 mm in height, were tightened. The width of the keratinized mucosa in the flap was measured at the mesiodistal mid-line of each implant. One lateral region was then fixed by pressing the buccal flap that had formed after fixing the stent to the healing abutment (test group) and the other lateral region was fixed with a simple interrupted suture using 3-0 black silk (control group) (Figure 3). The suture material and stent were removed from the healing abutment 1 week after stage 2 surgery.

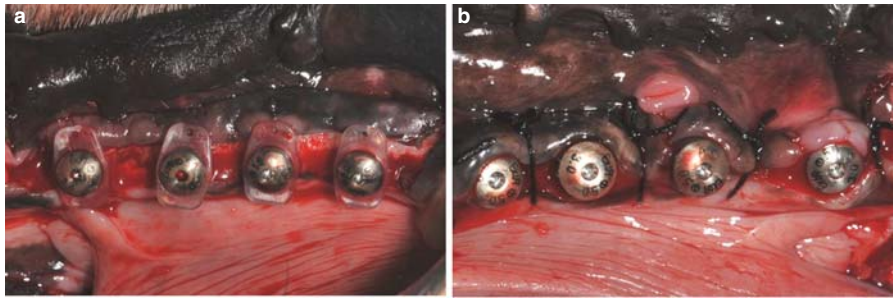

Figure 3. After stage 2 surgery: (a) The control group with simple interrupted sutures; and (b) The test group with ready-made plastic stents.

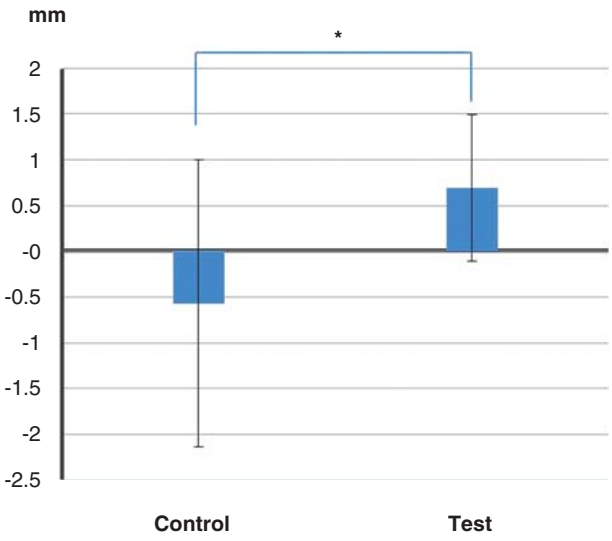

Figure 4. Changes in the keratinized mucosa width in both groups after gingival healing ($p < 0.05$).

Measurement of keratinized mucosa width and sacrifice of test animals

The keratinized mucosa width was measured at the buccal region of the mesiodistal mid-line of the implant 3 weeks after stage 2 surgery. Subsequently, all animals were sacrificed by CO_2 inhalation and fixed by perfusion using 10% paraformaldehyde (PFA). Tissue samples, including the implants, were prepared.

Clinical measurements

Measurements of the keratinized mucosa width immediately after stage 2 surgery. The flap formed after healing-abutment tightening was treated with iodine using a cotton stick and was washed with a saline solution. The keratinized mucosa was identified based on the fact that it was not stained with iodine. The keratinized mucosa width was measured using digital calipers. The distance from the apical region of the flap formed in the mesiodistal mid-line healing abutment of each implant to the mucogingival junction was measured.

Measurement of keratinized mucosa width after stage 2 surgery. Before sacrificing the animals 3 weeks after stage 2 surgery, the length of the buccal keratinized mucosa in the mesiodistal mid-line of the healing abutment of each implant (distance from the peripheral margin to the mucogingival junction and distance from the top of the implant platform to the mucogingival junction) was measured. The distance from the top of the implant platform to the mucogingival junction was measured using the following formula:

Distance from the top of the implant platform to the mucogingival junction = distance from the healing/abutment head margin to the mucogingival junction – healing/abutment height (3 mm).

Determination of the position of the mucogingival junction by setting the implant platform as a reference point. Keratinized mucosa is present in the crown region above the mucogingival junction, whereas the gingival mucosa is present in the apical region below the mucogingival junction. Therefore, the keratinized-mucosa width is determined by the location of the mucogingival junction. Since the mucogingival junction is generally set at the level of the implant platform upon measurements, the junction located below the implant platform is defined as having a positive value for the calculation and the junction located above the implant platform is defined as having a negative value. Therefore, a higher positive value means that the mucogingival junction is positioned more inferior to the implant platform.

Histometric analysis

The collected samples were fixed in neutral-buffered formalin (Sigma Aldrich, St. Louis, MO) for 2 weeks and dehydrated in a graded series of ethanol solutions. The samples were then embedded in Technovit 7200 resin (Heraeus KULZER, South Bend, IN). The embedded samples were sliced into ~400-μm-thick slices in the buccal direction, along the long axis of the implant using an EXAKT grinding machine (KULZER EXAKT 400CS, EXAKT) to obtain tissue samples of the central implants. Subsequently, 30-μm-thick samples were finally prepared using an EXAKT diamond cutter (KULZER EXAKT 300, EXAKT, Norderstedt, Germany). The samples were stained by hematoxylin-eosin (H-E) staining and digital images were obtained using an optical microscope (Olympus BX, Tokyo, Japan) equipped with a CCD camera (Polaroid DMC2 digital-microscope camera, Polaroid Corporation, Cambridge, MA). The stored images were measured using SPOT Software V4.0 (Diagnostic Instrument, Inc., Sterling Heights, MI). The pocket depth, length of connective-tissue contact and biological width in the tissue samples were measured.

Statistical analysis

The mean and standard deviation of the values were calculated and a Student's *t*-test was used to test the differences in the values between the control and test groups. All statistical analyses were conducted at the 95% confidence level.

Results

Changes in the keratinized-mucosa width after recovery

The keratinized mucosa width after stage 2 surgery was 3.61 ± 1.08 mm and 3.64 ± 1.02 mm in the test and control group, respectively. Three weeks after stage 2 surgery, the keratinized mucosa width was

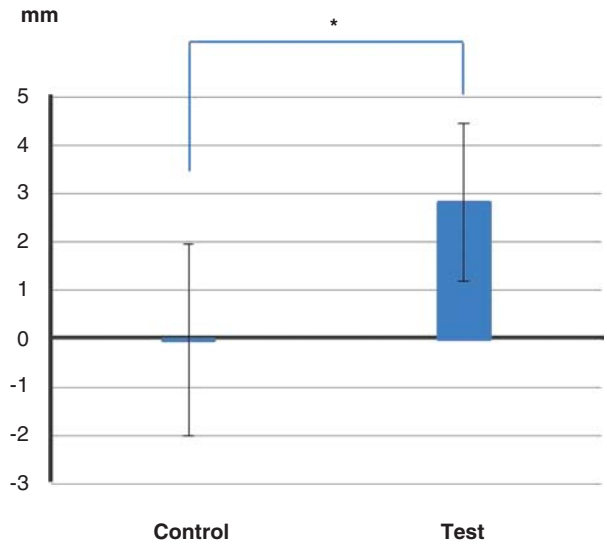

Figure 5. Distance from the top of the implant platform to the mucogingival junction in both groups ($p < 0.05$).

0.69 ± 0.80 mm in the test group, showing an increasing tendency and −0.57 ± 1.57 mm in the control group, showing a slightly decreasing tendency. The differences between both groups were statistically significant (Figure 4).

Position of the mucogingival junction when the implant platform was set as a reference point

The position of the mucogingival junction when the implant platform was set as the reference point in the test and control group was 2.83 ± 1.64 mm below the implant platform and −0.02 ± 1.99 mm above the implant platform, respectively (Figure 5).

Histometric analysis of the peri-implant tissues

Three indices of the peri-implant tissues were obtained and analyzed in the tissue samples, as shown in Figure 6. Of these three indices, the pocket depth and biological width were significantly lower in the test group than the control group. Table I lists the means and standard deviations.

Discussion

This study compared the keratinized mucosa width obtained from a method using a stent with that obtained from the conventional method and evaluated their histopathological effects on the gingival tissue.

A keratinized gingiva width of ≥2 mm was found to be essential for maintaining healthy soft tissues around the natural teeth [22]. A gingival attachment of ≥1 mm was found to be optimal [7]. Similar conditions are required in peri-implant keratinized tissues as in natural teeth [13]. On the other hand, the keratinized tissue width might not be an absolute requisite for tissue suitability [23]. The appropriate amount of attached gingiva was considered along with the patient's age, oral care ability, esthetic aspects and patient expectation [24]. Despite the controversy regarding the necessity of keratinized mucosa, the presence of peri-implant keratinized mucosa makes the prosthetic procedures easier, improves the esthetic outcomes and is advantageous over a gingivitis treatment [8,9]. A range of techniques have been used to increase the keratinized mucosa, but such techniques have the disadvantages of causing adverse events, such as post-operative pain or bleeding, and being technically difficult for clinicians.

Meanwhile, the procedure incorporating a fAPF with a lingual crestal incision is frequently used to have lingual keratinized mucosa apically positioned as a pedicle flap in the buccal area and to increase the buccal keratinized mucosa due to its simple approach, high predictability and few adverse events [25]. In addition, increased keratinized mucosa can be achieved using this approach. Although this method can be conducted easily by clinicians, it can produce a significant amount of keratinized mucosa from the lingual region, which becomes free gingiva due to failed attachment to the alveolar bone. The flap obtained by this method was not fixed to the inferior region but was displaced to the occlusal surface due to tension of the suturing materials generated by the longer flap positioned at the buccal healing abutment. Therefore, a ready-made plastic stent was used instead of the conventional method using suturing materials. This stent reduced the dead space and helped form stable keratinized mucosa anchored to the alveolar bone. This was achieved by pressing the keratinized mucosa mobilized from the lingual region in the buccal and apical directions while fixing the flap by inserting the stent into the healing abutment without sutures. In clinical practice, this method has the advantages of positioning the existing buccal keratinized mucosa flap in the buccal and apical directions, maintaining the position, tightly anchoring the flap to the top of the apically located periosteum and preventing the contraction or reduction of keratinized mucosa. In particular, this method is a very simple procedure because there is no need to suture, less ingestion of food due to the incomplete covering of the operated site with the stent after stage 2 surgery and less pain [26].

In the present study, after stage 2 surgery, the keratinized mucosa width was greater in the test group than in the control group. The mucogingival junction was located more apically from the implant platform. The mucogingival junction was measured from the implant platform because the implant platform is constant, unlike other tissues, which are changeable and cannot be used as a reference point, and the mucogingival junction is generally positioned apically to the implant platform in clinical situations. Furthermore, the length of the fixed keratinized mucosa positioned apically to the implant platform might

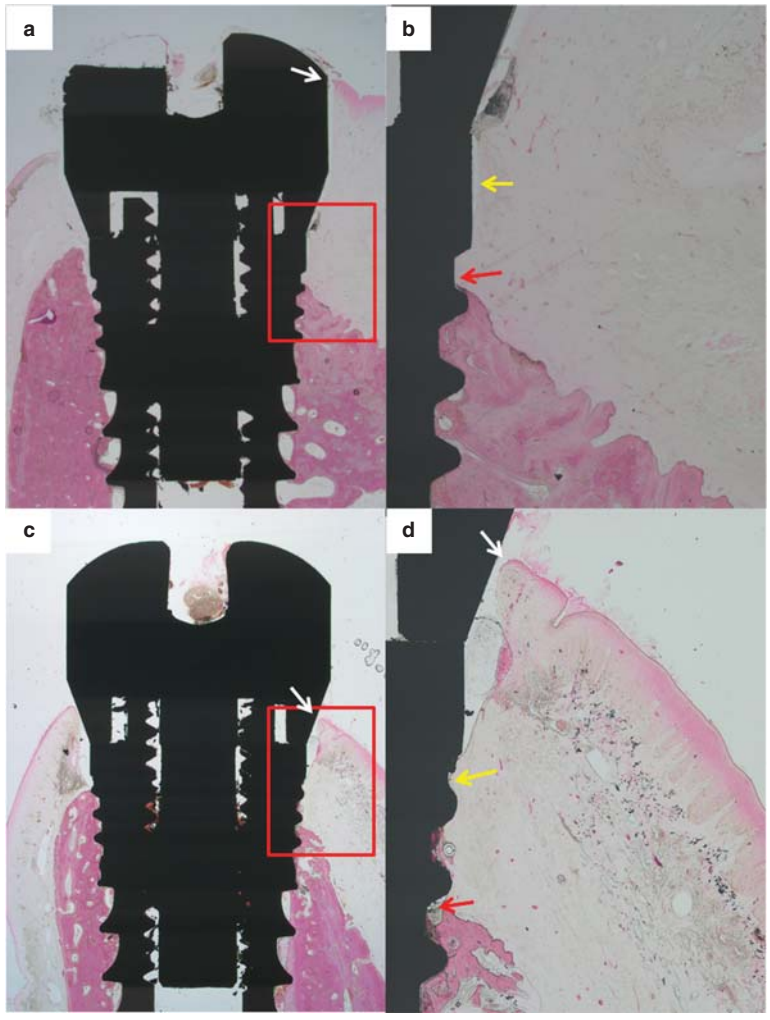

Figure 6. Buccal aspect of the histology section (hematoxylin and eosin stain). a) Histology section in the buccolingual direction in the control group (×12.5); (b) High-power view of the apical extension of the peri-implant epithelium in the control group (×40). (c) Histology section of a sample obtained from the test group (×12.5). (d) Histology section of a sample obtained from the test group (×40). Pocket depth and biological width were lower in the test group than in the control group. (White arrow: marginal portion of mucosa, yellow arrow: apical portion of the juctional epithelium, red arrow: first bone-implant contact.)

have clinical implications because keratinized mucosa positioned superior to the implant platform generally has free gingiva that is not attached to the alveolar bone. Since keratinized mucosa was positioned more apically in the test group than in the control group, it is possible that this method can increase keratinized mucosa attached to the alveolar bone.

In the present study, three indices of peri-implant tissues were measured, as shown in Figure 4, and when the values obtained from both groups were compared, pocket depth and biological width were lower in the test group than in the control group. The biological width represents the soft-tissue barrier that protects bone tissue and was reported to be 3–4 mm without inflammation in normal implants [21,27]. This value is constantly maintained through gingiva contraction despite bone loss after implant restoration [28,29]. In the current study, the mean biological width was 4 mm and 6 mm in the test and control group, respectively. This suggests that the biological width was maintained in the test group but not in the control group. A previous study reported that the mean peri-implant pocket depth was 3 mm [10]. In the present study, the mean pocket depth in the test and control group was 2.98 mm and 4.88 mm, respectively; a normal pocket depth was observed in the test group. Pseudo-pockets formed around the control implants after flap adaptation around the healing cap.

Table I. Mean ± SD (mm) of each parameter in the control and test groups ($p < 0.05$): pocket depth, length of connective-tissue contact and biological width.

	Control group	Test group	*p*
Pocket depth	4.88 ± 1.67	2.98 ± 1.66*	0.00
Connective tissue	1.21 ± 0.68	1.19 ± 0.75	0.94
Biologic width	6.09 ± 1.52	4.08 ± 0.14*	0.00

*$p < 0.05$ compared with the control group.

This study has a limitation in that the clinical measurements were performed at a single time point (3 weeks after stage 2 surgery). Nevertheless, this study examined the effect of the use of a stent on peri-implant tissues. Further comparative studies at various time points will be needed to confirm these results. Although the use of a stent is sometimes restricted due to insufficient fixation of the stent or oral hygiene difficulties, it was effective in securing sufficient keratinized mucosa and stabilizing the peri-implant tissues.

Conclusion

The use of a ready-made plastic stent in full thickness, positioned flap apically through a lingual crestal incision resulted in the preservation of or increase in the keratinized mucosa width compared to that using the conventional technique. In particular, this technique was effective in restoring the peri-implant tissues by reconstituting the appropriate biological width and pocket depth after surgery.

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***Declaration of interest*:** The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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