The effects of soft tissue punch size on the healing of peri-implant tissue in flapless implant surgery

Du-Hyeong Lee

Department of Medicine

The Graduate School, Yonsei University

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Directed by Professor Seung-Mi Jeong

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Du-Hyeong Lee

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This certifies that the Master's thesis of Du-Hyeong Lee is approved.

Thesis Supervisor: Prof. Seung-Mi Jeong

Thesis Committee Member #1: Prof. Byung-Ho Choi

Thesis Committee Member #2: Prof. Mee-Yon Cho

The Graduate School

Yonsei University

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감사의 글

이 논문이 완성되기까지 학위 과정뿐 아니라 여러 면에서 부족한 저를 이끌어 주시고 격려와 세심한 조언을 주신 정승미 교수님께 항상 고마움 느끼고 깊은 감사를 드립니다. 또한 처음으로 연구를 알게 하시고 학문적 기틀을 잡아 주셨으며 은혜의 소상한 가르침을 베풀어 주셨던 최병호 교수님께 진심으로 감사드립니다. 또한 논문 작성과 심사에 귀중한 조언과 격려를 해주신 조미연 교수님께도 깊은 감사를 드립니다. 항상 따뜻한 관심으로 지도해 주시는 유재하 교수님, 정원균 교수님, 이정섭 교수님, 김지훈 교수님께도 감사드립니다.

지난 2년여 동안 같이 논문 실험을 하며 많은 수고를 아끼지 않은 현봉 선생님께 무한한 감사를 드리며, 힘이 되며 의지가 되었던 유지현 선생님, 최형준 선생님, 설성한 선생님, 서국미 선생님께도 감사를 드립니다. 또한 힘든 수련 생활 속에서도 곁에서 옆에서 삶을 나누었던 잊을 수 없는 의국 식구들, 인턴 선생님들 및 직원들에게도 감사의 마음을 전합니다.

끝으로 이 모든 일을 허락하시고 인도하신 하나님께 감사드리며 마지막으로 항상 형언할 수 없는 사랑으로 아들을 믿고 걱정해 주시는 부모님과 형에게 마음을 담아 이 논문을 바칩니다.

2009년 6월

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The effects of soft tissue punch size on the healing of peri-implant tissue in flapless implant surgery

Du-Hyeong Lee

Department of Medicine

The Graduate School, Yonsei University

(Directed by Professor Seung-Mi Jeong, D.D.S., Ph.D.)

Objective. Flapless implant surgery using a soft tissue punch device requires a circumferential excision of the mucosa at the implant site. In an attempt to help produce guidelines for the use of soft tissue punches, this animal study was undertaken to examine the effect of soft tissue punch size on the healing of peri-implant tissue in a canine mandible model.

Study design. Bilateral, edentulated, flat alveolar ridges were created in the mandibles of six mongrel dogs. After a three month healing period, three fixtures (diameter, 4.0 mm) and healing abutments(diameter, 4.5 mm) were placed on each side of the mandible using 3 mm, 4 mm and 5 mm soft tissue punches. During subsequent healing periods, the peri-implant mucosa was evaluated using clinical, radiological, and histometric parameters, which included Gingival Index, bleeding on probing, probing pocket depth, marginal bone loss, and vertical dimension measurements of the peri-implant tissues.

Results. The results showed significant differences ($P < 0.05$) between the 3 mm, 4 mm, and 5 mm tissue punch groups for the length of the junctional epithelium, probing depth, and marginal bone loss at healing period after implant placement. When the mucosa was punched with a 3 mm tissue punch, the length of the junctional epithelium was shorter, the probing depth was shallower, and less crestal bone loss occurred than when using a tissue punch with a diameter ≥ 4 mm.

Conclusion. Within the limit of this study, the size of the soft tissue punch plays an important role in achieving optimal healing. Our findings support the use of tissue punch slightly narrower than the implant itself to obtain better peri-implant tissue healing around flapless implants.

Key-words: dental implant, flapless, tissue punch, peri-implant tissue

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Ⅰ. Introduction

With the rapid progress of implant therapeutics, the current issue is more geared toward enhancing esthetics. Similar to teeth, the soft tissue stability around implant is an important factor to achieve optimal esthetic outcomes of the restoration.[1] Thus, soft tissue change around peri-implant region such as papilla height and gingival level are major esthetic concerns, and plenty of scientific works focusing on this fields of study.[2,3]

In the latter half of the 1970s, Schröeder et al. mentioned that a non-submerged or one-stage surgical procedure with a transmucosal implant placement at the first surgery.[4] The fact that only one surgery is necessary enable transmucosal portion of the soft tissue to be healed by primary intention from the time of implant placement, enhancing successful tissue integration.[5-8] Moreover, less surgical intervention via one-stage surgical approach can significantly improve patient comfort, satisfaction, and acceptance. So one-stage surgical procedure is attractive alternative to the Bränemark's two-stage approach.[9,10]

Surgical technique is directly related to healing and morphologic change of soft tissue. Implant surgery can be divided to flap or flapless surgery whether to elevate soft tissue flap, and in flapless surgery, soft tissue punch can be utilized to uncover bone. The punch technique is a simple method to make circumferential incision. After implant placement, healing abutments are immediately connected to the fixtures so that the coronal portions of the abutments remain exposed in the oral cavity. Within this approach, there is no discontinuation of the alveolar blood supply of the surrounding tissue.[11] Soft tissue punches have demonstrated promise as a means of preserving the soft tissue architecture, shortening treatment time, and minimizing scarring of the peri-implant tissues.[12]

To date, Although there have been several reports on clinical outcomes of flapless implant surgeries, there are no published reports that address the appropriate size of the soft tissue punch for peri-implant tissue healing. To help produce guidelines for the use of soft tissue punches, this animal study was undertaken to examine the effect of different soft tissue punch sizes on peri-implant tissue healing in a canine mandible model.

Ⅱ. Materials and Methods

1. Animal model

Six adult female mongrel dogs, each weighing more than 15 kg (range, 15-20 kg), were used in this experiment. The protocol was approved by the Animal Care and Use Committee of the Wonju Christian Hospital, Yonsei University, Wonju, Korea.

2. Edentulated flat ridge induction

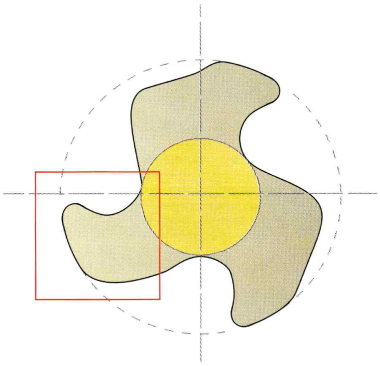
All surgical procedures were performed under systemic (5 mg/kg ketamine and 2 mg/kg xylazine) and local (2% lidocaine with 1:80,000 epinephrine) anesthesia. All mandibular premolars were removed to establish space for the implants. After one month of healing, bilateral, flat and edentulous alveolar ridges were surgically produced. Briefly, a mucoperiosteal flap was raised to expose the alveolar bone. Burs were used to flatten the alveolar crest under sterile saline irrigation such that an appropriate width of bone would be available for implant placement. The mucoperiosteal flap was replaced and sutured, and the resulting edentulated, flat, alveolar ridge was allowed to heal for three months.

3. Implantation procedure

Three fixtures from an Osstem Implant System (GSⅡ, Osstem, Seoul, Korea; length 10 mm, diameter 4.0 mm) were placed within the edentulated ridge on each side of the mandible in all six dogs. The soft tissue of the implant site was pierced with 3 mm, 4 mm and 5 mm tissue punches (Fig 1). To minimize the possibility of tissue injury, in our experiment, modified drills that had only 0.5 mm cutting edge at the terminal portion and a blunted edge at other portions of the drill were utilized. This resulted in minimal harmful irritation to adjacent tissue upon drilling(Fig 2A, B). Immediately after these tissue punches(Fig 3), the fixtures were placed as recommended by the manufacturer. After placing the fixtures, a 4.5 mm permucosal healing abutment was connected to the fixture so that the coronal portion of the abutment remained exposed to the oral cavity (Fig 4). Care was taken to place the three fixtures at the same height and to avoid perforation of both the lingual and buccal cortical plates. Antibiotic therapy was administered one hour before surgery and once daily for two days following the surgery. The exposed implant surfaces were cleansed daily with a soft toothbrush and 0.12% chlorhexidine digluconate-soaked gauze. The dogs were placed on a soft diet. Healing abutment loosening can occur and affect soft tissue parameters. Thus, careful observation on screw loosening was taken periodically.[13-15] Clinical evaluation was performed during healing periods.

Figure 1. Soft tissue punches 3 mm, 4 mm and 5 mm in diameter.

(A)



(B)

Figure 2. Clinical photograph of a drill that has only 0.5 mm cutting edge at terminal portion and a blunted edge at other portion (A) and diagram of cross section (B).

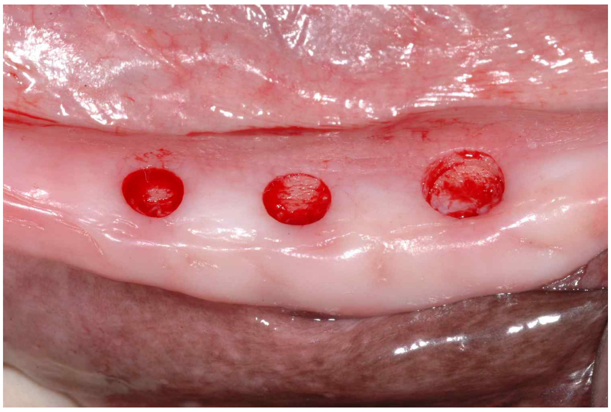


Figure 3. Clinical feature immediately after punching using 3 mm, 4 mm and 5 mm tissue punches.

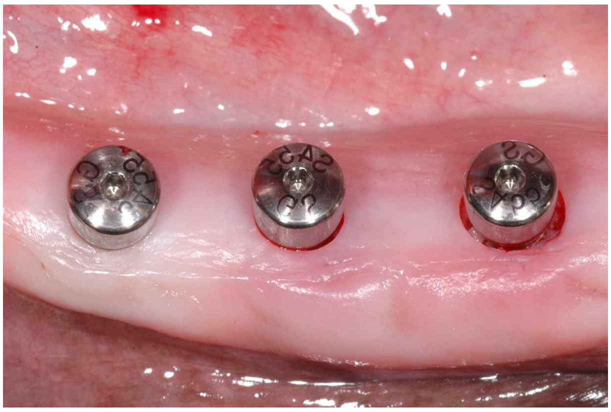


Figure 4. Clinical feature after placing a 4 mm fixture and a 4.5 mm permucosal healing abutment.

4. Clinical evaluation

One clinician performed the clinical evaluation, which involved measuring marginal gingiva morphology, soft tissue level, the probing pocket depth, assessing the Gingival Index(GI), and recording the presence of bleeding on probing(BOP). The first outcome variable for this study was the change of marginal gingival morphology after healing abutment connection. Gingival morphology was evaluated clinically by classifying its shape. An index score of 1 was assigned when the shape was concave; 2 when flat; 3 when convex(Fig 5). The change of soft tissue level was evaluated using a digital analysis. First of all, intraoral photos were taken of all abutments at each measurement time. To endow the same digital plane in each model, identical shooting angle was maintained. And then, these digitalized images were transferred to a computer program to compare the change of soft tissue level. Using this program, the change of marginal gingival level that was adjacent to implant was measured using 5x magnification. The measurements were made at the buccal aspects of each abutment and the mean value for the case was calculated. The tissue level apical to the baseline was recorded as positive, whereas a negative value was given when the tissue level is coronal to the reference(Fig 6). Pocket depths were measured using probes (PDT Sensor® probes, Zila Inc., Arizona, USA) with a probing force of 0.2 N. The mean pocket probing depth for each implant site was obtained from averaging measurements taken at four sites around each implant(Fig 7).

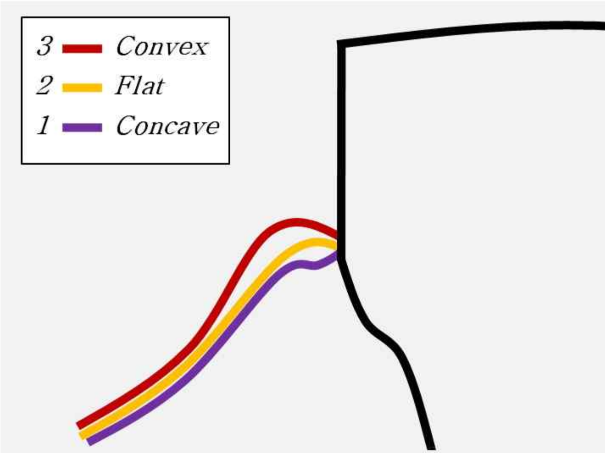


Figure 5. Diagram for classifying morphology of marginal gingiva.

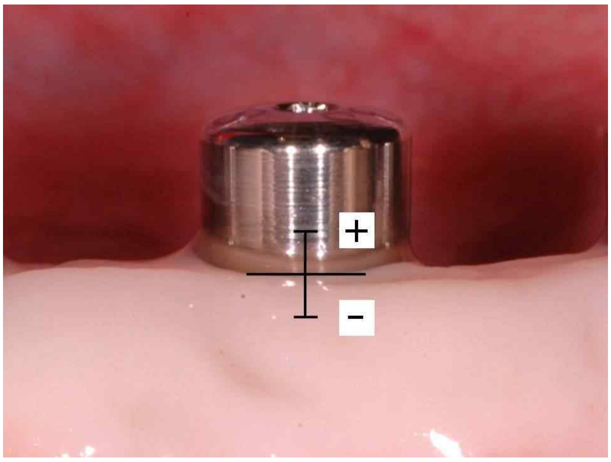


Figure 6. Measurement of level of the marginal gingiva at buccal side of the abutment.

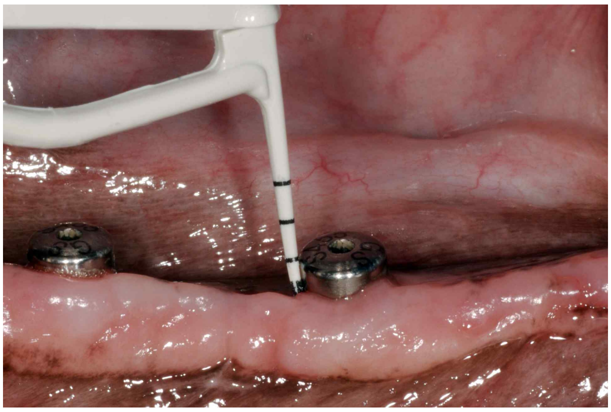


Figure 7. Clinical feature of measuring pocket depths using probes with a probing force of 0.2 N

5. Radiographic evaluation

To assess postsurgical changes in the crestal bone level, conventional dental x-rays were taken immediately and every weeks after implant placement. The images were digitized, and the distance between the fixture shoulder and apical level of the marginal bone in contact with the implant was measured using 8x magnification and the implant height (a known measurement) for calibration. Measurements were made at the mesial and distal aspects of each fixture, and the mean for each case was calculated. All measurements were performed by two examiners with no knowledge of the methods used in the study; when examiners disagreed, the values were rechecked and discussed until an agreement was reached.

6. Histometric analysis

After a healing period of three months, the dogs were sacrificed and bone blocks containing the implants were excised. The resected bone specimens were fixed in 10% buffered formalin and placed in an ethyl alcohol for three days to begin the dehydration process. After this process, the implants were embedded in light cure resin and cut parallel to the implant axis in a buccolingual plane. histological sections (40 μm) were stained with toluidine blue. A histometric analysis was performed to assess the vertical dimension of the peri-implant tissues. The following landmarks were used to make the linear measurements: PM − the marginal position of the peri-implant mucosa, aJE − the apical termination of the junctional epithelium, and B − the marginal level of bone to implant contact(Fig 8). The distances between these landmarks were determined using an image analysis system (IBAS, Contron, Erching, Germany).

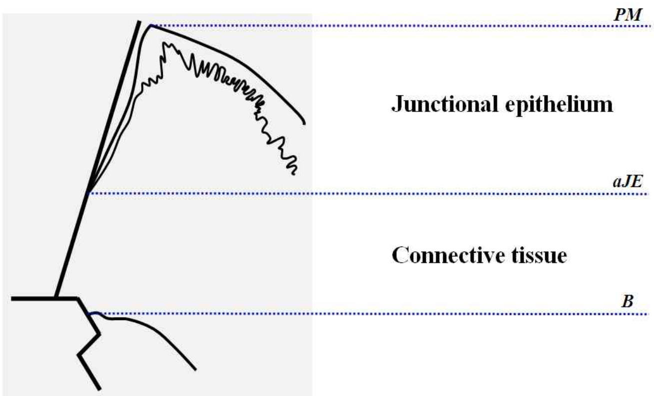


Figure 8. Diagram for histometric analysis

PM – the marginal position of the peri-implant mucosa, aJE – the apical termination of the junctional epithelium, B – the marginal level of bone to implant contact

7. Statistical analysis

The data obtained were processed with a statistical software package (SPSS for Windows, Chicago, IL, USA). Data were analyzed using the Wilcoxon signed rank test for comparison between two different time points. Kruskal-Wallis test was used to calculate significant differences between three different groups. A P-value < 0.05 was considered statistically significant.

Ⅲ. Results

1. Soft tissue punch size affects marginal gingiva morphology at early healing period.

In regards to marginal gingiva morphology around the healing abutments, the difference between the groups was significant at 0, 0.5 and 1 week(Table 1, Fig 9). The groups that punch size is smaller than abutment size(3, 4 mm tissue punch size group) demonstrated convex profile of marginal gingiva, the group that punch size is larger than abutment size(5 mm tissue punch size group) showed concave profile of marginal gingiva at initial healing period($P<0.05$). However, the marginal gingival shape between the groups became similar and was no longer significant in all groups at postoperative 2 weeks and thereafter.

Table 1. Marginal gingiva morphology

	3 mm group	4 mm group	5 mm group	*P-values*
0 week	3.0 ± 0.0	2.3 ± 0.5	1.0 ± 0.0	<0.05
0.5 week	2.3 ± 0.5	2.2 ± 0.4	1.5 ± 0.5	<0.05
1 week	2.2 ± 0.4	2.0 ± 0.3	1.7 ± 0.5	<0.05
2 weeks	2.0 ± 0.0	2.0 ± 0.0	2.0 ± 0.0	>0.05
3 weeks	2.0 ± 0.0	2.0 ± 0.0	2.0 ± 0.0	>0.05
6 weeks	2.0 ± 0.0	2.0 ± 0.0	2.0 ± 0.0	>0.05
12 weeks	2.0 ± 0.0	2.0 ± 0.0	2.0 ± 0.0	>0.05

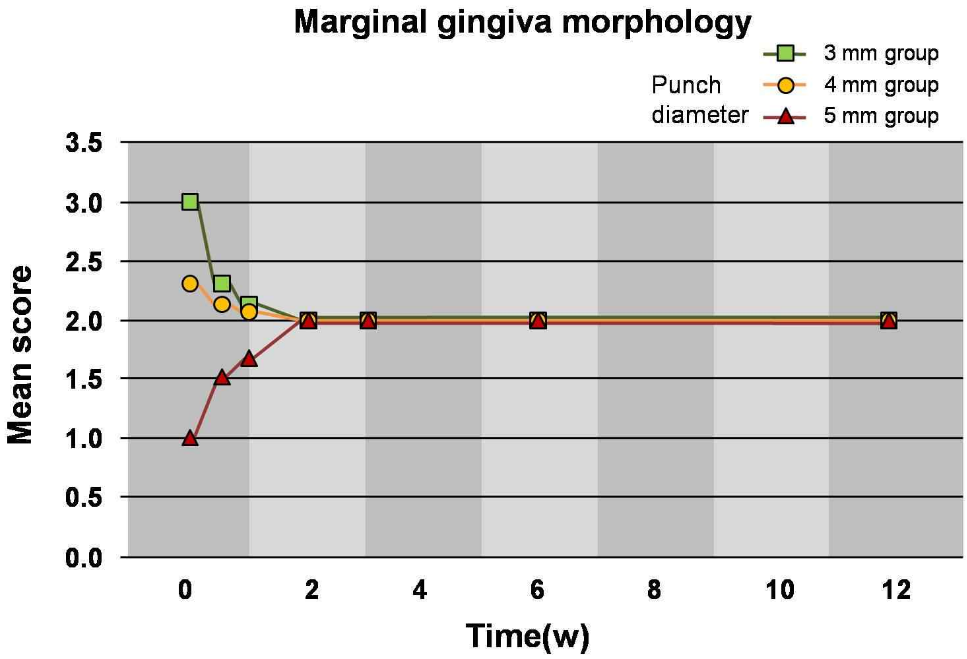


Figure 9. Graph of change of the marginal gingiva morphology

2. The smaller soft tissue punch size decreases the change of soft tissue level.

The longitudinal soft tissue measurements taken at each time points. In general, The mean values of all buccal sites around the implants showed coronal growth at the first 2 weeks, and then went down gradually. There were significant differences in soft tissue level between groups at each time point and over time in each group(Table 2, Fig 10). The mean level of 3 mm tissue punch group was 0.4 ± 0.1 mm at 2 weeks and 0.0 ± 0.2 mm at 12 weeks. On the other hand, the mean level in 5 mm tissue punch group were 1.1 ± 0.4 mm and -0.5 ± 0.7 mm at 2 weeks and 12 weeks, respectively. Namely, the soft tissue level around implant incised 3 mm tissue punch remained more stable over time.

Table 2. Soft tissue level : Buccal

	3 mm group	4 mm group	5 mm group	*P-values*
0 week	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	>0.05
0.5 week	0.4 ± 0.1	0.4 ± 0.2	0.6 ± 0.2	>0.05
1 week	0.5 ± 0.1	0.8 ± 0.2	0.9 ± 0.2	<0.05
2 weeks	0.4 ± 0.1	0.9 ± 0.3	1.1 ± 0.4	<0.05
3 weeks	0.2 ± 0.1	0.4 ± 0.2	0.5 ± 0.2	<0.05
6 weeks	0.1 ± 0.1	0.2 ± 0.2	0.2 ± 0.4	>0.05
12 weeks	0.0 ± 0.2	-0.3 ± 0.2	-0.5 ± 0.7	>0.05

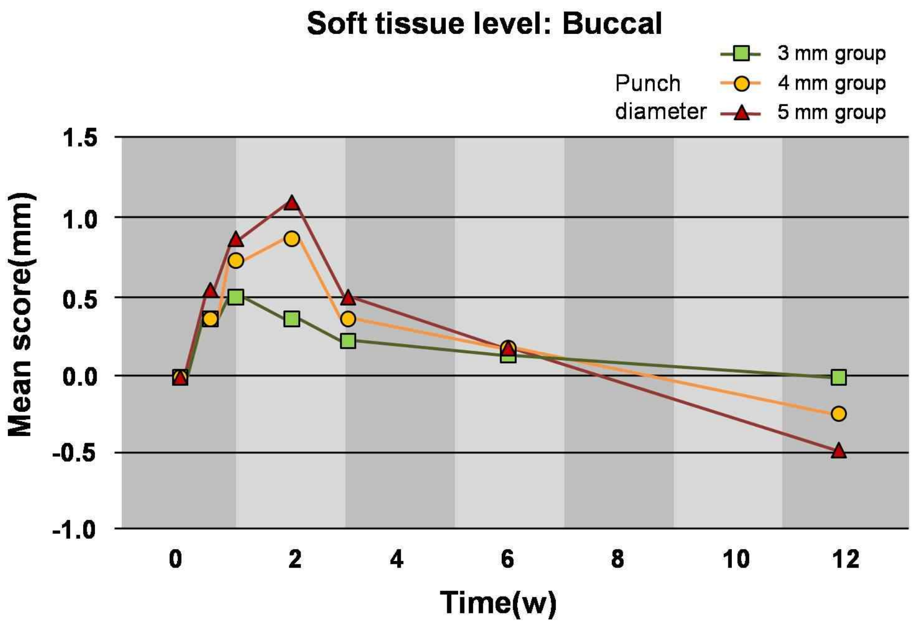


Figure 10. Graph of change of the soft tissue level

3. The smaller soft tissue punch size increases both gingival index and probing depth.

The average gingiva index in the 3 mm tissue punch group was low at initial healing stage, resolved to 0 at 2 weeks and remained stable for up to 12 weeks. However, in the 4, 5 mm punch groups, GI score was unfavorable at early stage and healing process was slow. The average GI score in all groups continuously generally decreased throughout the study, but its aspect were significantly different between groups(Table 3, Fig 11) Mean GI score in 3 mm punch group was 0.0 ± 0.0 and 0.0 ± 0.0 after three weeks and three months, respectively; for the 4 mm punch group the corresponding values were 0.2 ± 0.7 and 0.1 ± 0.1 after three weeks and three months, respectively. Finally, for the 5 mm punch group the corresponding values were 0.5 ± 0.5 and 0.2 ± 0.5. There were statistically significant differences (P <0.05) between groups after three weeks (Fig 12A); however, no statistically significant difference (P >0.05) was found in the inter-group comparison after three months (Fig 12B).

The average BOP index in the 3 mm punch group was 0.3 ± 0.5 and 0.1 ± 0.3 after three weeks and three months, respectively. The corresponding values in the 4 mm and 5 mm punch groups were 0.4 ± 0.5 and 0.2 ± 0.4, and 0.9 ± 0.7 and 0.3 ± 0.5 (Table 3). There were statistically significant differences (P <0.05) within groups; however, no statistically significant difference (P >0.05) was found between groups.

Table 3. Clinical and radiological parameters

	3 mm group	4 mm group	5 mm group	*P-values*
Probing depth (mm)				
3 weeks	1.6 ± 0.5	1.9 ± 0.7	2.2 ± 0.5	<0.05
6 weeks	1.5 ± 0.7	1.8 ± 0.4	2.0 ± 0.6	<0.05
12 weeks	1.2 ± 0.6	1.6 ± 0.7	1.8 ± 0.6	<0.05
Gingival index (GI)				
0 week	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	>0.05
0.5 week	0.2 ± 0.4	0.7 ± 0.5	1.3 ± 0.9	<0.05
1 week	0.1 ± 0.3	0.6 ± 0.5	0.9 ± 0.8	<0.05
2 weeks	0.0 ± 0.0	0.5 ± 0.5	0.8 ± 0.4	<0.05
3 weeks	0.0 ± 0.0	0.2 ± 0.7	0.5 ± 0.5	<0.05
6 weeks	0.0 ± 0.0	0.0 ± 0.0	0.4 ± 0.5	>0.05
12 weeks	0.0 ± 0.0	0.0 ± 0.0	0.2 ± 0.5	>0.05
Bleeding on probing				
3 weeks	0.3 ± 0.5	0.4 ± 0.5	0.9 ± 0.7	>0.05
6 weeks	0.1 ± 0.3	0.1 ± 0.3	0.6 ± 0.7	<0.05
12 weeks	0.1 ± 0.3	0.2 ± 0.4	0.3 ± 0.5	>0.05
Crestal bone loss				
0 week	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0	>0.05
1 week	0.0 ± 0.1	0.1 ± 0.1	0.2 ± 0.1	<0.05
2 weeks	0.2 ± 0.1	0.3 ± 0.2	0.4 ± 0.2	<0.05
3 weeks	0.2 ± 0.1	0.5 ± 0.3	0.6 ± 0.3	<0.05
6 weeks	0.3 ± 0.1	0.6 ± 0.4	0.7 ± 0.6	<0.05
12 weeks	0.3 ± 0.1	0.6 ± 0.5	0.7 ± 0.5	<0.05

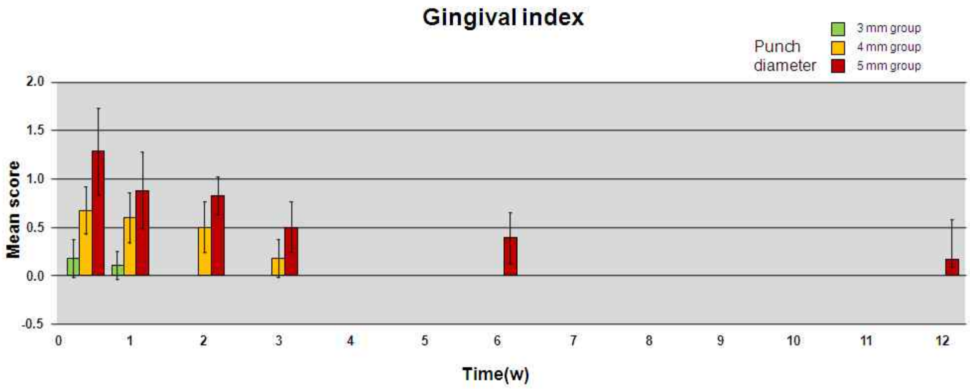
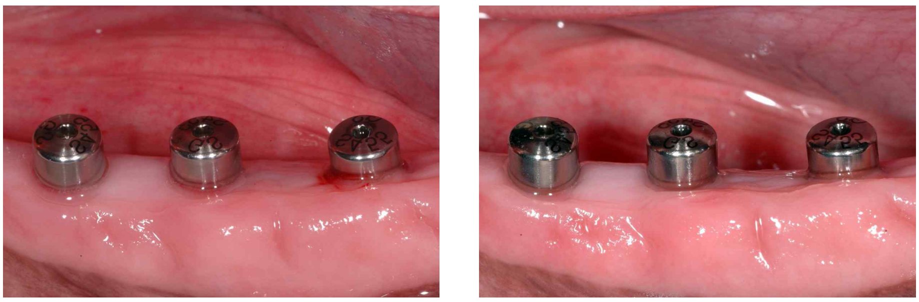


Figure 11. Graph of change of gingival index



3 mm 4 mm 5 mm 3 mm 4 mm 5 mm

(A) (B)

Figure 12. Clinical photograph of the implants at 3 weeks (A) and 12 weeks (B) after implant placement.

4. The smaller soft tissue punch size reduces crestal bone loss around implant.

Radiographic evaluations confirmed a various amount of crestal bone loss in each group during healing process(Table 3). A significant difference in bone loss between the different soft tissue punch groups was noted and the amount of bone loss increased with increasing diameter(Fig 13, 14). The average bone loss in the 3 mm punch group was 0.2 ± 0.1 mm and 0.3 ± 0.1 mm after three weeks and three months, respectively. The corresponding values for the 4mm punch group were 0.5 ± 0.3 and 0.6 ± 0.5. The corresponding values for the 5 mm punch group were 0.6 ± 0.3 and 0.7 ± 0.5. There were statistically significant differences (P <0.05) for the intra- and inter-group comparisons.

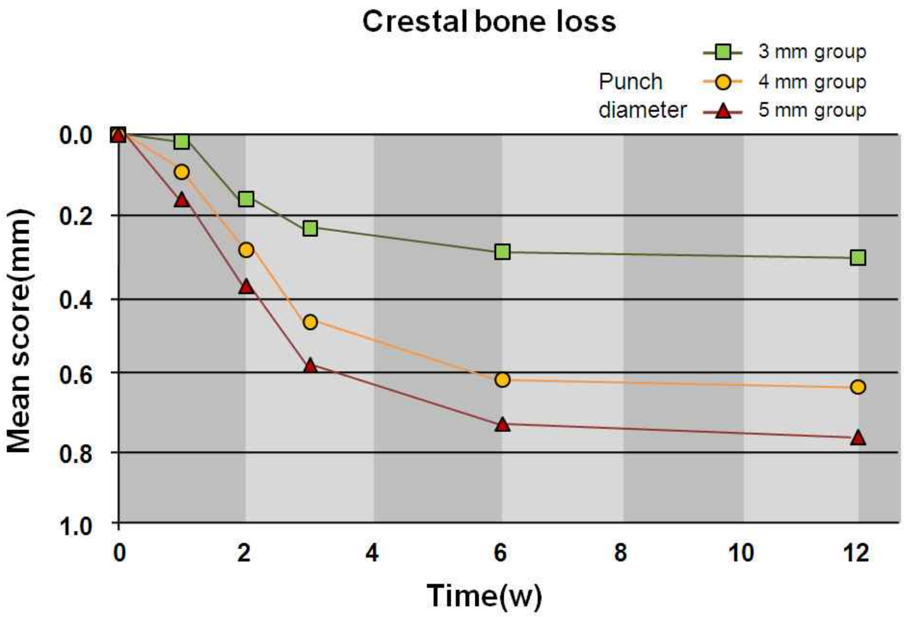
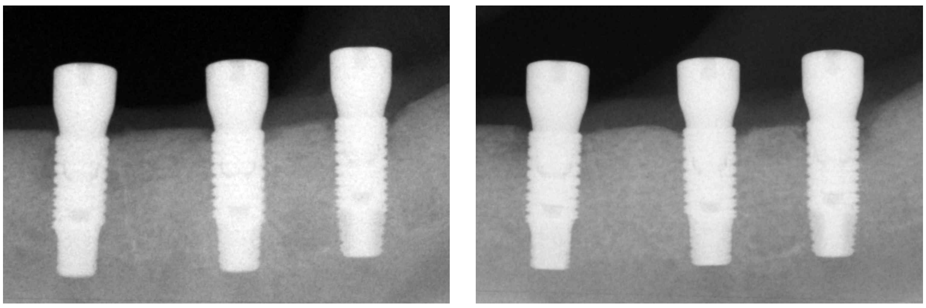


Figure 13. Graph of change of the crestal bone loss



3 mm 4 mm 5 mm 3 mm 4 mm 5 mm

(A) (B)

Figure 14. Periapical radiographs taken at 3 weeks (A) and 12 weeks (B) after implant placement.

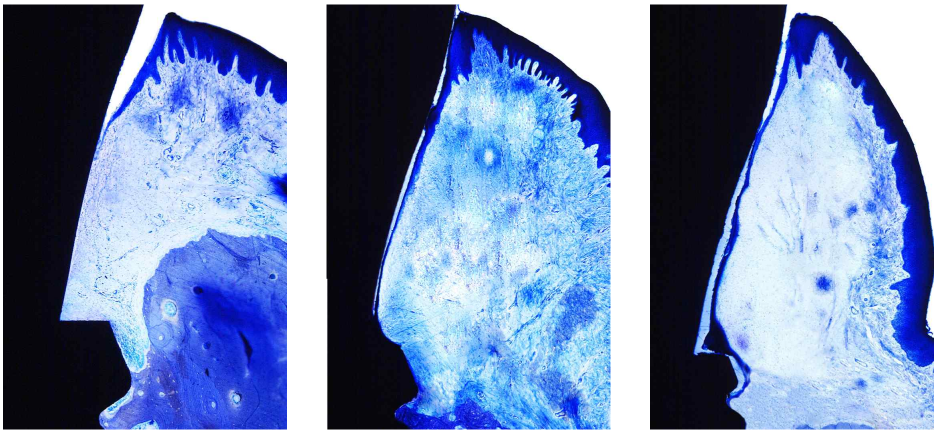
Note that most early bone loss occurred around the implants during the first three weeks after implant placement, and more marginal bone loss occurred with the ≥4 mm tissue punch than with the 3 mm tissue punch.

5. The length of the junctional epithelium is shorter in the smaller soft tissue punch size than using the larger one.

The results of the histometric measurements are reported in Table 4. The mean height of the junctional epithelium (PM-aJE) was 1.2 mm, 1.5 mm, and 1.7 mm for the 3 mm, 4 mm and 5 mm punch groups, respectively (Fig 15). There was a statistically significant difference ($P < 0.05$) between groups. The connective tissue compartment located between the aJE and the B, which is known as the “zone of connective tissue integration”, was 1.0 mm for the 3 mm punch group, 1.1 mm for the 4 mm punch group, and 1.2 mm for the 5 mm punch group. These differences were not statistically significant ($P > 0.05$).

Table 4. Histometric parameters

	3mm group	4 mm group	5 mm group	*P-values*
PM-aJE (mm)	1.2 ± 0.3	1.5 ± 0.6	1.7 ± 0.5	<0.05
aJE-B (mm)	1.0 ± 0.2	1.1 ± 0.3	1.2 ± 0.3	>0.05



(A) (B) (C)

Figure 15. Magnified view of the specimens showing the peri-implant mucosa.

(A) Implant placed with a 3 mm tissue punch. (B) Implant placed with a 4 mm tissue punch. (C) Implant placed with a 5 mm tissue punch. (Toluidine blue stain, x12)

Ⅳ. Discussion

Previously, in the conventional two-stage surgical approach, incisions around dental implant sites were designed to provide access to the underlying residual crest under direct visualization. From the surgical point of view, flap reflection is the most ideal approach for implant placement. But, it has been shown that flap elevation of the periosteum and placing releasing incisions can lead to adverse soft tissue changes as well as bone resorption in some cases.[11,12,16] These adverse changes seems to be the most unpredictable aspect of implant surgery in the aesthetic zone. However, the application of the flapless approach involves site preservation techniques developed for immediate or delayed implant placement in areas of high esthetic concern. It limits surgical trauma to vital peri-implant soft tissue because the incision is very small resulting in the preservation of circulation, soft tissue architecture, and hard tissue volume at the site; decreased surgical time; improved patient comfort; and accelerated recuperation.[17,18] In its simplest form, flapless surgery involves using tissue punch device to gain access to the alveolar ridge for implant placement or abutment connection. With appropriate conditions, the use of a tissue punch can make the soft tissue aspect of surgery more predictable.[19]

Although tissue punch technique has numerous advantages and a simple protocol, the successful use of this technique requires advanced surgical judgement. The tissue punch technique is now well established, but most literature pertains to technique or case reports demonstrating hard tissue changes and survival but not soft tissue data.[20-22] The present study is the first to evaluate the effect of diameter of tissue punch on soft tissue. The aim of this study was to make clinical, radiological and histological observations of the relationship between tissue punch diameter and soft tissue healing on peri-implant region.

This study showed that the diameter of soft tissue punch is directly related to both the soft tissue profile and healing around implants in the first 12 weeks of healing. Firstly, the diameter of soft tissue punch significantly affect the morphology of soft tissue profile at the initial healing period. The literature suggests that tension or mechanical factors may be important in determining the final appearance of a scar.[23-26] After making circular incisions and abutment connection, the tension derived from the retraction of wound edges and the difference of diameter between tissue punch and abutment would occur.[27] In this study, the group that had punch size smaller than abutment size demonstrated convex form of marginal gingiva, the group that had punch size larger than abutment size showed concave form of marginal gingiva($P<0.05$; 0, 0.5, 1 week). If the size of the tissue punch was small, marginal gingiva would have uniform tension in all directions and tissue around abutment would offer close initial sealing in the initial period. Whereas, if the diameter of tissue punch is larger than that of abutment, there would be no soft tissue tension around implant. Therefore, initial tight seal would not be formed. However, the difference between groups became smaller as healing progressed, the profile of marginal gingiva became flat in all group since postoperative 2 weeks. This probably occurred because the tissue remodeling and adaptation occurred in healing process.

The diameter of soft tissue punch significantly affected the change of soft tissue level, and the group with small punch underwent little change, when compared to the amount of change noted on other groups. The results showed that the group with 3 mm soft tissue punch had the most stable results in soft tissue level. It is noteworthy that soft tissue levels generally increased 1 week after implant placement in all groups. The initial coronal migration of the tissue is most likely attributed to postoperative edema.[28,29] The soft tissue level around implants in the group with 3 mm tissue punch increased by 0.5 mm at 1 week, and resolved to 0.0 mm by 12 weeks, indicating that the adjacent mucosa thickens following the surgery but returns to baseline. This suggests that the clinical maturity of soft tissue is established in early healing stage.[30] Thus it is anticipated that soft tissue change might be small in this 3 mm tissue punch group in future. However tissue tearing may occur when drilling due to small tissue punch size. To minimize the possibility of tissue injury, in our experiment, modified drills that have only 0.5 mm cutting edge at terminal portion and blunted edge at other portion of drill were utilized, resulting minimal harmful irritation to adjacent tissue on drilling. On the other hand, the group with 5 mm tissue punch showed that the soft tissue level around implants increased by 0.9 mm at 1 week, and fell to -0.5 mm by 12 weeks. The reason for such a large variation in soft tissue level is due to inflammation caused by initial gap between abutment and mucosa. This structure of the gap would act as a plaque-retentive site, thereby increasing peri-implant mucositis and bone loss.[31,32]

Our study showed that when the mucosa was punched with a 3 mm tissue punch for 4 mm implant placement, the length of the junctional epithelium was shorter than when using a tissue punch with a diameter ≥4 mm; this indicated that the junctional epithelium extended more apically with the ≥4 mm tissue punch than with the 3 mm tissue punch. The more apically-positioned junctional epithelium was directly related to an increased probing depth around the implant, which may provide an environment that is conducive to peri-implantitis.[33,34] There were more cases of peri-implantitis in the 4 mm or 5 mm tissue punch group than in the 3 mm tissue punch group, as confirmed by higher GI scores. The marginal bone resorption that was observed at the 4 mm or 5 mm tissue punch sites in the present study is believed to be the results of the deep pocket depth.

An explanation for the inferior peri-implant tissue healing at the 4 mm or 5 mm tissue punch sites might be that the gap was too large when the mucosa was punched with a tissue punch ≥4 mm in diameter. The gap between the implants and the peri-implant mucosa was determined from the sizes of the soft tissue punch and healing abutment. The contact was tight when the mucosa was punched with a 3 mm tissue punch in cases using a 4.5 mm healing abutment. When the peri-implant mucosa was in tight contact with the implants after implant placement, the peri-implant mucosa healed quickly with little inflammation, as confirmed by the lower GI scores.[35,36] This soft tissue seal may protect peri-implant tissue from factors released from plaque and also from the oral cavity.[37-39] Small, clean, closed wounds are known to heal quickly with little scar formation, whereas large, open wounds heal slowly and with significant scarring.[40-42] This principle can be applied to wounds around the flapless implants. The surrounding mucosa following the flapless procedure using a narrower tissue punch had smaller, cleaner and more closed wounds than that using a wider tissue punch. These neater wounds may improve the ability of the peri-implant mucosa to attach quickly to the surface of the implant following the procedure. Therefore, for optimal peri-implant mucosa healing, the implant should be in direct contact with the adjacent soft tissue, just as the implant needs to be in direct contact with the bone for optimal osseointegration. The results of the present study indicate that the optimal tissue punch size is slightly narrower than the healing abutment selected.

It is reported that bone remodeling occurs rapidly during the early healing phase after implant placement for non-submerged implants and most changes in alveolar crestal bone levels adjacent to implants occur at the initial healing period[43,44] The surgical manipulation of the site may cause tissue trauma resulting in bone remodeling.[45] The degree of bone remodeling can be carried out by measuring the change of the most coronal bone-to-implant contact in the periapical x-rays.[46] Our results indicate an crestal bone loss was related to soft tissue size and the amount of bone loss increased with increasing diameter. The reason that the larger size of soft tisse punch had more crestal bone loss, as mentioned above, may be associated with the initial gap between abutment and mucosa, namely, lack of peri-implant soft tissue seal. Such a lack of mechanical seal would increase the possibility of infection and inflammatory infiltration, thereby bringing about bone loss.

An interesting finding in this study was that there were statistically significant differences in the GI score among groups during the early healing phase (during the first three weeks after implant placement). However, no statistically significant differences were found in the score among groups after 12 weeks. The present study showed that inflammation occurring during the first three weeks of healing played a crucial role in early bone loss around the implants because most early bone loss occurred around the flapless implants during the first three weeks. The bone loss that occurred during the healing period is closely related to the degree and duration of inflammation and infections. Therefore, early implant bone loss can be prevented or minimized if soft tissue wounds around the implants heal quickly with little inflammation and scar tissue formation, conditions achieved when using a tissue punch slightly narrower than the selected healing abutment.

Collectively, in this study, different diameters of tissue punches were to exposure the underlying bone, and a healing abutment was connected immediately after implant placement. Subsequently, clinical, radiological and histological parameters were measured in regards to soft tissue healing. The findings of this study demonstrated that the group with 3 mm tissue punch showed the most stable and predictable tissue healing in peri-implant region. The intimate soft tissue seal and less surgical trauma may be principal reasons for this esthetic outcome in peri-implant soft tissue zone. On the other hand, the groups with larger tissue punch size exhibited relatively adverse healing aspects of soft and hard tissue with increased possibility of plaque accumulation and inflammation. So the effect of soft tissue punch size is important for enhancing mocosal health and esthetics.

The present study has several limitations, including small sample size and few division of groups. So, to investigate the detailed relationship of diameter between soft tissue punch and abutment, further groups according to soft punch size is required. Other controlled clinical trials with subgroups are recommended to expand the conclusions drawn in this study. However, despite these limitations, these results suggest that the diameter of soft tissue punch is a crucial factor for favorable tissue healing around implant, and also, the soft tissue punch that slightly narrower than the healing abutment utilized is recommended.

Ⅴ. Conclusion

In an attempt to help produce guidelines for the use of soft tissue punches, this animal study was undertaken to examine the effect of soft tissue punch size on the healing of peri-implant tissue. Three fixtures were placed on each side of the canine mandible using 3 mm, 4 mm and 5 mm soft tissue punches, and then the peri-implant mucosa was evaluated using clinical, radiological and histometric parameters during subsequent healing periods.

In conclusion, the size of the soft tissue punch plays an pivotal role in achieving intimate soft tissue sealing and optimal healing. Our findings support the use of tissue punch slightly narrower than the healing abutment itself to obtain better peri-implant tissue healing around flapless implants.

References

1. Belser UC, Buser D, Hess D, Schmid B, Bernard JP, Lang NP : Aesthetic implant restorations in partially edentulous patients: a critical appraisal. *Periodontol 2000* 17:132-50, 1998
2. Choquet V, Hermans M, Adriaenssens P, Daelemans P, Tarnow DP, Malevez C : Clinical and radiographic evaluation of the papilla level adjacent to single-tooth dental implants: A retrospective study in the maxillary anterior region. *J Periodontol* 72:1364-1371, 2001
3. Grossberg DE. : Interimplant papilla reconstruction: Assessment of soft tissue changes and results of 12 consecutive cases. *J Periodontol* 72:958-962, 2001
4. Schroeder A, van der Zypen E, Stich H, Sutter F : The reactions of bone, connective tissue, and epithelium to endosteal implants with titanium-sprayed surfaces. *J Maxillofac Surg* 9:15-25, 1981
5. Buser D, Mericske-Stern R, Bernard JP, et al. : Long term evaluation of non-submerged ITI implants. Part I: 8-year life table analysis of a prospective multi-center study with 2359 implants. *Clin Oral Implants Res* 8:161-172, 1997
6. Buser D, Mericske-Stern R, Dula K, Lang NP : Clinical experience with one-stage, non-submerged dentalimplants. *Adv Dent Res* 13:153-161, 1999
7. Buser D, Weber HP, Lang NP : Tissue integration of non-submerged implants: One-year results of a prospective study with 100 ITI hollow-screw and hollowcylinder implants. *Clin Oral Implants Res* 1:33-40, 1990
8. Weber HP, Buser D, Fiorellini JP, Williams RC : Radiographic evaluation of crestal bone levels adjacent to nonsubmerged titanium implants. *Clin Oral Implants Res*

3:181-188, 1992

9. Mericske-Stern R, Sterlin-Schaffner T, Marti P, Geering AH : Peri-implant mucosal aspects of ITI implants supporting overdentures. A five-year longitudinal study. *Clin Oral Implants Res* 5:9-18, 1994

10. Wismeyer D, van Waas MA, Vermeeren JI : Overdentures supported by ITI implants: a 6.5-year evaluation of patient satisfaction and prosthetic aftercare. *Int J Oral Maxillofac Implants* 10:744-9, 1995

11. Auty C, A Siddiqui : Punch technique for preservation of interdental papillae at nonsubmerged implant placement. *Implant Dent* 8(2):160-6, 1999

12. Salinas TJ : Soft tissue punch technique for aesthetic implant dentistry. *Pract Periodontics Aesthet Dent* 10(4):434, 1998

13. McGlumphy EA, Mendel DA, Holloway JA : Implant screw mechanics. *Dent Clin N Am*. 42:71−89, 1998

14. Jemt T, Lekholm U, Gr¨ondahl K : 3-year followup study of early single implant restorations ad modum Branemark. *Int J Periodontics Restorative Dent* 10:340-349, 1990

15. Jemt T, Lind´en L, Lekholm U : Failures and complications in 127 consecutively placed fixed partial prostheses supported by Branemark implants: From prosthetic treatment to first annual checkup. *Int J Oral Maxillofac Implants* 7:40-44, 1992

16. Saadoun A : Single tooth implant restoration: Surgical management for aesthetic results. *Int J Dent Symp* 3:30, 1995

17. Campelo LD, Camara JR. Flapless implant surgery : a 10-year clinical retrospective analysis. *Int J Oral Maxillofac Implants.* 17:271-276, 2002

18. Zunino HJ, Zunino D. Implant surgery : Our experience in performing second-stage surgery by punch approach. *J Oral Implantol*. 21:48-49, 1995

19. Kusek ER : Tissue-punch technique in nonattached tissue using the YSGG laser. *Dent Today* 28(1):132,134-5, 2009

20. Rocci A, Martignoni M, Gottlow J : Immediate loading in the maxilla using flapless surgery, implants placed in predetermined positions, and prefabricated provisional restorations: A retrospective 3-year clinical study. *Clin Implant Dent Relat Res* 5(Suppl.1):29-36, 2003

21. Lorenzoni M, Pertl C, Zhang K, Wimmer G, Wegscheider WA : Immediate loading of single-tooth implants in the anterior maxilla: Preliminary results after one year. *Clin Oral Implants Res* 14:180-187, 2003b

22. Andersen E, Haanæs HR, Knutsen BM : Immediate loading of single-tooth ITI implants in the anterior maxilla: A prospective 5-year pilot study. *Clin Oral Implants Res* 13:281-287, 2002

23. Borges AF : Scar prognosis of wounds. *Br J Plast Surg* 13:47e54, 1960

24. Arem AJ, Madden JW : Effects of stress on healing wounds. *J Surg Res* 20:93e102, 1976

25. Burgess LP, Morin GV, Rand M, et al. : Wound healing. Relationship of wound closing tension to scar width in rats. *Arch Otolaryngol Head Neck Surg* 116:798e802, 1990

26. Meyer M, McGrouther DA : A study relating wound tension to scar morphology in the pre-sternal scar using Langer's technique. *Br J Plast Surg* 44:291e4, 1991

27. Langer K : On the anatomy and physiology of the skin II. Skin tension. *Br J Plast Surg* 31:93e106, 1978

28. Small PN, DP Tarnow : Gingival recession around implants: a 1-year longitudinal prospective study. *Int J Oral Maxillofac Implants* 15(4): 527-32, 2000

29. Cardaropoli G, Lekholm U, Wennstrom JL : Tissue alterations at implant

supported single tooth replacement: a 1-year prospective clinical study. *Clin Oral Implants Res* 17:165-171, 2006

30. DeAngelo SJ, Kumar PS, Beck FM, Tatakis DN, Leblebicioglu B : Early soft tissue healing around one-stage dental implants: clinical and microbiologic parameters. *J Periodontol* 78(10):1878-86, 2007
31. Tal H, Dayan D : Spontaneous early exposure of submerged implants: II. Histopathology and histomorphometry of non-perforated mucosa covering submerged healed implants. *J Periodontol* 71:1224-30, 2000
32. Tal H, Dayan D : Spontaneous early exposure of submerged implants: III. Histopathology of perforated mucosa covering submerged implants. *J Periodontol* 71:1231-5, 2000
33. Martins MC, Abi-Rached RS, Shibli JA, Araujo MW, Marcantonio E : Experimental peri-implant tissue breakdown around different dental implant surfaces: clinical and radiographic evaluation in dogs. *Int J Oral Maxillofac Implants* 19:839-848, 2004
34. Haas R, Haimboek W, Mailath G, Watzek G : The relationship of smoking on peri-implant tissue: a retrospective study. *J Prosthet Dent* 76:592-596, 1996
35. Abrahamsson I, Berglundh T, Lindhe J : The mucosal barrier following abutment disconnection. An experimental study in dogs. *J Clin Periodontol* 24:568-72, 1997
36. Cochran DL, Hermann JS, Schenk RK, Higginbottom FL, Buser D : Biologic width around titanium implants. A histometric analysis of the implanto-gingival junction around unloaded and loaded non-submerged implants in the canine mandible. *J Periodontol* 68:186-98, 1997
37. Hansson HA, Ablrektsson T, Branemark PI : Structural aspects of the interface between tissue and titanium implants. *J Prosth Dent* 50:108-113, 1983

38. Gould TR, Westbury L, Brunette DM : Ultrastructural study of the attachment of human gingival to titanium in vivo. *J Prosth Dent* 52:418-420, 1984

39. Hashimoto M : Ultrastructure of the peri-implant junctional epithelium on single-crystal sapphire endosseous dental implant loaded with functional stress. *J Oral Rehabil* 16:261-270, 1989

40. Homans J : A textbook of surgery. Illinois: Charles C Thomas Publisher 1-30, 1945

41. Sabiston DC, Lyerly HK : Textbook of surgery. The biological basis of modern surgical practice. WB Saunders Company 207-220, 1997

42. Mathes SJ : Plastic surgery. Saunders Elsevier Company 209-234, 2006

43. Pham AN, Fiorellini JP, Paquette DP, Williams RC, Weber HP : Longitudinal radiographic study of crestal bone levels adjacent to non-submerged dental implants. *J Oral Impl* 10:26-34, 1994

44. Hermann JS, Cochran DL, Nummikoski PV, Buser D : Crestal bone changes around titanium implants. A radiographic evaluation of unloaded nonsubmerged and submerged implants in the canine mandible. *J Periodontol* 68:1117-1130, 1997

45. Naert I, Gizani S, van Steenberghe D : Bone behavior around sleeping and non-sleeping implants retaining a mandibular hinging overdenture. *Clinical Oral Implants Research* 10:149-154, 1999

46. Wennström JL, Ekestubbe A, Gröndahl K, Karlsson S, Lindhe J : Implant-supported single-tooth restorations. A 5-year prospective study. *J Clin Periodontol* Jun;32(6):567-74, 2005

Abstract in Korean (국문요약)

무피판 임플란트 수술에서 연조직 펀치의 크기가 임플란트 주위 조직의 치유에 미치는 영향

이 두 형

연세대학교 대학원 의학과

(지도교수 정승미)

목적. 연조직 펀치를 이용한 무피판 임플란트 수술법은 임플란트를 식립할 부위에 환상형의 절개를 필요로 한다. 이에 연조직 펀치의 사용을 위한 지침을 만드는 데 도움을 주고자 성견의 하악에서 임플란트 주위 조직의 치유에 대한 연조직 펀치의 영향을 조사하는 실험이 수행되었다.

연구 설계. 6 마리의 성견에서 하악의 양측에 무치악의 평편한 치조제를 만들었다. 3 개월 동안의 치유 기간 후, 3 mm, 4 mm, 5 mm 연조직 펀치를 사용하여 절개하고 양측에 각각 3개의 임플란트(직경 4.0 mm)를 식립하였다. 그리고 즉시 치유지대주(직경 4.5 mm)를 연결하였다. 그 후 치유 기간 동안 임플란트 주위 점막을 임상적, 방사선학적 그리고 조직학적 방법으로 평가하였다. 평가 요소는 치은 지수, 탐침시 출혈, 치주 탐침 깊이, 변연골 상실 그리고 임플란트 주위 조직의 수직적인 변화이다.

결과. 임플란트 식립 후 치유 기간 동안에 3 mm, 4 mm, 5 mm 연조직 펀치 군 사이에 접합 상피의 길이, 치주 탐침 깊이, 변연골 상실이 유의할 만한 차이가

관찰되었다(P < 0.05). 3 mm 연조직 펀치를 사용한 경우가 4 mm 이상의 연조직 펀치를 사용한 것에 비해 상대적으로 접합 상피의 깊이는 짧았고, 치주 탐침 깊이는 얕았으며, 변연골 흡수량이 적었다.

결론. 무피판 임플란트 수술에서 연조직 펀치의 직경은 최적의 연조직 밀폐의 형성과 연조직의 치유에 있어 중요한 역할을 한다. 선택된 치유지대주보다 약간 작은 직경의 연조직 펀치를 사용하는 경우 임플란트 주변 점막과 긴밀한 접촉을 이룰 수 있고 창상 치유가 가장 양호 하다.

핵심 되는 말: 임플란트, 무피판, 연조직 펀치, 임플란트 주위 조직