

## Peri-implant soft tissue management with commercial healing abutment and customized sealing socket abutment after immediate implantation on upper molars: A case report of profilometric analysis

Running Title : Peri-implant soft tissue healing after immediate implant placement

Young Woo Song<sup>1</sup>, Sung-Wook Yoon<sup>2</sup>, Seung Ha Yoo<sup>2</sup>, Ui-Won Jung<sup>2</sup>


<sup>1</sup>Department of Periodontology, Dental Hospital, Veterans Health Service Medical Center,

<sup>2</sup>Department of Periodontology, Research Institute for Periodontal Regeneration, Yonsei University College of Dentistry

### ORCID ID

Young Woo Song,  <https://orcid.org/0000-0003-1835-5646>

Sung-Wook Yoon,  <https://orcid.org/0000-0003-3309-0287>

Seung Ha Yoo,  <https://orcid.org/0009-0002-6885-8786>

Ui-Won Jung,  <https://orcid.org/0000-0001-6371-4172>

### ABSTRACT

#### Peri-implant soft tissue management with commercial healing abutment and customized sealing socket abutment after immediate implantation on upper molars: A case report of profilometric analysis

Young Woo Song<sup>1</sup>, Sung-Wook Yoon<sup>2</sup>, Seung Ha Yoo<sup>2</sup>, Ui-Won Jung<sup>2</sup>

<sup>1</sup>Department of Periodontology, Dental Hospital, Veterans Health Service Medical Center,

<sup>2</sup>Department of Periodontology, Research Institute for Periodontal Regeneration, Yonsei University College of Dentistry

The purpose of this case report is to compare the mucosal change that occurs at the coronal aspect on the posterior teeth with commercial healing abutment (HA) and sealing socket abutment (SSA). A total of 4 cases are introduced in the present case report. Two cases of immediate implant using HA (one premolar and one molar) and two cases using SSA (one premolar and one molar) method are compared. Intra-oral scanned stereolithographic (STL) images are used to compare the horizontal and vertical change before extraction and 6 months post-surgery. Less horizontal and vertical changes were observed when SSAs are used compared to HAs. With the aid of digital dentistry, SSA is a prompt and effective method to maintain peri-implant mucosal contour after the immediate implantation in the posterior site.

Key words : Case reports; Dental implant therapy; Cone-beam computed tomography; Computer-aided design and manufacturing (CAD-CAM); Stereolithography

#### Corresponding Author

Young Woo Song, DDS, PhD

Department of Periodontology, Dental Hospital, Veterans Health Service Medical Center

53 Jinhwangdo-ro, Gangdong-gu, Seoul 05368, Republic of Korea

E-mail : ywsong84@gmail.com

Ui-Won Jung, DDS, MS, PhD

Department of Periodontology, Research Institute for Periodontal Regeneration, Yonsei University College of Dentistry,

50-1, Yonsei-ro, Seodaemun-gu, Seoul 03722, Republic of Korea

E-mail : drjew@yuhs.ac

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Young Woo Song and Ui-Won Jung equally contributed as corresponding authors to this work

## 1. Introduction

Implant placement immediately after extraction has been advocated for its advantage of reduced overall treatment period and number of appointments as well as cost-efficiency higher than delayed implant placement<sup>1-3</sup>). However, due to unavoidable morphological and structural change of soft and hard tissue on the extraction sites<sup>1</sup>), immediate implant placement may result in unexpected post-operative remodeling of soft and hard tissue after surgery such as mid-facial mucosal recession, papillary height loss due to resorption of the facial and interproximal bone, and vertical and horizontal bone resorption<sup>4-6</sup>).

When the commercial healing abutment(HA) is applied after immediate implant surgery, it is usually difficult to completely seal the extraction socket area, which causes the area to be healed by secondarily. In particular, unlike the anterior region, the diameter of the extraction socket in the posterior area is much larger than the implant fixture diameter. Thus, it is a challenge to maintain the bone graft material placed in the gap between the extraction socket wall and the fixture and to prevent the peri-implant soft tissue from collapsing<sup>5,7,8</sup>). These problems can be resolved by applying the interim restoration which allows to optimize the outcome in the regenerative and esthetic aspects, however, clinicians may face the mechanical complications, such as provisional crown fracture or loosening of the abutment, as well as the biological complications, i.e. mucosal inflammation or marginal bone loss due to excessive cement or food impaction<sup>9</sup>). In addition, especially for the single implant placement

in the posterior region, it is difficult to consider the immediate restoration unless the primary stability is sufficient to endure immediate loading<sup>10</sup>), since it has been reported that the failure rate of implant after immediate loading may increase due to the micromotion and masticatory force<sup>11</sup>).

Regarding the forementioned shortcomings of immediate restoration, several previous research have recently introduced a customized healing abutment designed which fits the extraction socket entrance after immediate implantation<sup>12,13</sup>). By covering the extraction socket, it can maintain the graft materials surrounding immediately placed implants and capture the existing soft tissues while eliminating the adverse effects of immediate restoration such as micromotion and cement leakage. In the early days, the concept of creating a sealing socket abutment(SSA) was proposed by adding composite resin directly to the ready-made abutment at the chair-side to secure the graft materials in the gap around the fixture, which not only increased chair time and lab work but also damaged soft tissue to the residual monomers<sup>14</sup>). Nowadays, computer-aided design and manufacturing(CAD/CAM) technology has enabled the clinicians to create SSA in a more comfortable way by taking optical impression with intraoral scanner, designing the abutment with computer software and fabricating it with a three-dimensional(3D) printer or milling machine, and the scientific evidence of this novel treatment modality is getting established by the recent publications<sup>15-17</sup>). Among many restorative materials, polymethylmethacrylate(PMMA) and poly etheretherketone(PEEK) are commonly used for their physical and mechanical advantages<sup>18</sup>). While

SSA appears to be attractive in immediate implantation to maintain natural tooth profile, cost-effectiveness and additional steps to fabricate SSA are some of inconvenient factors to consider.

To help this, this case report presents the cases treated by the HA or SSA fabricated by CAD/CAM technology to compare the soft tissue healing and volumetric change in peri-implant mucosal contour after the immediate implantation in the posterior region.

## 2. Case description and post-treatment analysis

The present case report includes the cases of the patients who were treated at Department of Periodontology, Yonsei University Dental Hospital, Seoul, Republic of Korea. The retrospective data collection, ex-

cept for any personal information of the patients, was ethically approved by the Institutional Review Board at Yonsei University Dental Hospital, Seoul, Republic of Korea(Approval No. 2-2024-0042).

Of the four patients immediately implantation in the posterior area, two patients(case 1 and case 2) had HA connected and the other 2 patients(case 3 and case 4) had SSA for 3 months before final prosthesis delivery. All four patients were recommended for extraction and implantation due to endodontic problem(root fracture, root canal failure), and all had a buccal wall thickness of 1 mm or more. All of the treatment procedures were conducted by a single practitioner(S.-W.Y.), and Table 1 presents demographic information for four patients.

All site numbers used in the present case report are based on FDI(Fédération Dentaire Internationale) World Dental Federation notation.

Table 1. Demographic information

Demographics of patients	HA		SSA	
	Case 1	Case 2	Case 3	Case 4
Age / Sex	69 / M	76 / F	76 / F	78 / F
Tooth number	#16	#25	#16	#15
Reason of extraction	Endodontic failure	Endodontic failure	Root Fracture	Endodontic failure
Buccal wall thickness	1.54mm	1.29mm	1.56mm	1.01mm
Fixture	5.0x10mm	4.0x10mm	5.0x10mm	4.0x10mm
Gap defect size	3mm	2mm	3mm	2mm
Graft materials	Xenograft	Xenograft	Xenograft	Xenograft
Periodontal phenotype*	Thick	Thick	Thick	Thick

\*Definition of periodontal phenotype in 2017 world workshop<sup>19)</sup>

\*\*Abbreviations: HA, commercial healing abutment; SSA, Sealing socket abutment

## 2.1 Case description of immediate implantation with HA

### *Case 1: Immediate implantation of #16i*

A 67-year-old male, diagnosed with a cracked tooth, was referred for extraction and implant placement on the maxillary right first molar. A crack line and apical radiolucency lesion were observed at the mesiobuccal root on the periapical radiograph. The virtual planning was conducted with a computer software(OnDemand3D version 1.0, Cybermed Inc., Daejeon, South Korea) based on the conebeam-computed tomography(CBCT) taken before the surgery. Intact buccal wall was observed in the cross-sectional view, which allowed immediate implant placement. At the day of surgery, the maxillary right first molar was extracted and a dental implant fixture with sandblasted, large-grit and acid-etched(SLA) surface(Superline, Dentium, Suwon, South Korea), 5.0 x 10mm(diameter x length), was placed at the septal bone by free-hand surgery, followed by grafting of porcine-derived xenogeneic bone substitute(THE Graft, Purgo Biologics, South Korea) in the 3-mm circumferential gap defect. After applying a collagen sponge(Teruplug, Olympus Terumo Biomaterials, Tokyo, Japan) to secure the bone graft, HA(Healing abutment, Dentium) was connected to the fixture and then sutured with a resorbable 4-0 glyconate monofilament suture material(Monosyn<sup>®</sup>, B. Braun, Tuttlingen, Germany). The overall procedure is summarized in Figure 1.

### *Case 2: Immediate implantation of #25i*

A 75-year-old female patient who was referred from

the Department of Conservative Dentistry visited to extract the maxillary left second premolar which had a history of root canal treatment and crown restoration about 15 years ago at a local dental clinic. A periapical radiolucency and poorly positioned post in a calcified canal were found on the radiograph and the tooth was judged hopeless. A virtual planning using the pre-operative CBCT(OnDemand3D version 1.0, Cybermed Inc.) revealed that both the buccal and palatal walls were intact in the cross-sectional view. A 4.0 x 11.5-mm, SLA-surfaced implant(IS-III Active, Neobiotech, Seoul, South Korea) was placed immediately after extraction and porcine-derived bone graft(THE Graft, Purgo Biologics) was applied in the buccal gap defect, which was covered by a collagen sponge(CollaTape, Zimmer Biomet, Warsaw, USA) and HA(Healing abutment, Neobiotech), followed by suturing with a resorbable 4-0 glyconate monofilament suture material (Monosyn<sup>®</sup>, B. Braun)(Figure 2).

## 2.2 Case description of immediate implantation with SSAs

### *Case 3: Immediate implantation of #16i*

A 73-year-old female patient was referred from the Department of Prosthodontics for extraction of the right maxillary first molar and implant placement due to a horizontal fracture of the mesiobuccal root. Pre-operative CBCT showed that the buccal and palatal walls were intact, and immediate implantation was planned. After superimposing the impression obtained by an intraoral scanner(Trios 3, 3Shape, Copenhagen, Denmark) to the CBCT scan, a provisional crown was

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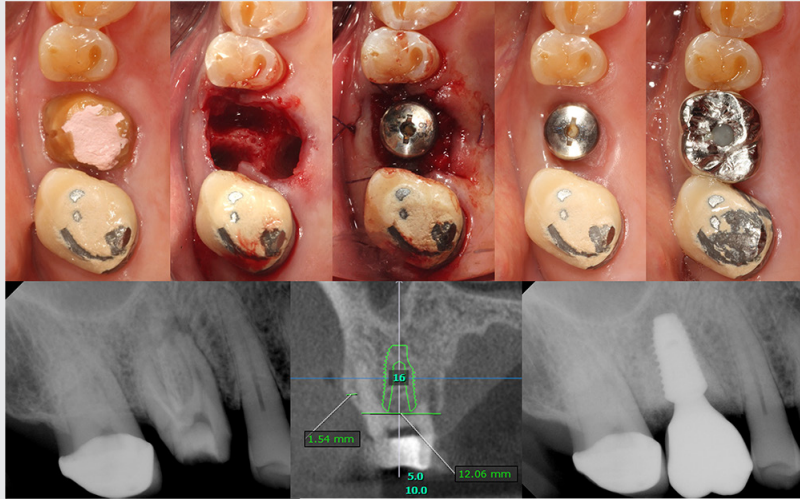


Figure 1. Clinical photographs and radiographs of Case 1 with commercial healing abutment (HA) connection after immediate implantation.

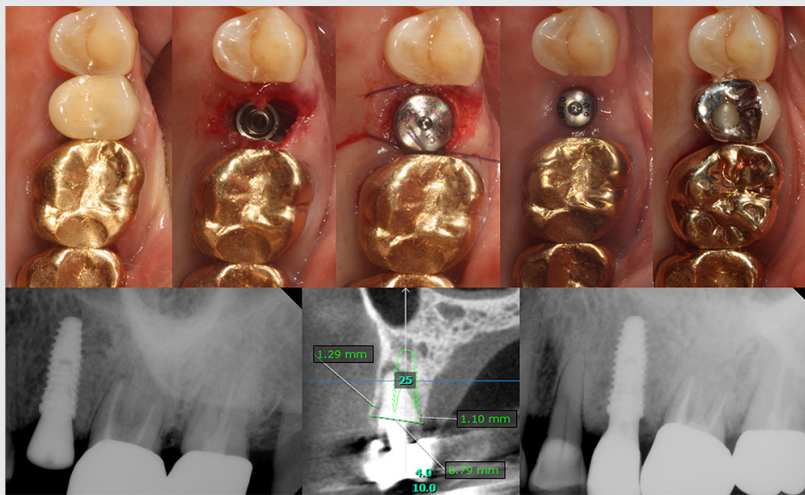


Figure 2. Clinical photographs and radiographs of Case 2 with HA connection after immediate implantation.

virtually designed using a computer software(Exocad, exocad GmbH, Darmstadt, Germany), matched to the crown shape of the existing tooth. The virtual provisional crown was milled from a polymethyl methacrylate(PMMA) block by a milling machine(IDC Mikro 5X, Amann Gurrbach, Koblach, Austria), and then adhered to a non-hex type, pre-manufactured polyether ether ketone(PEEK) abutment(Custom Healing Abutment, Osstem, Busan, South Korea) in order to create the SSA, followed by removing the cusps to avoid any unnecessary occlusal interference with the opposing tooth(Figure 3). A 5.0 x 10mm, SLA surfaced implant(TS III, Osstem) was placed in the septal bone area after the atraumatic extraction with the deproteinized bovine bone mineral(Bio-Oss, Geistlich Parma AG, Wolhusen, Switzerland) grafted to the gap defect, and the pre-fabricated SSA was connected to the fixture to secure the surgical site without any suture(Figure 4).

#### *Case 4: Immediate implantation of #15i*

A 53-year-old female patient was referred from the Department of Conservative Dentistry for the extraction and implant placement due to the endodontic failure of the right maxillary second premolar which appeared to have an apical lesion with external root resorption. Virtual implant planning using a computer software(OnDemand3D, CyberMed Inc.) was performed with the CBCT scan. After an atraumatic extraction, active suppuration was not found therefore, an immediate implant placement was proceeded. Following thorough debridement of apical granulation tissue, an SLA-surfaced implant with the size of 4.0 x

10mm(Superline, Dentium) was placed, and porcine-derived xenograft(THE Graft, Purgo Biologics) was applied to the gap defect in the buccal and palatal sides, which was secured by a collagen sponge(CollaTape, Zimmer Biomet) and HA(Healing Abutment, Dentium). Just before connecting the HA, the optical impression was taken by the intraoral scanner(Trios 3, 3Shape) with a PMMA scan body(Geo Scanbody, Geo, Uiwang, South Korea) connected to the fixture, and the scan body was virtually converted into a titanium abutment on a computer software(Implant studio, 3Shape) in order to design an SSA and PMMA crown, which were finally fabricated by the milling machine(IDC Mikro 5X, Amann Gurrbach)(Figure 5). The next day of the surgery, the SSA and PMMA crown were delivered to the patient, and occlusal adjustment of 4mm or more was conducted to ensure that the crown did not occlude or interfere with the opposing tooth. The whole procedure was summarized in Figure 6.

#### **2.3 Profilometric analysis of changes in peri-implant soft tissue contour**

To quantify the buccal mucosal contour change over time in the horizontal and vertical aspects, optical impression was taken serially with the intraoral scanner(Trios 3, 3Shape) at different time points. Stereolithography(STL) images were obtained before the surgery and 3 months after the prosthetic loading which corresponded to 6 months post-surgery. These STL images were superimposed to each other by a computer software(SMOP, Swissmeda AG, Baar, Switzerland), and a single examiner(S.-W. Y) evaluated

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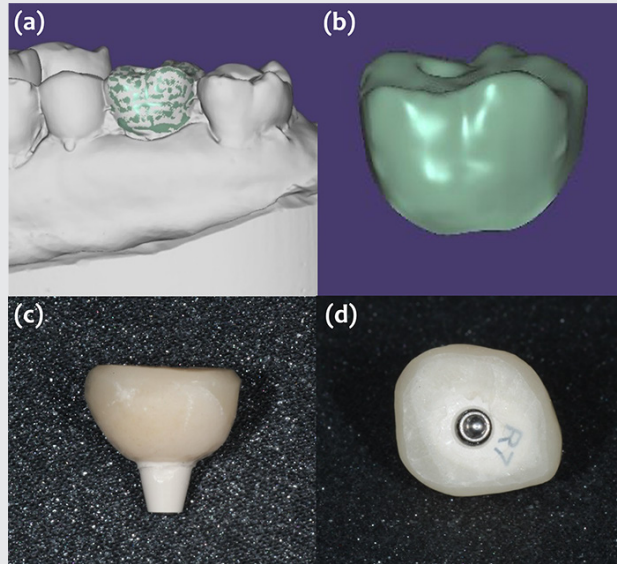


Figure 3. Computer-aided design and manufacturing of the sealing socket abutment(SSA) of Case 3. (a and b) Virtual design of abutment and provisional crown. (c and d) Pre-fabricated SSA, consisting of abutment and provisional crown with occlusal reduction.

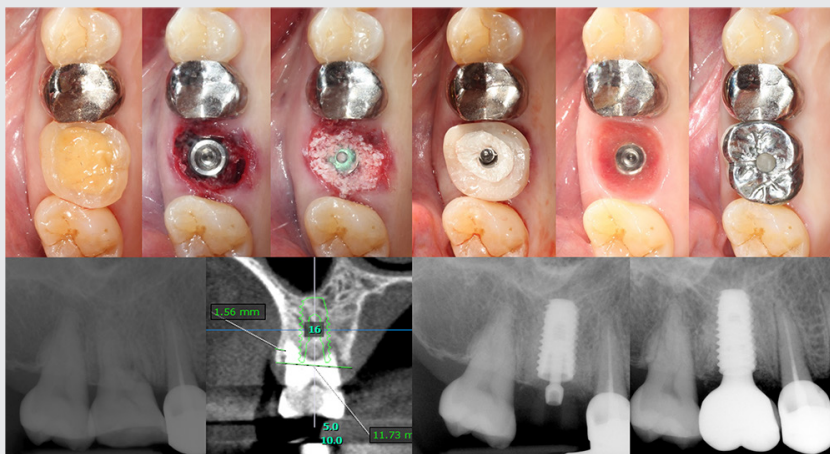


Figure 4. Clinical photographs and radiographs of Case 3.

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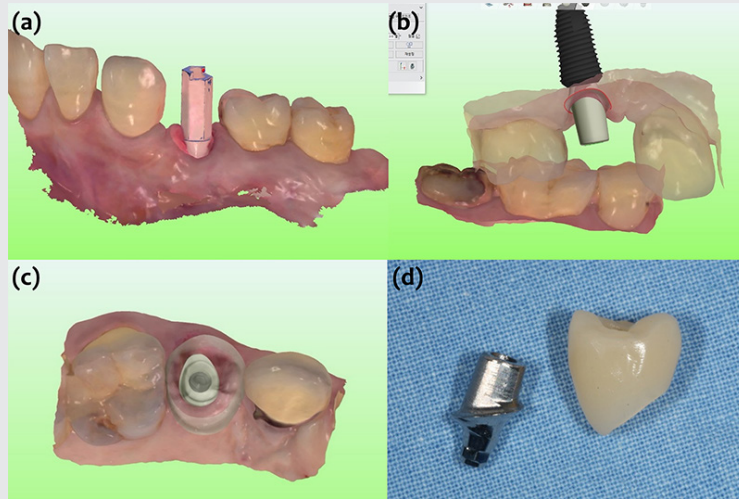


Figure 5. Computer-aided design and manufacturing of the sealing socket abutment (SSA) of Case 4. (a, b, and c) Virtual design of abutment and provisional crown. (d) Pre-fabricated SSA, consisting of abutment and provisional crown.

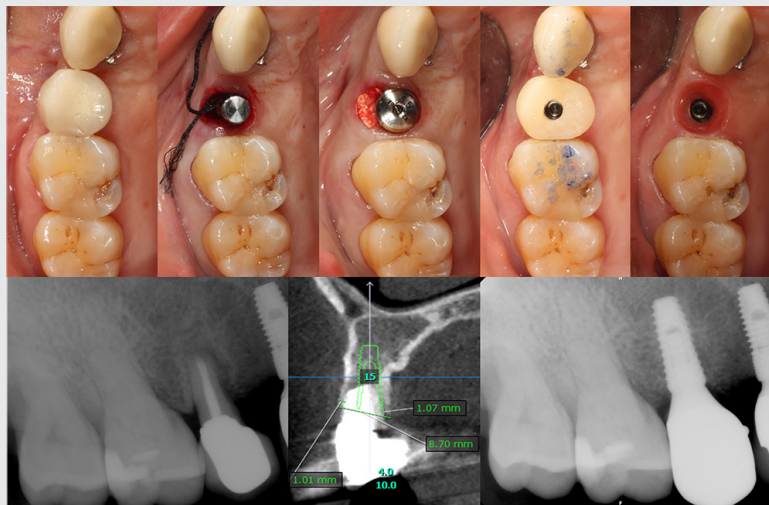


Figure 6. Clinical photographs and radiographs of Case 4.

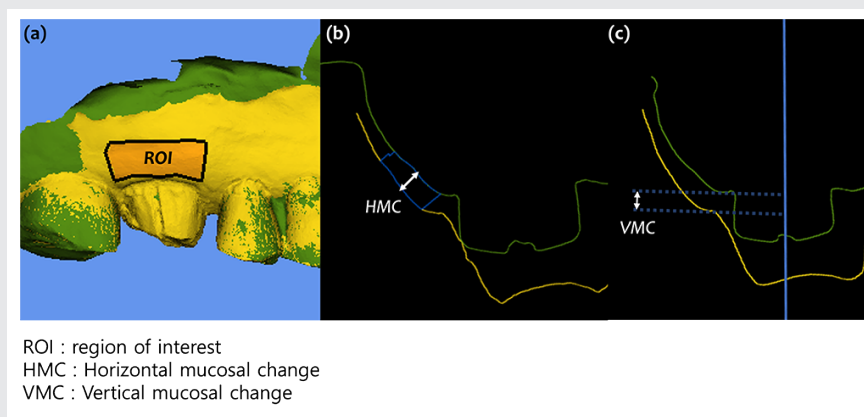


Figure 7. Profilometric analysis. (a) Pre-surgical (yellow) and post-surgical (green) stereolithography (STL) files were superimposed, and region of interest (ROI) was defined at 1mm below the implant buccal mucosal margin with 4mm in corono-apical width ranging from the mesial line angle to the distal line angle of the buccal mucosal zenith. (b) Within the ROI, horizontal mucosal change was measured by mean distance (mm, volume change divided by the area of ROI). (c) Vertical mucosal change was estimated by measuring the vertical distance between the pre-surgical gingival and post-surgical mucosal margins along the reference line corresponding the long axis of the implant fixture.

the horizontal and vertical soft tissue contour changes on the buccal aspect around the implant. A region of interest(ROI) with 4mm in corono-apical width ranging from the mesial line angle to the distal line angle of the buccal mucosal zenith was set 1 mm below the implant buccal mucosal margin(Figure 7a). The amount of horizontal contour change was estimated as a mean distance(mm), which was calculated by dividing total volume within the ROI by total area within the ROI(Figure 7b)<sup>20</sup>. In order to measure the vertical contour change, a cross-sectional cut parallel to the long axis of the implant was obtained and the distance between the lines, which were perpendicular to the long axis of the implant and passing through the mucosal margin at different time

point, was estimated(Figure 7c).

### 3. Results

In terms of horizontal contour change, the cases 1 and 2 that the HAs were applied demonstrated reduction of approximately 1mm after final prosthesis delivery when compared to the pre-surgical state, while the cases 3 and 4 which the SSA were used showed a smaller reduction less than 0.5mm during the same time period.

In the aspect of vertical contour change, the cases 2, 3 and 4 did not present any change, whereas the mucosal margin of the case 1 receded 0.7mm after load-

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Table 2. Horizontal and vertical mucosal change

		HA		SSA	
		Case 1	Case 2	Case 3	Case 4
Horizontal mucosal change (mm)	Pre-surgical - post-prosthesis delivery	-1.2	-1.1	-0.4	-0.3
Vertical mucosal change (mm)	Pre-surgical - post-prosthesis delivery	-0.7	0	0	0

\*\*Abbreviations: HA, commercial healing abutment; SSA, Sealing socket abutment

ing compared to the pre-surgical state.

All measurements are summarized in Table 2.

### 4. Discussion

The cases described in the present report showed that the mucosal contour change could be minimized by sealing the extraction socket entrance with HA or SSA following the immediate implant placement after the posterior tooth extraction, however, there was a difference between using the HA and SSA.

In terms of both horizontal and vertical change, the SSA resulted in less change compared to the HA, which implies that the SSA was better in optimizing the maintenance of soft tissue contour. In the recently published papers, it was also demonstrated that there was a benefit in terms of maintaining soft tissue contour, keeping papilla index and minimizing ridge dimension change when SSA was used<sup>21-23)</sup> just as the outcomes from the cases 3 and 4 of the present study. Furthermore, a retrospective study done by Tarnow et al. emphasized on the use of bone graft and provisional restoration to minimize the ridge contour change<sup>24)</sup>.

On the contrary, the cases 1 and 2 with HA resulted in larger reduction of horizontal soft tissue dimension eventually having peri-implant mucosal margin unmaintained and even though there was a compensation of mucosal level of approximately 0.5mm in the vertical direction achieved after the final prosthesis installation, more reduction of mucosal level occurred in both horizontal and vertical aspects compared to the SSA-applied cases.

In the immediate implantation, mucosal level may change after a surgery depending on a patient's periodontal phenotype, which may cause an unexpected recession in marginal mucosa<sup>1)</sup>. Based on the previous studies<sup>21-23)</sup> and the outcome from the present report, SSA could assist to minimize the unexpected mucosal level change and it was also previously reported that both not only the soft tissue but also the hard tissue could be better maintained with SSA<sup>22,23,25)</sup>

Unlike the immediate implantation in the anterior region, the size of gap defect used to be wider when the implant is immediately placed in the extraction socket of the posterior tooth. Therefore, the amount of bone graft material needs to be increased as well, which eventually makes the stability of the graft material more crucial<sup>14,26)</sup>. Taking this notion into account,

the SSA would be more useful in the posterior, since there used to be a larger discrepancy in the size between the HA and socket entrance. Not only the increase of the wound stability, but the peri-implant marginal mucosa with a physiologic emergence similar to that of a natural tooth could be obtained by the SSA during the early healing stage.

In the present cases, the fabricating methods for the SSA in the case 3 and that in the case 4 were different to each other. In the case 3, the SSA was made by applying 3D-printed PMMA crown over the non-hex type PEEK abutment, which was designed and fabricated before the implant surgery, whereas in the case 4, the provisional crown and customized titanium abutment were designed and milled after the implant placement according to the mucosal profile, resembling the appearance of natural teeth. Since the pre-fabricated provisional crown needed to be relined by resin to fill the gap between the mucosa and the PEEK abutment, the chair time spent for delivering the SSA took longer in the case 3 compared to the case 4. This implies that the pre-fabricated SSA could be beneficial in terms of reducing the number of visits, but on the other hand, it may increase the discomfort of both the clinicians and patients due to the longer chair time.

Recently published randomized controlled clinical have shown the efficacy of applying the SSA following the immediate implant placement in the anterior site<sup>23,27</sup>. Perez et al<sup>23</sup>. reported that the SSA resulted in better outcomes in terms of preserving the papilla contour and preventing the peri-implant marginal bone loss for a year after the implant placement. Meanwhile, the study of Fernandes et al<sup>27</sup>. demonstrated that the

SSA and HA did not show significant difference for a year, but the peri-implant tissue volume shrinkage in the early healing stage (between the immediate implant placement and one month post-surgery) was significantly lower when the SSA was applied. This implies that the SSA would provide a benefit in terms of preserving the peri-implant marginal bone level and mucosal contour and volume in the posterior area as well. However, the well-designed clinical study dealing with this issue is still scarce. Despite the limitations of the present case report in the aspect of small number of patients, the present case report has suggested that the SSA may prevent mucosal volume shrinkage and it could be thought that the present case report provides a cornerstone and starting point for the future research which will investigate the efficacy of the SSA in the immediate implant placement in the posterior region.

## 5. Conclusion

Within the limitation of the present case report, to resemble the emergence profile of natural tooth, the SSA could be promptly prepared pre- or post-operation through digital dentistry and maintain peri-implant mucosal contour in the immediate implantation in the posterior site.

## Conflict of interest statement

The authors declare that they have no conflict of interest related to this study.

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