Dimensional Change of Peri-implant Soft Tissue Following Immediate Implant Placement and Customized Healing Abutment in Posterior Teeth

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Abstract

The present study aimed to evaluate the change of soft tissue with 6-month follow-up after immediate implant placement (IIP) with customized healing abutment (CHA) in posterior teeth. Patients were received IIP with bone graft and connected of CHA. Silicone impression were taken at pre-extraction, immediate post-extraction, 1, 3, and 6 months after extraction. Scanned models were superimposed and measured. Data were analyzed by Friedman test for comparing between time interval of the same region and Wilcoxon signed rank test for analyzing the comparison between regions.

The results showed that soft tissue had most rate of changes during the first month. After that, the dimensional of tissue was almost constant (±0.01 mm per month) except on the buccal side. At 3-month follow-up, there was a significant difference of buccolingual width (*P = .019*). The median change of buccolingual width was -0.73 mm. but no significant difference change of gingival margins and heights throughout 6-months follow-up except on the lingual height that show difference (*P = .001*).

In conclusion, IIP with CHA could maintain the architecture and horizontal dimension of "transmucosal tissue" but could not maintain the vertical dimension of lingual height and buccolingual width during the 6-month follow-up.

Clinical article (J Int Dent Med Res 2021; 14(1): 273-279)

Keywords: Peri-implant soft tissue, customized healing abutment, immediate provisionalization.

Received date: 18 November 2020 **Accept date:** 06 January 2021

Introduction

Nowadays, there was a tendency for immediate implant placement (IIP)-type 1, according to Hammerle et al.[1] instead of delayed placement, especially in the esthetic zone. This technique had several advantages: ease of positioning, reducing chair time, reducing visits of surgery, and higher patient satisfaction compared to conventional protocol.[2-4] IIP also shows a high survival rate over 95% in 1 year.[5-8] However, compared to a conventional protocol, IIP would be more esthetic complications such as midfacial gingival recession and papillary height loss.[9,10] Accordingly, strict patient selection and proper technique for IIP are essential for reducing these complications and achieving the esthetic outcome that is considered as one of the success criteria for implant restoration.[10,11]

Alveolar ridge preservation techniques have been used to prevent hard tissue resorption after tooth extraction, such as using bone grafting with or without the socket sealing with membrane.[12,13] These techniques were applied with IIP and shown the ability to compensate for tissue alterations.[14]

For soft tissue dimension, the healing abutment affected the soft tissue's final shape during the wound healing process. The healing abutment was divided into 2 types. First is stock or prefabricated healing abutment, which was commonly used because it is easier to manipulate. But it had a round shape in cross-section that cannot maintain the natural tissue. Later is customized healing abutment (CHA), one of the trends and became increasingly used in implant dentistry. The concept of this abutment was to develop tissue support adequately and preserving their presurgical architecture by

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molding the "transmucosal tissue", soft tissue from the implant shoulder to the gingival margin.

From previous studies showed that CHA provided better papilla height and prevented midfacial soft tissue recessions.[8] Kinaia et al. found that IIP with the immediate restoration retained better papilla height than late placement restoration.[9] Recently, a randomized clinical trial study revealed that using CHA could prevent mesial bone loss and showed a higher papilla index than using conventional healing abutment.[15] Because CHA could improve soft tissue profile and architecture around the implant.

However, these studies were also limit to anterior maxillary teeth. The change of soft tissue in posterior teeth by this protocol has not been evaluated yet. Therefore, the purpose of this study is to assess peri-implant soft tissue changes after IIP with CHA in posterior areas.

Materials and methods

Patient selection

This prospective observational study was approved by Mahidol University, Faculty of Dentistry/ Faculty of Pharmacy, Institutional Review Board (MU-DT/PY-IRB 2016/DT012). Patients who were referred for posterior teeth extraction and subsequent IIP between 2016-2018 at the Advanced General Dentistry Department, Mahidol University, Bangkok, Thailand, were included in this study. Patients were provided with overall information regarding the study and their informed consent was taken. Then, they underwent intraoral examination and CBCT imaging was taken before the surgical procedure.

Inclusion criteria include healthy patients (ASA class I or II), aged ≥ 18 years, with acceptable oral hygiene and had adequate hard tissue volume for implant engagement.

Patients with severe periodontitis, severe infection, uncontrolled diabetes, pregnancy, smoking ≥10 cigarettes/day or presence of any medical conditions which contraindicate implant placement (such as immunosuppressive taking, bisphosphonates taking, radio-chemotherapy) were excluded from this study.

Surgical procedure

The tooth was extracted under local anesthesia with minimal traumatic technique. Then, bone level tapered implant (Straumann SLA® Bone Level, Straumann, Basel, Switzerland) was immediately placed slightly shifted to the palatal or lingual aspect. The gap between the implant and socket wall were filled with locally harvested autogenous bone and xenograft (Cerabone®, botiss biomaterial, Brandenburg, Germany).

CHA (Variobase®, Straumann, Basel, Switzerland) was placed onto the implant and bis-acrylic material (Protemp™4, 3M ESPE, Minnesota, USA) was applied into the socket to simulate the emergence profile of extracted tooth. CHA was adjusted extraorally with a flowable composite (Filtek™ Z350 XT flowable composite, 3M ESPE, Minnesota, USA), polished with abrasive discs, and cleaned with high-pressure steam, then installed onto the implant (Fig.1).

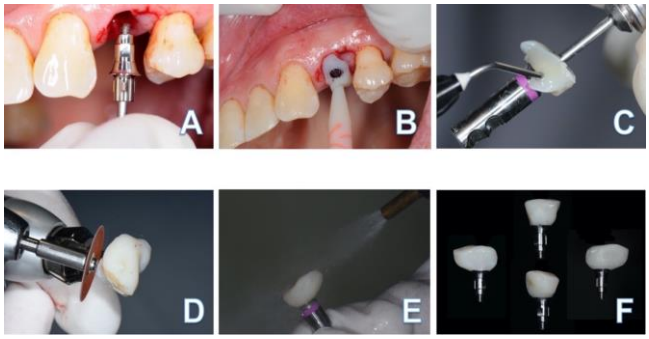

Figure 1. (A) CHA was placed onto the implant. (B) Protemp™ 4 was applied into the socket. (C) CHA was adjusted with a flowable composite, (D) polished, (E) cleaned with high-pressure steam, and (F) Final healing abutment.

Patients were advised to not masticate the side of the surgical site and rinses with 0.12% chlorhexidine gluconate (M-dent, Nakhon Pathom, Thailand) for 1 week. Antibiotics (Amoxicillin 500 mg, 3 times daily for 7 days) and analgesic (Ibuprofen 400 mg, 3 times daily for 3 days) were prescribed. Patients were appointed one week after surgery to follow-up for any complications and evaluated oral hygiene.

Soft tissue evaluation

The soft tissue changes were assessed by intraoral impression at different periods including pre-extraction, immediate post-extraction, 1, 3, and 6 months after extraction.

At 6 months, the CHA was replaced by the final prosthesis.

In each visit, the CHA was removed and replaced with the cover screw, then impression was taken with polyvinyl-siloxane (Variotime,

Heraeus Kulzer GmbH, Hanau, Germany). Dental casts were fabricated by stone type IV (Vel-mix™stone, Kerr, Peterborough, UK). The casts were scanned by a laboratory scanner (Scanner S600 ARTI, Zirkonzahn®, South Tyrol, Italy) as 3D-image files. The digital image software (Zirkonzahn.Modellier, Zirkonzahn®, South Tyrol, Italy) was used to superimpose these files of each patient by using the remaining teeth as a reference object. The superimposed images were then measured by the computer software (ImageJ, National Institutes of Health, USA).

Model measurement

For each superimposed model, buccal-lingual and mesial-distal sections were evaluated (Fig. 2).

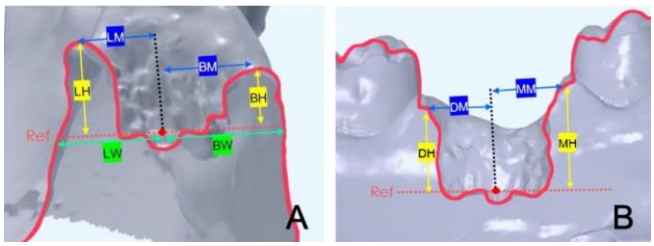

Figure 2. (A) Measurement in the buccal-lingual section. (B) Measurement in mesial-distal section.

Reference line was drawn through the top of the cover screw of the implant, and central line was drawn perpendicular to the reference line at the center of the cover screw. These lines were transferred to other images, which were in original position using a digital image program. Three regions were observed: width of contour, distance of gingival margin, and gingival height. The width of contour was measured from central line through the reference line to the most prominent points buccally (buccal width; BW) and lingually (lingual width; LW). BW and LW are combined as buccolingual width (BLW). The distance of gingival margin was measured from a central line perpendicular to the highest points of gingival margin buccally (buccal margin; BM), lingually (lingual margin; LM), mesially (mesial margin; MM) and distally (distal margin; DM). Gingival height was measured from reference line perpendicular to highest points of gingival margin buccally (buccal height; BH), lingually (lingual height; LH), mesially (mesial height; MH) and distally (distal height; DH).

Statistically analysis

Each of the procedures (surgical procedure, prosthetic procedure, and model measurement) was performed by the same person to standardize the procedures. Each model was measured twice at different times and the mean of the first and second measures was used.

Data was statistically analyzed using Friedman test for comparing between time interval of the same region and Wilcoxon signed rank test was used to analyze the comparison between regions, at a significance level of $\alpha = 0.05$ by SPSS (IBM Company Inc. Chicago, IL, USA).

Results

Sixteen patients (6 men and 10 women) with 16 implants were enrolled in this study. Three patients were excluded due to unsuitable for IIP. The mean patient's age was 51.25±16 years old (range 25 to 71 years old). Implant sites included 5 maxilla (3 premolars and 2 molars) and 11 mandibles (1 premolar and 10 molars). The teeth were extracted due to extensive caries (9 teeth), severe tooth fractures (6 teeth), and endodontic failure (1 tooth). No implant failure was reported throughout this study.

Gingival architecture

After the 6-month follow-up, the clinical gingival architecture had no change from immediate post-extraction (Fig. 3).

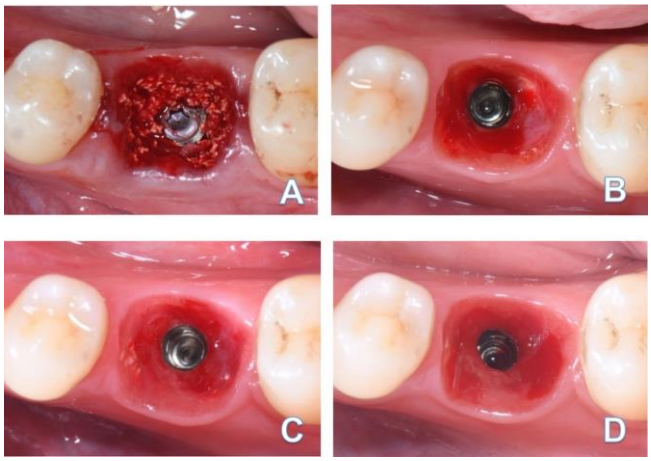

Figure 3. Clinical gingival architecture after immediate (A) post-extraction, (B) one, (C) three and (D) six-month follow-up.

The cross-sectional analysis found that the socket's shape at immediate post-extraction was a cylinder or square box. Then, it

transformed into cone-shaped according to the shape of CHA. In the first phase of socket healing, the study showed a large gap at the lower part of the socket between the socket wall and the CHA rather than its upper part. The gaps decreased rapidly in the first month, and it almost no changed after three months (Fig. 4).

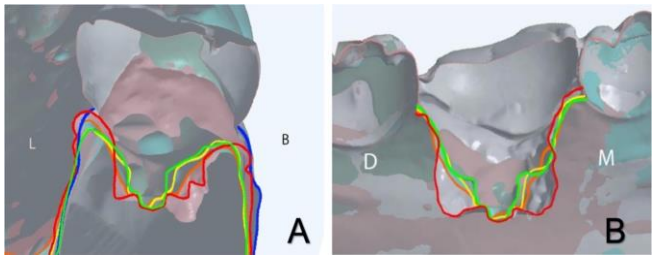

Figure 4. (A) Analysis in the buccal-lingual section. (B) Analysis in mesial-distal section. Sample models showed the changes of the soft tissue architecture over time. (Blue = pre-extraction, Red = immediate post-extraction, Orange = 1-month, Yellow = 3-month, Green = 6-month follow-up).

Model measurement

The intraclass correlation coefficient (ICC) showed good agreement between repeated measurements in each region (range 0.96 - 0.99). The changes of soft tissue in each time interval and a cumulative change were shown in tables 1 and 2. The monthly rate of changes was shown in table 3.

Width of contour	BW	0.02 (-0.08, 0.34)	-0.43 (-0.67,0.06)	-0.05 (-0.42,0.10)	-0.17 (-0.29,0.01)	-0.62 (-1.11,0.00)	-0.37 (-0.71,0.01)
	LW	0.15 (0.04,0.20)	-0.27 (-0.38,0.00)	-0.09 (-0.19,0.03)	0.02 (-0.08,0.09)	-0.37 (-0.49,-0.21)†	-0.24 (-0.47,0.02)
	BLW	0.17 (-0.02,0.53)	-0.48 (-1.38,-0.17)†	-0.13 (-0.45,0.05)	-0.11 (-0.32,0.09)	-0.77 (-1.44,-0.37)†	-0.73 (0.90,0.23)†
Distance of gingival margin	MM	N/A	0.04 (-0.16,0.30)	0.00 (-0.01,0.12)	0.04 (0.00,0.23)	0.15 (0.07,0.33)	N/A
	DM	N/A	0.11 (-0.19,0.49)	0.00 (-0.04,0.09)	0.01 (0.00,0.13)	0.25 (0.01,0.56)	N/A
	BM	-0.01 (-0.37,0.34)	-0.48 (-0.77,0.25)	-0.03 (-0.29,0.34)	-0.19 (-0.40,0.16)	-0.43 (-0.88,-0.04)	-0.46 (-0.68,0.09)
	LM	0.00 (-0.06,0.16)	-0.28 (-0.55,0.08)	-0.04 (-0.23,0.15)	0.08 (-0.10,0.17)	0.03 (-0.61,0.25)	-0.52 (-0.65,0.27)
Gingival height	MH	N/A	-0.21 (-1.01,0.28)	-0.08 (-0.41,0.18)	0.10 (-0.01,0.25)	-0.33 (-0.90,0.06)	N/A
	DH	N/A	-0.11 (-0.55,0.20)	0.08 (0.00,0.23)	-0.03 (-0.40,0.15)	-0.30 (-0.58,-0.02)	N/A
	BH	-0.29 (-0.60,-0.09)	-0.25 (-0.55,0.30)	0.03 (-0.33,0.31)	0.04 (-0.15,0.21)	-0.04 (-0.52,0.15)	-0.27 (-0.92,-0.04)
	LH	-0.27 (-0.63,0.05)	-0.56 (-0.74,-0.25)†	-0.08 (-0.25,0.28)	0.08 (-0.01,0.17)	-0.44 (-0.94,-0.16)†	-0.94 (-1.26,-0.46)†

Table 1. Median changes of soft tissue in each time interval (mm)*.
* Median (25th, 75th percentiles)
Pre = pre-extraction, Post = immediate post-extraction,
N/A = could not be measured in the most cases,
† = Significant at *P* <.05

Region		Pre - Post	Baseline - 1 month	Baseline – 3 month	Baseline - 6 month
Width of contour	BW	0.02 (-0.08, 0.34)	-0.17(-0.54,0.11)	-0.23 (-0.68,-0.04)	-0.37(-0.71, 0.01)
	LW	0.15 (0.04,0.20)	-0.07 (-0.42,0.17)	-0.22 (-0.48,0.00)	-0.24 (-0.47,-0.02)
	BLW	0.17(-0.02,0.53)	-0.32(-0.82,-0.01)	-0.47(-0.91,-0.07)†	-0.73(-0.90,-0.23)†
Gingival margin	MM	N/A	0.04 (-0.16,0.30)	0.16 (-0.01,0.30)	0.15 (0.07,0.33)
	DM	N/A	0.11 (-0.19,0.49)	0.12 (-0.01,0.49)	0.25 (0.01,0.56)
	BM	-0.01(-0.37,0.34)	-0.20 (-0.52,0.13)	-0.31 (-0.73,0.19)	-0.46 (-0.68,0.09)
	LM	0.00 (-0.06,0.16)	-0.36 (-0.73,0.14)	-0.49 (-0.68,0.04)	-0.52 (-0.65,0.27)
Gingival height	MH	N/A	-0.21 (-1.01,0.28)	-0.59 (-1.02,0.07)	-0.33 (-0.90,0.06)
	DH	N/A	-0.11(-0.55,0.20)	-0.03(-0.56,0.28)	-0.30(-0.58,-0.02)
	BH	-0.29(-0.60,-0.09)	-0.49 (-1.00,-0.16) †	-0.39 (-0.89,-0.11) †	-0.27 (-0.92,-0.04)
	LH	-0.27(-0.63,0.05)	-0.81 (-1.05,-0.66) †	-0.91 (-1.34,-0.54) †	-0.94 (-1.26,-0.46) †

Table 2. A cumulative median change of soft tissue (mm)*.
* Median (25th, 75th percentiles)
Pre = pre-extraction, Post = immediate post-extraction,
N/A = could not be measured in the most cases,
† = Significant at *P* <.05.

Region		Baseline to 1 month	1 – 3 months	3 – 6 months	Baseline to 3 months	1 – 6 months
Width of contour	BW	-0.17	-0.03	-0.06	-0.08	-0.05
	LW	-0.07	-0.05	0.01	-0.07	-0.01
	BLW	-0.18	-0.06	-0.04	-0.13	-0.05
Gingival margin	MM	0.04	0.00	0.01	0.05	0.01
	DM	0.11	0.00	0.00	0.04	0.00
	BM	-0.20	-0.02	-0.06	-0.10	-0.04
	LM	-0.36	-0.02	0.03	-0.16	0.01
Gingival height	MH	-0.21	-0.04	0.03	-0.20	0.00
	DH	-0.11	0.04	-0.01	-0.01	0.01
	BH	-0.49	0.01	0.01	-0.13	0.01
	LH	-0.81	-0.04	0.03	-0.30	0.00

Table 3. The monthly rate of changes of soft tissue (mm per month).

1. Width of contour

There was an expansion of BLW about 0.17 mm immediately after tooth extraction. Then, after the 6-month follow-up, the median change [range] of BW, LW and BLW were -0.37 [-1.09 to 0.21], -0.24 [-0.75 to 0.30] and -0.73 [-1.42 to -0.03] mm, respectively. The BLW had the most changes rate during the first month. BLW changes rate during the first month, 1 to 3 months, 3 to 6 months were -0.18, -0.06, and -0.04 mm per month, respectively. The ratio of the monthly change was calculated as 4.85: 1.74: 1.

In the first month, the BW and LW change rates were -0.17 and -0.07 mm per month. Then BW changes gradually decreased to -0.05 mm

per month, while LW was -0.01 mm per month.

When comparing the differences between immediate post-extraction and another period, BLW, LW, and BW had significantly different since the 1, 3, and 6 months of follow-up (P<.05). However, when comparing pre-extraction and another period, it was found that only BLW had significantly different since the 3 months of follow-up (P = .019). BW and LW show no significant difference.

Consider between sides, BLW changes were affected by the reduction of BW rather than the LW (2.62 times in the first month of follow-up). However, there was no significant difference when compared in the same periods.

2. Distance of gingival margin

At the end of the observation period, the median change [range] of MM and DM increased to 0.15 [-0.22 to 0.94] and 0.25 [-0.38 to 0.89] mm, respectively. However, the BM and LM were reduced to -0.46 [-1.52 to 0.88] and -0.52 [-0.90 to 1.23] mm, respectively. These mean that the mesial and distal margin moved to adjacent teeth while the buccal and lingual margin collapsed to the socket center.

During the first month, the MM and DM changes were 0.04 and 0.11 mm per month. Then almost unchanged (0.00 - 0.01 mm per month). The BM and LM also rapidly changed during the first month (-0.20 and -0.36 mm per month, respectively). The LM was noticeably stable (0.01 mm per month), while the BM changes still slightly decreased (-0.04 mm per month). This study also found that the rate of BM changes during the first months was 4.61 times higher than the later period.

There was no significant difference in margin change throughout 6 months follow-up in all sides, between the MM and DM and the BM and LM compared in the same time interval.

3. Gingival height

After immediate post-extraction, the BH and LH was immediately recessed -0.29 and -0.27 mm respectively and after the 6-month follow-up, the median change [range] of MH, DH, BH, and LH were -0.33 [-1.04, 0.60], -0.30 [-0.76, 0.64], -0.27 [-2.24, 0.14], -0.94 [-1.71, -0.08] mm respectively.

The MH, DH, BH, and LH changes were high in the first month (-0.21, -0.11, -0.49, and -0.81 mm per month, respectively), and the later period was almost constant (0.00 to 0.01 mm per month).

There was a significant difference in BH and LH changes in the first month's follow-up (P= .008 and .000, respectively). Later, at 6 months follow-up, there was no significant difference change of BH. However, LH still show significant difference (P = .001).

After 6 months follow-up, there was no significant difference between the MH and DH as well as between the BH and LH. However, there was a difference between BH and MH, LH and MH, LH and DH (P = .000, .000, .037 respectively)

Discussion

This study found that the soft tissue changed into 3 phases. In the first phase, immediately after tooth extraction, there was a slightly expansion on the tissue contour at the level of the implant platform. It was shown that the BLW change at 6-month follow-up compared to the pre-extraction presented no significant difference. On the other hand, the result was contrast when compared to the immediate post-extraction. This might be caused by tissue swelling following the surgery.[16, 17] Therefore, the results which considered the immediate post-extraction as a baseline should be carefully interpreted and the pre-extraction values were mainly used in this study.

No horizontal change of gingival margins was found at this time due to there was supported by CHA. However, there was the vertical changes of the gingival margins. This change might cause by the breaking of gingival fiber after extraction. Nissan et al. reported that gingival marginal significantly collapsed in few seconds after removal of the healing abutment.[18] Thus, it was very important that the gingival margin should be supported as soon as possible for preserving original gingival architecture.

The second phase, it occurred during the first-month post-extraction, changes during this phase are major in both volume and rate of change. There were significant differences of gingival height and width of contour at this phase. Interestingly, the shrinkage mainly occurred on buccal and lingual areas, The authors hypothesized that caused by the breaking of connective tissue fibers of the free gingiva after tooth extraction. In contrast, the mesial and distal sides supporting might be contributed by connective tissue fiber of adjacent teeth. The

histological study reported that fiber around the implant's body typically show an orientation parallel to the implant surface and lack of attachment of connective tissue fibers to the implant surface, while natural teeth show fibers of connective tissue inserted into supracreastal root cementum.[19] Recently studies had presented a laser micro-grooved design on the coronal part of implant or abutments surface could improve this problem. The histological study found that the orientation of connective tissue fibers was perpendicular to the micro-grooved surface, which could reduce the rate of hard and soft tissue change.[20,21] Renzo et al. found no statistically differences of soft tissue parameters and marginal bone loss both regenerated extraction socket group and spontaneously healed socket group when the delayed implant with laser micro-grooved were performed.[22]

This phase had a rapid rate of changes compared to the third phase, first to 6 month-follow-up, that the soft tissue was unlikely to change. The changes in the second phase might cause by the resorption and remodeling of hard and soft tissue. These data supported the results as reported by Schropp et al. that found the width of contour was significantly decrease during the first month then, it slightly decreased.[23] Arau´jo & Lindhe also found that tissue alterations occurred during the first 2 months following the extraction.[24] Accordance with a systematic review of Lang NP et al. found that soft tissue changed in IIP occurred mostly in the first 3 months, and then gradually changed towards the end of the first year.[6] Experiment in the dog had shown that in this period there was a marked osteoclastic activity resulting in resorption of the crestal bone of both the buccal and the lingual bone wall.[24]

From this study found that the horizontal changes of tissue were mainly influenced by the collapse of buccal tissue more than the lingual side as reported in many previous studies that found the greater buccal bone resorption.[23-25] Accordingly, there was a suggestion that implant should be placed slightly to the lingual side more than the buccal side to increase buccal volume and reduce buccal bone resorption.[26]

It indicated that CHA had several benefits. In the early stage, the well-adaptation between CHA and socket minimized gap prevented leakage of bone graft and provided environment leading to osseointegration. In the final stage, the CHA could be used in the laboratory process to guide in making the final prosthesis. Because of its precision of transmucosal tissue, the final prosthesis could easily be inserted without the patient's discomfort. Consequently, local anesthesia injection was not necessary for this procedure, and the misfit of abutment insertion could be prevented.

The superimposing of digital models is a well-established method for the detection of soft tissue change. Nevertheless, errors might occur from the distortion of the impression and model fabrication, number of abutment disconnection/ reconnection.[27] Al-watter et al. found that the implant or its components could induce the localized reaction by inflammatory reaction (peri-implant mucositis and peri-implantitis) or induce the severe systemic reaction.[28] CHA which was used in this study consisted of acrylic material that might irritate those who were allergic which may interfere with the healing process. The CHA that made from tissue-compatible materials should be studied in the future.

Moreover, there were other factors related to soft tissue dimension changes such as gingival biotype, periodontal status, cause of extraction and material and surface treatment of abutment. The small sample size and short follow-up period were the limitations of this study. Finally, in the future study need more evaluation for the other factors and long-term investigation.

Conclusions

IIP with CHA could maintain the architecture and horizontal dimension of "transmucosal tissue" but could not maintain the vertical dimension of lingual height and buccolingual width during the 6-month follow-up.

Although this protocol may not preserve the total soft tissue dimension, however it could maintain the soft tissue profile for good final prosthesis and may also promote the self-cleansing area around the implant which leads to long term implant success. This technique is predictable and favorable to soft tissue aesthetic outcomes and shown to be a successful alternative procedure for implant placement in posterior region.

Acknowledgements

This research project is supported by Department of Advanced General Dentistry, Faculty of Dentistry, Mahidol University, Thailand.

Declaration of Interest

There is no conflict of interests regarding the publication of this paper.

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