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Soft tissue outcomes following alveolar ridge preservation with/without primary flap closure for periodontally damaged extraction socket: A randomized clinical trial

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Abstract

Introduction: The changes in soft tissue profile following alveolar ridge preservation (ARP) with/without primary flap closure (PC) in periodontally damaged sockets have yet to be discovered.

Methods: For periodontally damaged non-molar extraction sockets, ARP with PC (group PC)/without PC (group SC) was performed using granule-type xenogeneic bone substitute material and a collagen barrier. Intraoral scans were performed at the time of ARP and 4 months thereafter. Superimposition of STL files was performed to examine tissue change on the soft tissue level. The level of mucogingival junction (MGJ) was also evaluated.

Results: A total of 28 patient (13 in group PC, 15 in group SC) completed the study. Soft tissue profile change was evaluated only when the measurement level was located on the non-mobile tissue. Group PC tended to shrink less on the long axis of the extraction socket than group SC (−4.3 ± 3.1 mm vs. −5.9 ± 4.4 mm at the 1 mm below the pre-extraction gingival margin, $p > 0.05$). Profilometric analysis (on the region of interest) also have a tendency of less tissue profile change in group PC than group SC (−1.0 ± 0.8 mm vs. −1.3 ± 0.5 mm, $p > 0.05$). The MGJ level change was not statistically significantly different between the groups ($p > 0.05$) even though the MGJ level was located more apically at 4 months in group SC compared with group PC.

Conclusions: Alveolar ridge preservation with PC tended to yield less soft tissue shrinkage than ARP without PC.

KEYWORDS
alveolar bone remodeling, alveolar ridge reconstruction, bone regeneration, randomized controlled trial

Summary Box

What is known

- Compared to hard tissue change, little was known about soft tissue change after alveolar ridge preservation (ARP).

Gil-Jong Seo and Hyun-Chang Lim contributed equally to this study.

- The effect of primary wound closure (PC) on ARP to periodontally damaged extraction sockets was not fully discovered yet.

What this study adds

For periodontally damaged sockets,

- ARP with PC tended to show less soft tissue shrinkage without statistically significant difference compared to ARP without PC.
- The mucogingival junction change may not significantly differ between ARPs with/without PC.

1 | INTRODUCTION

Alveolar ridge preservation (ARP) is nowadays one of the popular treatment modalities to ease future implant placement and increase esthetic on the pontic site.[1–4] A systematic review revealed that 1.54 mm greater hard tissue dimension resulted in ARP-performed sockets, compared to naturally healed sockets.[5] Such preservation effect eventually leads to a decrease in the need for ancillary hard tissue augmentation at the time of implant. Very recently, it was reported in a retrospective study that the odds ratio of not performing hard tissue augmentation was 17.80 with ARP compared to without ARP.[6]

In ARP-related studies, one can find some alienation between the study and the actual clinical settings. Many studies include extraction sockets with intact socket walls and minimally damaged sockets.[7] Immediate or early implant placement protocol may be more beneficial for those sockets.[8] More specifically, ARP may be unnecessary for those.[9] However, most extraction sockets presenting difficulty placing the implants at an early timepoint are periodontally damaged. Without ARP, such sites may entail increased technical difficulty and patient morbidity at the time of implant placement. Therefore, several recent studies have focused on periodontally damaged sockets.[10–14]

Alveolar ridge preservation for periodontally damaged sockets tends to entail similar surgical procedures to guided bone regeneration: flap elevation (with a vertical incision[s]), bone substitute material grafting for recreating the ridge contour (possibly over-augmentation relative to the neighboring ridge),[1,15] and applying a barrier membrane. Moreover, considering some parts of the damaged socket walls need to be regenerated, ARP for periodontally damaged sockets might require healing in a fully closed environment, that is, a necessity of primary flap closure (PC). Our previous study compared hard tissue dimensional change and new bone formation between ARPs with/without PC in periodontally damaged non-molar extraction sockets.[13] The study exhibited no significant difference in both parameters between the two groups, suggesting no obligation for PC.

To date, a few studies have demonstrated post-ARP tissue changes on the soft-tissue level.[16–20] Given the role of soft tissue in peri-implant health and aesthetics, more data on the post-ARP changes at the soft tissue level should be collected. Such information would be more valuable for periodontally damaged sockets because these sometimes accompany soft-tissue deficiency. Furthermore, depending on the effect size of ARP for this issue, the actual clinical situation can be predicted more accurately, and the ARP protocol can be modified (whether or not additional soft−/hard-tissue grafting is needed).

The aim of the present study is to assess the changes in soft tissue profile following ARP with/without PC based on an intraoral scanning dataset.

2 | MATERIALS AND METHODS

2.1 | Study design

The present study is a prospective randomized clinical trial in conformity with the 1975 Declaration of Helsinki (revised in Fortaleza in 2013) and the Good Clinical Practice guidelines. The study protocol was approved by the Institutional Review Board at the Kyung Hee University Dental Hospital (approval no.: KT-DT19001). This clinical trial was not registered prior to participant recruitment and randomization (https://cris.nih.go.kr/cris/search/detailSearch.do/19718).

2.2 | Study population

Patients requiring non-molar tooth extraction were included in the present study. From March 2019 to December 2020, patients were recruited as the following inclusion and exclusion criteria.

2.2.1 | Inclusion criteria

- Between 20 and 75 years old
- Adequate oral hygiene
- A non-molar tooth with type III or IV classification by Caplanis et al. (2005)[21] (≥3 mm of hard tissue loss in 1 or more socket walls)

The extent of socket wall destruction was present in Table S1.

2.2.2 | Exclusion criteria

- Heavy smoking (>10 cigarettes per day),

- Systematic conditions interfering healing after oral surgery
- Pregnancy or lactation
- Alcoholism/drug abuse
- Untreated or uncontrolled periodontal disease

2.3 | Study groups

Two experimental groups were established depending on primary flap closure in ARP (group PC: ARP with primary wound closure, group SC: ARP with secondary wound closure). In both groups, a granule-type xenogeneic bone substitute material (InterOss®, SigmaGraft) and a native bilayer collagen membrane (Bio-Gide®, Geistlich) were applied.

After the enrollment of the study patient, random group allocation was performed by an independent investigator. Group assignment was revealed immediately after flap elevation in ARP surgery.

2.4 | Surgical procedures

Surgical procedures were described in our previous study.[13] Briefly, ARP was performed as follows: elevating a full-thickness flap (with/without vertical incision), meticulous degranulation, grafting bone substitute material (leading to slight horizontal over-augmentation relative to the adjacent bony envelope, but no vertical overfilling), covering the bone substitute material by a collagen membrane. Then, periosteal releasing incision was performed for coronally advancing the flap in the group PC. The flaps were closed using mattress and interrupted sutures. Primary flap closure was not attempted in group SC. After 7–10 days, the suture material was removed. Four months post-ARP, bone-level implants were placed on the ARP sites (Figure S1).

All surgeries were followed by antibiotics and analgesics medication for 5–7 days. A 0.12% chlorhexidine gargle solution (twice a day) was prescribed to patients.

2.5 | Outcome measures

- Linear and profilometric changes on the soft-tissue level between before extraction and 4 months thereafter, assessed using Standard Tessellation Language (STL) files.
- Mucogingival junction (MGJ) location and change.

2.6 | Analyses

One investigator (Gil-Jong Seo) performed analyses without prior information regarding group assignments. The analyses were supervised by a senior investigator (Hyun-Chang Lim). Prior to the main analysis, randomly selected five sample data were measured by both investigators. For those data, interclass correlation coefficients between the two investigators ranged from 0.954 to 0.997 ($p < 0.05$).

2.6.1 | Linear and profilometric changes on the soft-tissue level

Intraoral scanning (Medit I500, Medit) was performed before extraction/ARP (T0), immediately after extraction/ARP (T1), and at 4 months post-ARP (T2). The STL files from those time points were imported into digital image analysis software (SMOP, Swissmeda). The STL images were then manually superimposed using adjacent teeth as fixed references.

The gingival margin (GM) was identified on the image at T0, and the reference levels at the 1, 2, and 3 mm levels below the mid-buccal GM were then set. At those levels, the ridge width at each time point (soft tissue width at the 1, 2, and 3 mm below the GM: SW1, SW2, and SW3, respectively) and linear changes between T0 and T2 (ΔSW1, ΔSW2, and ΔSW3) were measured. The ridge changes on the buccal (ΔSW_B), and oral (ΔSW_O) surfaces were also calculated in the same horizontal planes. When there was no keratinized tissue (KT) at the reference level, measurement was not performed at that level due to the mobility of the tissue (Figure 1A).

For profilometric measurement, a region of interest (ROI) was established on the buccal surface of the tooth. The apicocoronal extent of the ROI was between 1 and 3 mm apical to the GM at T0. The mesiodistal extent of ROI was mesial and distal to the line angles of the tooth. Consequently, a trapezoidal shape of the ROI resembling a root form was made. When there was no KT at the 3-mm level, the 2-mm level was set as the apical border. In cases of no KT at the 2-mm level, profilometric measurement was not performed. The mean distance and volume difference between the two surfaces within the ROI was calculated (Figure 1B).

2.6.2 | Changes in MGJ

The MGJ was identified in the STL images at T0 and T2. The MGJ level was additionally confirmed using clinical photographs. A 1 mm-long zone was set continuously from the GM to the MGJ; for example, form the GM to 1 mm below the GM and from 1 to 2 mm below the GM, and goes on until reaching the MGJ. Then, at T0 and T2, it was determined which zone the MGJ belonged to. In addition, the zonal changes of the MGJ between T0 and T2 were examined.

2.7 | Statistics

Data are presented as mean ± SD or median [interquartile range] values. The Shapiro–Wilk test was performed to determine whether data conformed to normal distribution. The independent *t*-test and Mann–Whitney U test were used for intergroup comparisons. Intragroup comparisons were performed using the paired t-test and Wilcoxon signed-rank test. A statistically significant difference was set at $p < 0.05$.

3 | RESULTS

Among the initially enrolled 30 patients, 28 completed the study: 13 and 15 in groups PC and SC, respectively. Wound dehiscence was presented in 8 out of the 13 patients in group PC, but there were no specific adverse events during the study. Some patients exhibited mobile tissue on the measurement sites; these patients or sites were excluded from the analyses because the mobile tissue carries a potential risk of over- or under-registration depending on the direction and extent of lip/cheek retraction. The number of sites in the analysis is presented in the tables.

3.1 | Linear changes on the soft-tissue level

In general, tissue shrinkages were found on the soft-tissue level. Linearly, the total tissue changes tended to be smaller in group PC than in group SC (−4.3 ± 3.1 mm vs. −5.9 ± 4.4 mm at SW1, −2.7 ± 1.8 mm

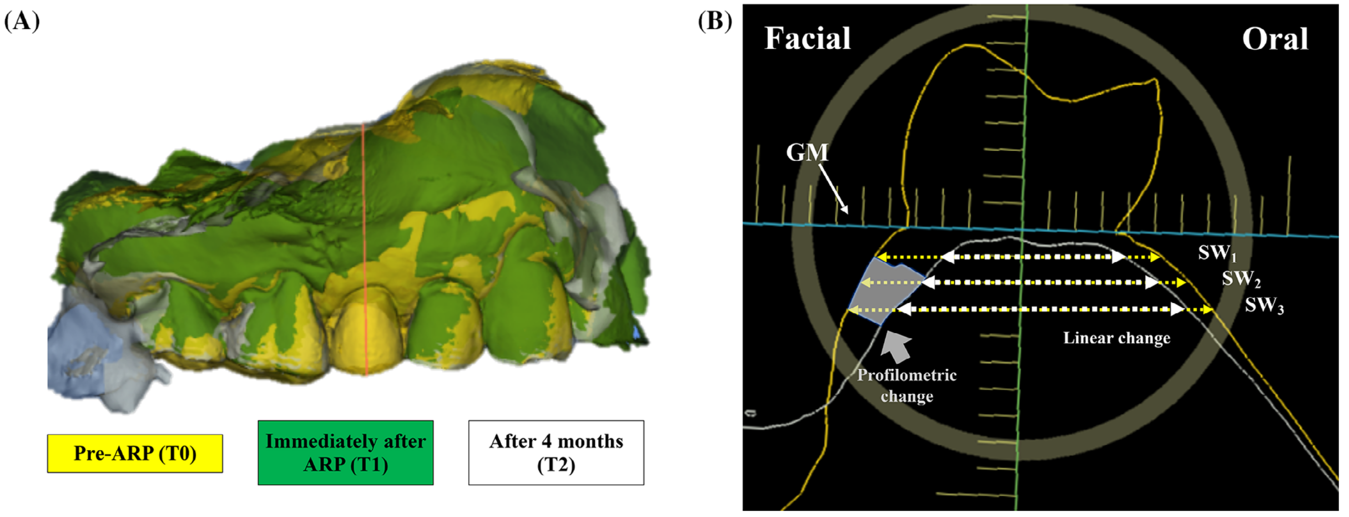

FIGURE 1 Measurements. (A) Superimposition of Standard Tessellation Language files. (B) Linear and profilometric measurements. SW1, SW2, and SW3: linear soft tissue width at the 1, 2, and 3 mm level below the gingival margin (GM) pre-extraction.

TABLE 1 Linear tissue changes on the soft-tissue level (in mm).

		Group PC	Group SC	*p*
ΔSW_1 ($n = 10$ [group PC], $n = 14$ [group SC])	Total	−4.3 ± 3.1 −3.3 [−6.8, −2.4]	−5.9 ± 4.4 −4.0 [−11.0, −2.2]	0.380
	Buccal	−2.3 ± 1.7 −1.8 [−3.3, −0.8]	−3.3 ± 2.2 −2.5 [−5.7, −1.5]	0.230
	Oral	−2.0 ± 1.7 −1.9 [−2.9, −0.8]	−2.5 ± 2.3 −1.7 [−5.0, −0.5]	0.815
ΔSW_2 ($n = 8$ [group PC], $n = 14$ [group SC])	Total	−2.7 ± 1.8 −2.5 [−4.6, −1.1]	−3.2 ± 1.5 −3.3 [−4.5, −2.0]	0.482
	Buccal	−1.4 ± 1.1 −1.6 [−2.1, −0.2]	−1.9 ± 0.7 −2.1 [−2.3, −1.5]	0.168
	Oral	−1.3 ± 0.9 −1.2 [−2.2, −0.7]	−1.3 ± 0.9 −1.1 [−1.9, −0.4]	0.910
ΔSW_3 ($n = 5$ [group PC], $n = 11$ [group SC])	Total	−1.5 ± 1.3 −1.7 [−2.6, −0.3]	−2.7 ± 1.2 −2.6 [−3.6, −1.8]	0.097
	Buccal	−0.7 ± 0.9 −1.1 [−1.5, 0.2]	−1.6 ± 0.6 −1.6 [−1.9, −1.2]	0.032[a]
	Oral	−0.8 ± 0.7 −0.6 [−1.4, −0.2]	−1.1 ± 0.9 −0.9 [−1.7, −0.4]	0.489

Note: Data are mean ± SD or median [interquartile range] values in millimeters. Group PC: alveolar ridge preservation (ARP) with primary wound closure; group SC: ARP with secondary wound closure; ΔSW_1, ΔSW_2 and ΔSW_3: linear tissue changes on the soft-tissue level at 1, 2, and 3 mm below the gingival margin pre-extraction. For the parameters regarding ΔSW_1, the Mann–Whitney U test was used. For the rest of parameters, the independent *t*-test was used.

[a]Significant difference between the groups ($p < 0.05$).

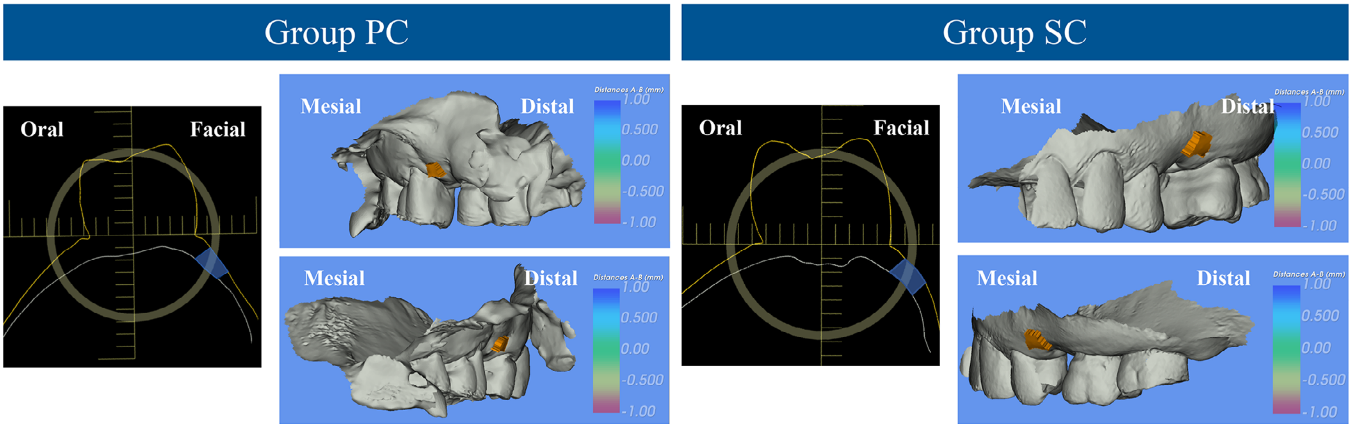

FIGURE 2 Representative views of two groups, showing profilometric changes. Group PC: alveolar ridge preservation (ARP) with primary wound closure (PC); group SC: ARP with secondary wound closure (SC).

TABLE 2 Profilometric tissue changes.

	Group PC ($n = 8$)	Group SC ($n = 14$)	p
Mean difference (in mm)	−1.0 ± 0.8 −1.0 [−1.9, −0.2]	−1.3 ± 0.5 −1.4 [−1.6, −0.9]	0.435
Volume difference (in mm^3)	−5.8 ± 4.9 −4.5 [−1.5, −10.6]	−7.3 ± 4.0 −7.2 [−5.1, −8.6]	0.441

Note: Data are mean ± SD or median [interquartile range] values. Group PC: alveolar ridge preservation (ARP) with primary wound closure; group SC: ARP with secondary wound closure. The Mann–Whitney U and independent *t*-tests were used for mean and volume difference, respectively. Statistically significant difference between the groups was set at $p < 0.05$.

vs. −3.2 ± 1.5 mm at SW2 and − 1.5 ± 1.3 mm vs. −2.7 ± 1.2 mm at SW3). However, there were no significant differences in ΔSW1, ΔSW2, and ΔSW3 between the groups ($p > 0.05$) (Table 1, Figure 2).

The tissue changes on the buccal aspect exhibited the same trends in total tissue changes. ΔSW_B1, ΔSW_B2 and ΔSW_B3 were−2.3 ± 1.7 mm, −1.4 ± 1.1 mm and −0.7 ± 0.9 mm, respectively, in group PC, and −3.3 ± 2.2 mm, −1.9 ± 0.7 mm and −1.6 ± 0.6 mm in group SC. Only ΔSW_B3 differed significantly between the groups ($p = 0.032$). Regarding ΔSW_Os, no statistically significant difference was noted at any level between the groups ($p > 0.05$) (Table 1, Figure 2).

When PC was successfully achieved in group PC, more tissue change was found in all levels (Table S2).

3.2 | Profilometric changes on the soft-tissue level

The mean differences between T0 and T2 in the ROI were −1.0 ± 0.8 mm in group PC and −1.3 ± 0.5 mm in group SC, with no significant difference between the groups ($p > 0.05$). The volumetric difference was −5.8 ± 4.87 mm^3 in group PC and −7.3 ± 4.0 mm^3 in group SC ($p > 0.05$) (Table 2, Figure 3).

3.3 | MGJ location and changes

The MGJ shifted coronally in both groups, leading to a decreased height of the KT. The change in the MGJ zone did not differ significantly between the groups ($p > 0.05$). However, the final MGJ level was significantly apically located in group SC compared with group PC ($p < 0.05$). At T0, 11 patients in group PC and 14 in group SC presented >2 mm of KT. At T2, the number of patients with >2 mm of KT decreased to 8 in group PC but remained the same in group SC (Table 3, Figure 4).

4 | DISCUSSION

This study investigated the changes in soft tissue profile following ARP with/without primary flap closure (PC) in periodontally damaged sockets. Group PC tended to bring less tissue shrinkage on the soft tissue level (without a statistically significant difference between groups PC and SC). The change in the MGJ zone did not differ significantly between the groups, even though the final level of the MGJ was favored in group SC.

4.1 | Linear and profilometric tissue changes on the soft-tissue level

Both groups exhibited horizontal shrinkage in total tissue dimension. The total tissue shrinkage was the greatest in the most-coronal measurement level (−4.3 ± 3.1 mm in group PC vs. −5.9 ± 4.4 in group SC), which is not clinically negligible. Such significant loss of tissue dimension was attributed to the nature of periodontally damaged

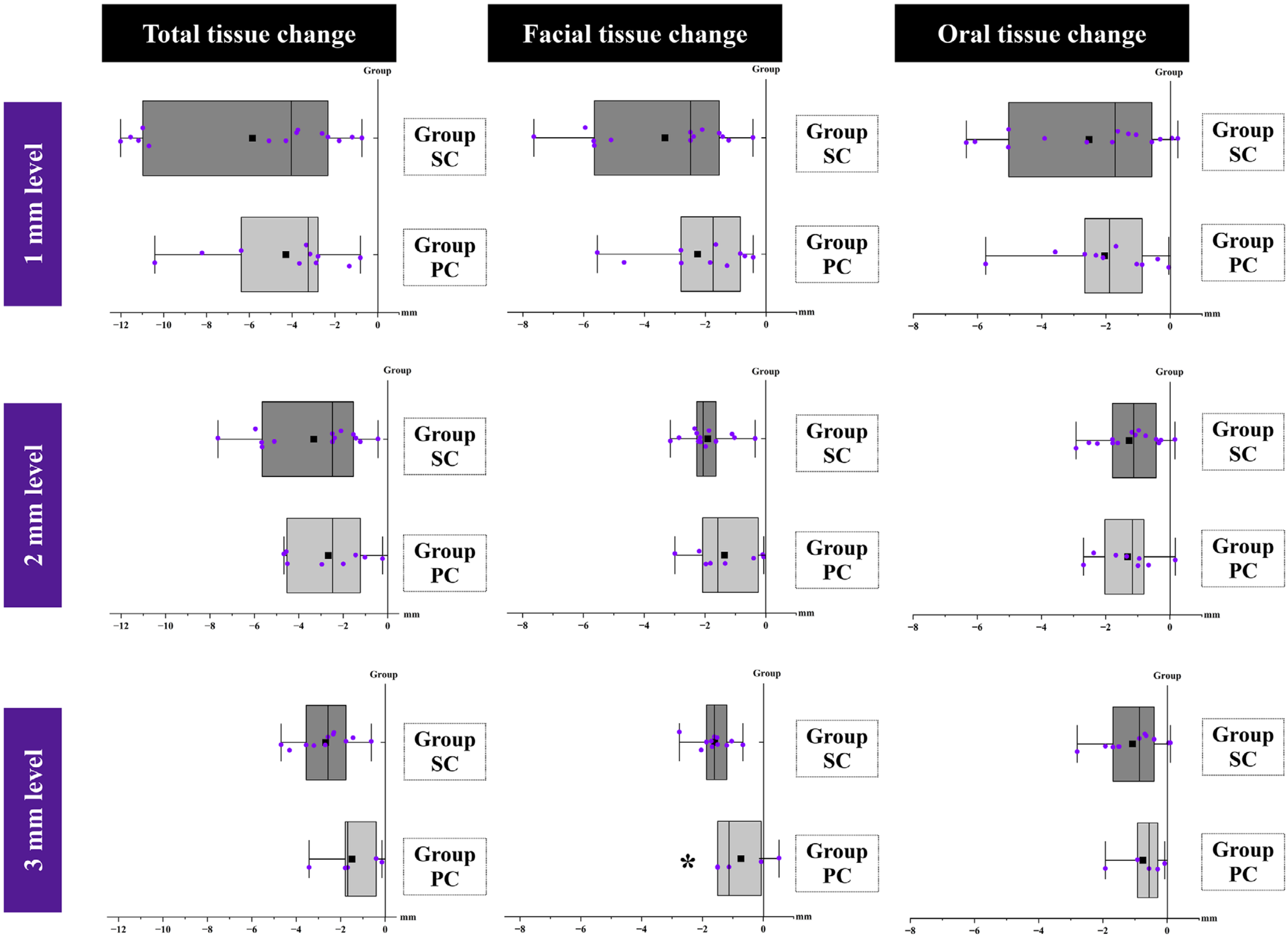

FIGURE 3 Box-and-whisker plots & scatter plots showing linear tissue changes on the soft tissue level. The measurement was performed at 1, 2, and 3 mm below the gingival margin pre-extraction. Each level is perpendicular to the longitudinal axis along the extraction socket. The whiskers cover the entire data range. The line and black tetragon within the box indicate mean and median values, respectively. Group PC: alveolar ridge preservation (ARP) with primary wound closure (PC); group SC: ARP with secondary wound closure (SC). "*" Significant difference between the groups ($p < 0.05$).

TABLE 3 Mucogingival junction (MGJ) location and changes.

	Group PC ($n = 13$)	Group SC ($n = 15$)	p
MGJ zone at T0	4.1 ± 1.4 5 [3, 5]	4.8 ± 1.4 5 [4, 6]	0.241
MGJ zone at T2	2.9 ± 1.4 3 [1.5, 4]	4.1 ± 1.2 4 [3, 5]	0.020[a]
ΔMGJ zone	1.2 ± 1.2 1 [0, 2]	0.7 ± 1.0 0 [0, 1]	0.178

Note: Data are mean ± SD or median [interquartile range] values. Group PC: alveolar ridge preservation (ARP) with primary wound closure; group SC: ARP with secondary wound closure; ΔMGJ zone: change in the MGJ zone; T0: immediately before extraction; T2: at 4 months post-ARP. The Mann–Whitney U test was used for MGJ location and change.
[a]Significant difference between the groups ($p < 0.05$).

sockets in this study; some soft tissue was unsupported by underlying bone. Even though bone substitute material was inserted up to the level to compensate for the missing socket walls, the coronal level of the soft tissue might be vulnerable to collapse due to augmentation resorption and pressure from oral activities.

A few clinical studies compared the tissue changes on the soft-tissue level after ARP.[12,18,19] At the most-coronal measurement level, one of those studies exhibited less contraction than the present study (−1.60 ± 0.27),[18] and two studies exhibited soft-tissue reduction similar to the present study, with approximately 4 mm of shrinkage; −4.12 ± 1.80 mm[19] and −4.74 ± 3.14 mm.[12] This reported discrepancy might be derived from the inclusion criteria for the sockets (the extent of wall destruction, molar or non-molar) and tissue phenotype. In the present study, the analyzed sockets exhibited bone destruction of >7 mm in the facial wall (Table S1).

The total tissue changes tended to favor group PC (with no statistically significant intergroup difference). Despite the wound dehiscence in group PC (8 out of 13 sites), some of the coronally advanced tissue by means of PC appeared to contribute less to tissue changes. On the other hand, 5 sites in group SC exhibited conspicuous tissue loss at SW1 (total loss at three sites, and <1 mm of tissue remained at two sites).

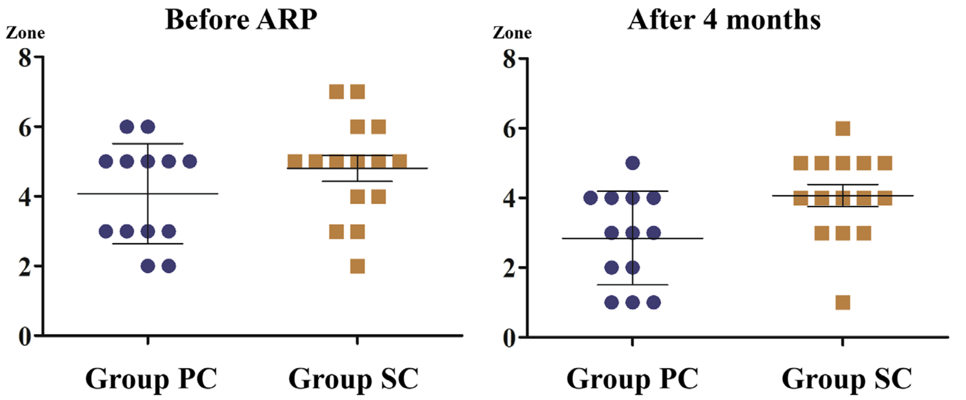

FIGURE 4 Scatter plots showing the zone of mugogingival junction. The lines indicate mean and standard deviation, respectively. Group PC: alveolar ridge preservation (ARP) with primary wound closure (PC); group SC: ARP with secondary wound closure (SC).

When comparing the facial aspect with the oral aspect, the extent of tissue shrinkage tended to be slightly greater on the facial than on the oral aspect. That might be due to the soft tissue condition of the facial aspect pre-extraction; for example, recession and soft-tissue thickness. Especially most of the experimental site was in the maxilla. The thick and keratinized palatal mucosa might be more resistant to tissue collapse. In the study by Ismael and the colleagues (2021), the authors evaluated clinical attachment level (CAL) of adjacent teeth of extraction sockets, demonstrating significant CAL gain at the mesio-palatal area of adjacent tooth of ARP-received socket.[22] Such further supports the stability of palatal tissue. Tissue shrinkage in each aspect can have different clinical relevance. The shrinkage on the facial aspect may affect aesthetics, but that on the oral aspect may not, even though the change on the latter was not negligible.

The profilometric changes reflect a tendency of tissue changes in the selected area. The ROI in the present study was established near pre-extraction GM and coronal to the MGJ because such a region is important for the emergence profile of implant prosthesis. The profilometric change was -1.0 ± 0.8 mm (-5.8 ± 4.9 mm^3) in group PC and -1.3 ± 0.5 mm (-7.3 ± 4.0 mm^3) in group SC, indicating a net loss of tissue. Such values were consistent with the tissue changes found in other studies,[16,18–20,23] ranging between -0.84 ± 0.3 mm and -1.5 ± 0.6 mm.

Interestingly, when group PC was divided into successful/unsuccessful PCs, more tissue shrinkage was found in the successful PC group. Despite a small number of the sites in each subgroup, such may indicate that the success of primary flap closure in ARP does not guarantee optimal soft tissue profile. Considerable surgical trauma from greater flap release might play a role in more tissue shrinkage in the subgroup of successful PC. From the authors' experience, a significant extent of tissue advancement is needed for PC for ARP due to irregular GMs and downgrowth of junctional epithelium in the periodontally damaged sockets.[13]

The tissue changes on the hard-tissue level appeared to be somewhat different from those on the soft-tissue level. In our previous study, the dimensional changes on the hard-tissue level slightly favored group SC,[13] whereas group PC is favored on the soft-tissue level (without statistically significant difference). Such was due to the difference in measurement levels between the analyses for hard and soft tissues. Considering that the thickness of soft tissue above the bone crest was generally around 2 mm, most of the reported tissue changes on the soft-tissue level occurred coronally from the bone crest. Such inconsistency between the changes on different tissue levels was also found in other studies.[16,20] Another factor explaining the difference may be the change in the soft-tissue thickness. Chappuis et al. found spontaneous soft tissue thickening at 8 weeks post-extraction.[24] Romito et al. also observed a similar phenomenon at 16 weeks post-ARP to compensate for hard tissue change below the soft tissue.[25] In the study by Song et al. (2020), soft tissue thickness from the bone surface was measured using cone-beam computed tomographic images,[26] but in the present study, it was hard to differentiate the soft tissue margin from the background due to similar radiodensity.

In terms of measuring the tissue change of the soft tissue level, the level of MGJ and the presence of KT are of importance. If the measurement is performed on the mobile tissue surface, that measurement can probably be either over or under-estimated. Therefore, the present authors first identified the MGJ prior to the measurement. Keeping the above in mind, the results of other studies should be critically appraised. In one study, the authors measured the soft and hard tissue changes at the 1, 3, and 5 mm levels below the soft tissue margin.[18] However, the mean KT height in that study was between 2.70 and 4.00 mm, potentially indicating that some measurement was done on the mobile tissue. In another study, the measurement was performed at the 1, 3, 5, and 7 mm levels below the bone crest for the teeth in the anterior maxilla.[25] One can suspect that some of the measurement levels, especially the level at the apical area, might be on the mobile tissue, considering the average height of KT in the anterior maxilla.[27]

4.2 | MGJ location and changes

To the authors' knowledge, this study was the first one reporting an effect of PC on the MGJ level in ARP for periodontally damaged sockets. Group SC yielded a significantly favorable MGJ location at T2 compared to group PC, but this finding should be cautiously interpreted due to the following: (1) different baseline values (despite no statistically significant difference between the groups), and (2) no significant difference in terms of the zonal change in the MGJ. A recent systematic review demonstrated that ARP with SC led to less KT loss than ARP with PC (mean difference = −2.42 mm).[28] Nonetheless, group SC presented more sites presenting >2 mm of KT, which may benefit in implant health considering the protective effect of KT.[29]

One study regarding methodology to measure KT demonstrated the superiority of digital assessment over conventional one using a periodontal probe in pig jaws.[30] The conventional assessment produced an overestimation by approximately 1 mm, owing to rounding error and the vertical position of the examiner's eyes. However, clinical situations after surgeries may differ somewhat from in vitro situations without surgical intervention. Clinically, scar tissue band, some corrugation on the soft tissue, and ambiguous junction between KT and non-KT zones can be observed after surgeries, which is also a source of measurement error. Thus, the present study identified MGJ by 1 mm height zone and confirmed additionally using clinical photographs.

4.3 | Limitation

This study has some limitations. First, the areas within the mobile mucosa had to be excluded from the analysis for reproducible measurements.[16] Thus, fewer patients were included in the analysis in group PC than in group SC at all measure levels, especially at SW3 (5 patients in group PC, 11 patients in group SC), which weakened statistical power. The same goes for the subgroups in group PC. Second, most sites in group PC presented wound dehiscence. Such unwanted wound dehiscence is mandated to use a full analysis set, not a per protocol set.

5 | CONCLUSION

For periodontally damaged sockets, ARP with PC tended to yield less soft tissue shrinkage than ARP without PC.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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