Pressure Bearing Device Affects Extraction Socket Remodeling of Maxillary Anterior Tooth. A Prospective Clinical Trial

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ABSTRACT

Background: Extraction socket remodeling and ridge preservation strategies have been extensively explored.

Purpose: To evaluate the efficacy of applying a micro-titanium stent as a pressure bearing device on extraction socket remodeling of maxillary anterior tooth.

Materials and Methods: Twenty-four patients with a extraction socket of maxillary incisor were treated with spontaneous healing (control group) or by applying a micro-titanium stent as a facial pressure bearing device over the facial bone wall (test group). Two virtual models obtained from cone beam computed tomography data before extraction and 4 months after healing were 3-dimenionally superimposed. Facial bone wall resorption, extraction socket remodeling features and ridge width preservation rate were determined and compared between the groups.

Results: Thin facial bone wall resulted in marked resorption in both groups. The greatest palatal shifting distance of facial bone located at the coronal level in the control group, but middle level in the test group. Compared with the original extraction socket, 87.61 ± 5.88% ridge width was preserved in the test group and 55.09 ± 14.46% in the control group.

Conclusions: Due to the facial pressure bearing property, the rigid micro-titanium stent might preserve the ridge width and alter the resorption features of extraction socket.

KEY WORDS: alveolar bone remodeling, bone regeneration, clinical study, cone beam CT, crestal bone resorption, extraction socket

INTRODUCTION

Implant therapy has recently focused on aesthetics rather than function alone. Restoring missing teeth in the aesthetic zone can be challenging due to the presence of tissue defect following tooth loss. Because the healing process of extraction socket is resorptive in nature, a substantial reduction of the alveolar ridge usually occurs. Study had revealed that 12 months after extraction the width of the alveolar ridge decreased by 50%, and the buccal side underwent more evident bone loss.[1] Unfortunately, ridge resorption might be more severe and problematic in the anterior maxilla, where the facial bone wall is often extremely thin and fragile.[2,3] The resultant tissue defects preclude the optimal aesthetic outcome of implant restoration, and further reconstructive surgery can usually not be avoided.[4,5]

To prevent drawbacks and find ways to avoid tissue defects after tooth loss, many studies have tried to reveal the healing and remodeling mechanism of extraction sockets. Using a canine model, Araujo and Lindhe reported that the loss of bundle bone after tooth extraction may be the cause of marked ridge

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reduction. Bundle bone develops with tooth eruption and comprises the alveolar bone wall, where periodontal ligaments insert. The resorption of bundle bone following tooth extraction seems unavoidable due to the lack of functional loading. A greater loss of the facial bone wall was attributed to the fact that it is mainly composed of bundle bone, which results in an apparent horizontal ridge alteration.[6]

Moreover, evidence indicates that similar bone remodeling mechanisms may be involved in post-extraction sockets in humans. A clinical study on maxillary single incisor or premolar described that a significant ridge reduction was noted after a short soft tissue healing period following tooth extraction, especially in the most coronal mid-buccal aspect. The facial bone wall exhibited an "inverted V shape" bone defect, and 42% of the subjects exhibited 4 mm or more of buccal bone loss.[5] A radiographic study based on cone beam computed tomography demonstrated that thin-wall phenotypes ($\leq$1 mm) displayed pronounced vertical bone resorption, with a median buccal bone loss of 7.5 mm in maxillary single incisor or premolar in a short healing period.[7] Other clinical studies also described this ridge alteration process; rapid facial bone wall resorption and the subsequent caving in of soft tissue led to marked horizontal ridge reduction.[8,9]

Bundle bone resorption is inevitable, but the alveolar ridge may be preserved by methods that would prevent subsequent soft tissue collapse. These methods could include supporting the labial gingival with a biologically compatible pressure bearing device. To our knowledge, this issue has not yet been explored. Our hypothesis is that tissue pressure from the labial side, which leads to gingival collapse, might play a role in ridge contour shrinkage. Counteracting the labial pressure might lead to better ridge preservation outcomes than spontaneous healing. The aim of this study was to evaluate the effect of applying a micro-titanium stent as a pressure bearing device on extraction socket remodeling of a maxillary anterior tooth compared with spontaneous socket healing.

MATERIALS AND METHODS

Patients Enrollment Protocol

This study was carried out from February 2014 to November 2015 at the Peking University School and Hospital of Stomatology, department of oral implantology. Subjects were selected from patients with a failing tooth who were in need of a single implant restoration of the middle or lateral maxillary incisor for different reasons. Twenty-four patients (13 males and 11 females), ranging in age from 19 to 45 years, with 24 maxillary incisors to be extracted, were enrolled in the present study. The inclusion and exclusion criteria were set as follow:

Inclusion criteria:

- At least 18 years of age
- Single tooth failure of an incisor in the maxillary (12-22) with neighbouring teeth of healthy periodontal conditions
- Intact facial bone wall at the time of tooth extraction
- Willing to return for the follow-up examinations

Exclusion criteria:

- Smoking
- History of periodontal disease
- Acute periapical or soft tissue inflammation
- Other systemic diseases or general health conditions that would contraindicate oral surgery treatment

The study was conducted in accordance with the Helsinki declaration of 1975 as revised in 2000, and the study protocol was approved by the local ethical committee (Institutional Review Board of Peking University School and Hospital of Stomatology, Approval Number: *PKUSSIRB-201423074*). Patients who met these criteria were informed about the study and signed the informed consent. The first 12 consecutive subjects were assigned to the test group, and the following 12 patients were assigned to the control group.

Surgical Procedure

Prior to tooth extraction, prophylactic antibiotic therapy (cefuroxime 0.25 g) was started 1 hour before surgery, and patients rinsed with a 0.2% chlorhexidine solution for 1 minute. During the surgery, the site was anesthetized on both the buccal and palatal aspects using Primacaine™ Adrenaline (Produits Dentaires Pierre Rolland, Acteon Pharma Division, Merignac, France). Flapless tooth extraction was performed as little trauma as possible. Any granulation

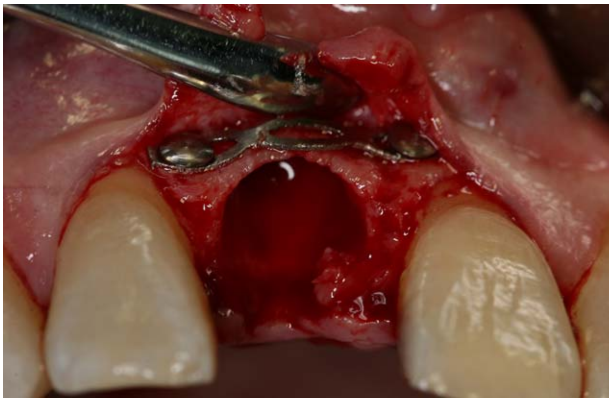

Figure 1 A micro-titanium stent was coronally fixed onto the facial bone wall of the extraction socket.

tissue was meticulously curated and irrigated with sterile saline solution. The integrity of the buccal wall was checked by intrasocket probing.

In the test group, the full thickness flap was then reflected 3–5 mm beyond the bone margin to expose the buccal wall of the extraction socket by intrasulcular incision extending to the neighbouring teeth. A micro-titanium stent (Xi'an Zhong Bang titanium biological materials, Xi'An, China) was trimmed and deformed to fit the convexity of the facial bone wall, and the coronal edge of the micro-titanium stent was placed within the buccal bone margin. The bilateral sites of the micro-titanium stent were fixed at the interalveolar septum area with mini pins. The soft tissue flap was repositioned and secured with single sutures, and no coronal advancement was intended. No bone graft materials were used, the socket was left to heal secondarily (Figure 1). In the control group, no additional treatment was performed after the extraction of the unsalvageable tooth.

The post-surgery healing process was monitored at recall visits, one week, one month and four months later. The micro-titanium stent was later removed at the time of implant placement surgery.

CBCT Measurement

All of the patients underwent cone beam computerized tomography (CBCT) scan before tooth extraction (base line) and 4 months later under the same projection conditions (Planmeca ProMax 3D, Planmeca Oy, Helsinki, Finland). The two sets of dicom® data were transferred to a volumetric imaging software (Mimics® 15.0, Materialise, Leuven, Belgium) in which three-dimensional reconstruction was performed, and virtual models were superimposed (Figure 2).

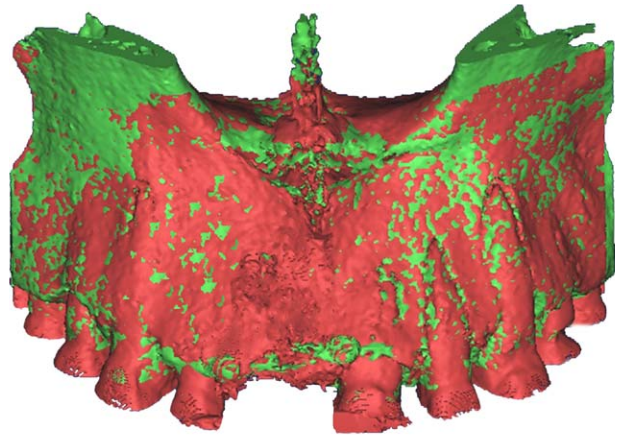

Figure 2 Superimposed images of the two 3-dimensional virtual maxilla. Red: before tooth extraction; Green: 4 months after healing.

After the virtual models had been superimposed, a sagittal plane (buccal-palatal) that bisected the residual tooth root mesio-distally was used to evaluate the socket remodeling (Figure 3). The bony profile of the extraction socket and the healed alveolar ridge were outlined, and the following landmarks were identified (Figure 4):

1. The most coronal points of the extraction socket were identified as *A* on the buccal side and *P* on the palatal side. The most coronal extensions of healed ridge in the buccal direction and the palatal section were marked as *A′* and *P′*, respectively;
2. Line "r" along the long axis of the alveolar ridge was drawn as a reference line. Three lines, "a", "b", and "c" perpendicular to line "r", were drawn.

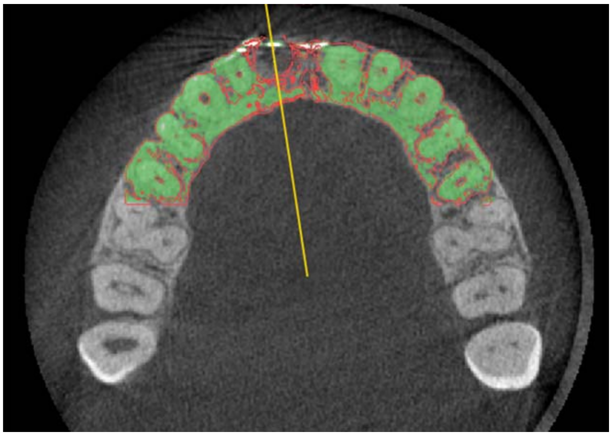

Figure 3 A sagittal plane (yellow line) that bisected the residual tooth root mesio-distally was used to evaluate socket remodeling.

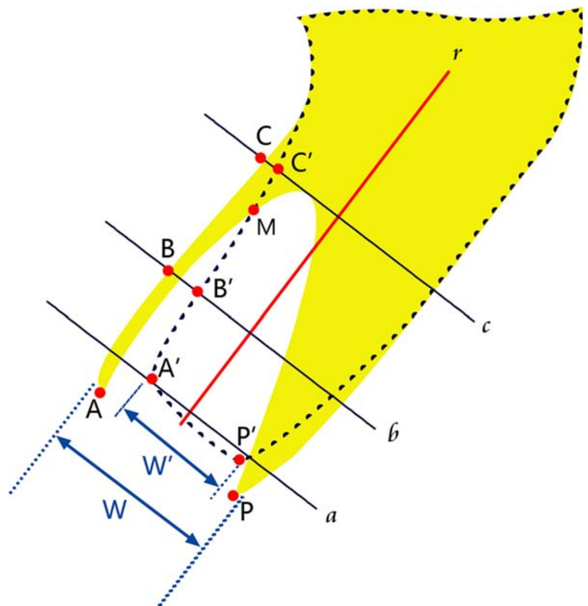

Figure 4 Schematic drawing of the landmarks for measurements. The yellow part represents the extraction socket, and the dotted brown line indicates the bony outline of the healed ridge 4 months post-extraction.

Line "a" passed through A′. Line "b" passed through the middle of the tooth root and intersected with the buccal outlines of the extraction socket and the healed ridge at *B* and *B*′. Line "c" passed through the apical end of the extracted tooth, and the intersection points were identified as *C* and *C*′;

3. The intersection point of the inner outline of the facial bone wall before tooth extraction with the buccal outline of the healed ridge was identified as *M*.

The following dimensions were measured using the ImageJ software (ImageJ, version 1.47, NIH, Bethesda, MD, USA):

1. The thickness of the facial bone wall of the extraction socket was recorded at the coronal, middle and apical positions.
2. The width of extraction socket $W = AP$ and healed ridge $W' = A'P'$; the vertical resorption of the buccal side: AA' projection to line "r", vertical resorption of palatal side: PP' projection to line "r".
3. The height of the resorbed facial bone wall: *AM* projection to line "r".
4. The palatal shifting distance of the facial bone wall at three different levels: AA' projection to line "a" (coronal), BB' (middle), CC' (apical).

Statistical Evaluation

All measurements were recorded in an Excel 2013 spreadsheet (Microsoft Corporation, Redmond, WA, USA), and transferred to SPSS version 13.0 (SPSS Inc., Chicago, IL, USA) for statistical analysis. The measurements for the two-time point (base line and 4 month post extraction) and the three different vertical levels were compared. If normally distributed data with approximately equal variances were present, parametric methods (Student's *t* test or multi-factor analysis of variance) were used. Otherwise, nonparametric tests (Mann–Whitney *U* test) were used instead. For all tests, a p-value < 0.05 was considered significant.

RESULTS

Tissue Healing and Implant Restoration

All of the healing processes were uneventful ($n = 24$). Soft tissue sealing was achieved after one month. Complete ridges covered with keratinized mucosa were detected at 4 months, with harmonious mucogingival lines present in both group. In the test group, no micro-titanium stent exposure was observed, but the micro-titanium stent and fixation pins could be detected through direct visualization in case of thin soft tissue or could be palpated in patient with relatively thick gingiva at the one-month follow-up appointment. One of the 12 subjects exhibited a fixation pin immobilization that was partially exposed at the four-month follow-up appointment; no signs of inflammation were noted.

Dental implants were successfully placed in all patients. In the test group, the micro-titanium stent was found to be encapsulated in the mucoperiosteum flap, and a thin layer of connective tissue was present between the stent and the healed ridge surface. Seven (58.3%) of the 12 subjects had simultaneous contour bone augmentation surgery for aesthetic reasons, and 5 (41.7%) of these patients did not need further bone grafting. In the control group, all of the patients ($n = 12$) needed simultaneous guided bone regeneration.

Radiographs

In both group, all of the extraction sockets exhibited a bony outline shrinkage in the ridge width and height after 4 months of healing. The buccal side

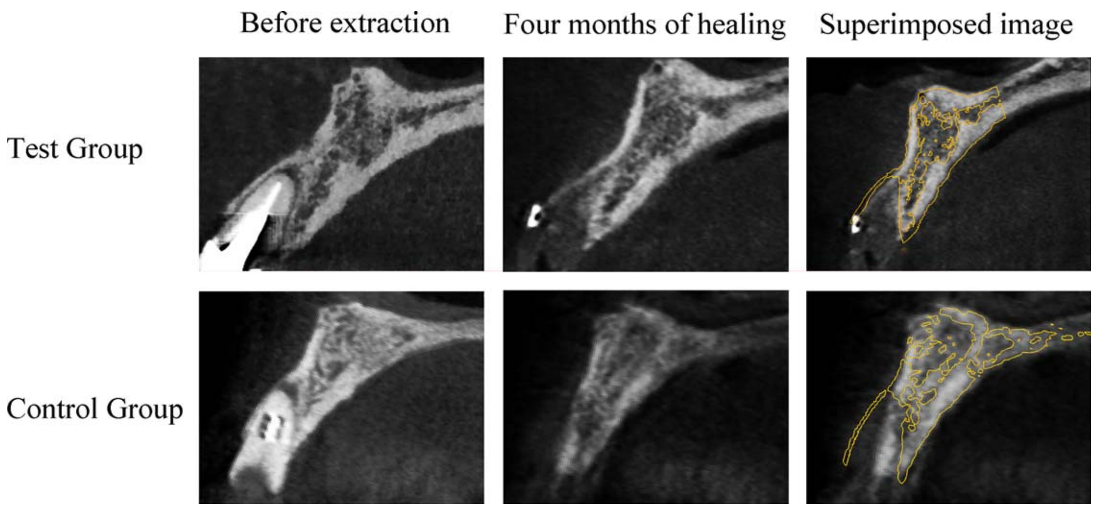

Figure 5 Sagittal slices before extraction and after healing, and superimposed images of the virtual models of the test and control groups (yellow line indicates the bony outline before extraction). Note the different ridge contours (middle column) after 4 months of healing.

exhibited a more pronounced contour change than the palatal side.

In the control group, the coronal region exhibited the most prominent width resorption due to the greatest degree of palatal shifting of the facial bone wall compared with the middle and apical levels. This resulted in a gradually narrowing trend from the apical to the coronal direction. In the test group, the most obvious ridge width reduction occurred at the middle level. The prominent facial bone wall became flat or concave in the middle buccal portion. Therefore, the residual ridge contours in the sagittal view of the test and control groups manifested in two different shapes after 4 months of healing (Figure 5).

In the sagittal slice of the superimposed image, 11 of the 12 micro-titanium stents did not hold the original position and migrated palatally, overlapping with the original facial bone wall of the extraction socket (Figure 6). The bilateral portion, which was fixed at the interalveolar septa did not show any movement. This observation implied that the micro-titanium stent underwent deformation to some degree during the 4-month healing period.

Measurements

The thickness of the facial bone wall was 0.57 ± 0.16 mm, 0.48 ± 0.14 mm, and 0.67 ± 0.29 mm at the coronal, middle and apical level respectively before tooth extraction in the test group and was 0.68 ± 0.25 mm, 0.54 ± 0.20 mm, and 0.68 ± 0.35 mm at the coronal, middle and apical levels, respectively, in the control group. No statistically significant differences were found between the groups. During the 4 months of healing, the facial bone wall had become markedly reduced. The dimension of the vertical resorption of the facial bone wall was 6.79 ± 2.88 mm in the test group and 7.85 ± 0.67 mm in the control group. No statistically significant differences between the groups were detected with respect to the height of facial bone wall resorption ($p = .33$) (Table 1).

The palatal shifting distance of the facial bone wall at the three different vertical levels (coronal, middle, apical) was 0.53 ± 0.25 mm, 1.21 ± 0.51 mm, and 0.51 ± 0.42 mm, respectively, in the test group and 2.45 ± 1.11 mm, 1.54 ± 0.81 mm, 0.79 ± 0.62 mm,

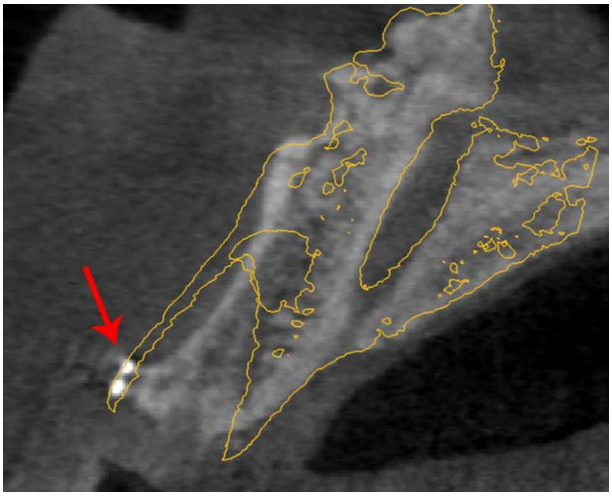

Figure 6 The micro-titanium stent (red arrow), which was originally located more buccally over the facial bone wall, did not retain this position and migrated palatally.

TABLE 1 Facial Bone Wall Thickness and Height of Facial Bone Wall Resorption After Four Months in Test and Control Groups

	Facial Bone Wall Thickness Before Extraction			
Group	Coronal	Middle	Apical	Height of Facial Bone Wall Resorption
Test	0.57 ± 0.16 mm	0.48 ± 0.14 mm	0.67 ± 0.29 mm	6.79 ± 2.88 mm
Control	0.68 ± 0.25 mm	0.54 ± 0.20 mm	0.68 ± 0.35 mm	7.85 ± 0.67 mm
p Value	0.25	0.32	0.37	0.33

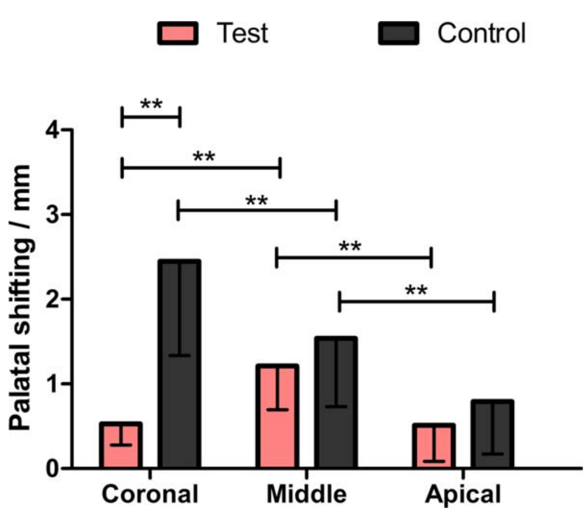

Figure 7 Comparison of the palatal shifting distance of the facial bone wall at different vertical levels between the test and control groups. The coronal region had a significantly smaller palatal shifting distance in the test group than did the control group; however, the middle and apical levels were not significantly different between groups (** $p < .01$).

respectively, in the control group. At the coronal level, the test group represented with a significantly smaller palatal shifting distance than did the control group ($p < .01$). No statistically significant differences were found at the middle ($p = .25$) and apical levels ($p = .21$) between the groups (Figure 7).

TABLE 2 Buccal-Palatal Ridge Width Before Tooth Removal and Four Months after Extraction and Ridge Width Preservation Rate in Test and Control Groups

Group	Ridge Width before Extraction	Ridge Width 4 Months after Extraction	Ridge Width Preservation Rate
Test	7.12 ± 0.52 mm	6.23 ± 0.65 mm	87.61 ± 5.88%
Control	6.97 ± 0.91 mm	3.85 ± 1.14 mm	55.09 ± 14.46%
p Value	0.66	<0.01	<0.01

The buccal-palatal ridge width before tooth extraction was 7.12 ± 0.52 mm in the test group and 6.97 ± 0.91 in the control group. No statistically significant differences were found between the groups ($p = .66$). Four months later, the ridge width was 6.23 ± 0.65 mm in the test group and 3.85 ± 1.14 mm in the control group ($p < .01$). The ridge width preservation rates were 87.61 ± 5.88% and 55.09 ± 14.46% in the test and control groups, respectively ($p < .01$) (Table 2).

After 4 months of healing, the vertical bone resorption of the alveolar ridge in the test group was 0.91 ± 0.43 mm at the buccal side and 0.61 ± 0.23 mm at the palatal site. In the control group, the bone height reduction on the buccal and palatal sides was 0.55 ± 0.39 mm and 0.47 ± 0.36 mm respectively. Only the buccal side in test group showed significantly more vertical bone resorption.

DISCUSSION

Aesthetic implant restoration requires not only three-dimensional alveolar bone around the implant, but also a sufficient amount of tissue to maintain both the gingival height and the labial soft tissue profile. This paradigm shift from function to aesthetics has attracted much more attention to the study of physiological ridge resorption following tooth removal and preservative strategies.

The findings concerning facial bone wall thickness in the present study are in agreement with the data from a radiographic study conducted by Januario and colleagues. The authors revealed that the facial bone wall in maxillary incisors and canines was on average only 0.6 mm wide but that in approximately 50% of such sites, the marginal portion of the wall was <0.5 mm wide.[7] Similar findings were also reported in other studies.[3,10,11] The thin facial bone wall would undergo marked resorption due to osteoclastic activity at the inner and outer surfaces of the socket walls,[6] and significant ridge resorption could be expected.[7,12]

Nevins and colleagues observed that a significant proportion of the facial bone wall would be lost after the removal of maxillary frontal teeth.[9] Farmer and Darby studied the range of facial bone wall reduction of a single maxillary extraction socket after 6–8 weeks of healing; they found that the facial bone wall resorbed in an "inverted V shape" and that 42% of the subjects had lost 4 mm or more of buccal bone at the midpoint of the extraction socket.[5] In a recent CBCT study, Araujo and colleagues reported that the buccal bone had diminished 3.6–4.2 mm after 4 months of healing and that the intrasocket grafting of xenograft cannot alter the resorption process.[13]

In the present study, the average vertical facial bone wall resorption were 6.79 mm in the test group and 7.85 mm in the control group, which is higher than the results of the other studies mentioned above. The reason for this discrepancy is most likely due to the different following time and measurement strategies. Farmer measured the bone defect at the re-entry surgery only 6–8 weeks post tooth extraction. Nevins and Araujo used the CBCT to evaluate bone remodeling, but they did not match the pre and post CBCT data three-dimensionally. However, by using the superimposed images, similar as we did in the current study, Chappuis and colleagues found a median vertical bone loss of 7.5 mm in thin-wall phenotypes ($\leq$1 mm),[12] which was comparable with our result. In our study, most cases had a very thin facial bone wall along the entire tooth root. If it is assumed that the bundle bone resorption is independent of location, completely buccal bone resorption might happened from coronal to apical site. Furthermore, the middle sagittal slice of extraction socket mesiodistally was chosen as the evaluation plan, where most severe bone resorption usually takes place.[7,8]

Few studies have documented the contour changes of the alveolar ridge following tooth extraction with natural healing. Schropp and colleagues demonstrated that the ridge is reduced by 50% over a 12-month healing period following extraction, which equates to approximately 5–7 mm[1]. Covani and colleagues reported a higher reduction in ridge width of 10.6 mm in posterior teeth after a mean healing time of 1.3 years.[8] In maxillary teeth in the aesthetic zone, Pelegrine and colleagues reported a 31.35 ± 11.88% reduction in bone width after 6 months of healing without grafting procedures.[14] In a dog model, Araujo and Lindhe found there was a 35% reduction in ridge thickness at the most coronal level 6 months after extraction.[15] These findings of horizontal ridge alterations are consistent with the results of the control group in our study. The horizontal ridge width was diminished by 44.9% on average, primarily due to the palatal shifting of the facial bone wall. However, a direct comparison of our results in the control group with the studies mentioned above should be carried out with caution due to the different tooth locations and different species.

To avoid the unfavorable clinical conditions caused by bone resorption after tooth loss and to maintain the original volume and contour of the alveolar process, ridge preservation techniques such as intrasocket grafting are now widely used. This technique is well documented in the literature and has been clinically proven to result in less dimensional change compared to spontaneous healing.[16,17] Better aesthetic outcomes and less invasive surgical interventions can be expected when using the intrasocket grafting procedure. The idea that preserving the tissue is better than reconstructing it is generally accepted.[18] However, complete alveolar ridge preservation cannot be accomplished.[19] Eskow and Mealey grafted the non-molar extraction sockets with cortical or cancellous allografts. The mean ridge width reduction after healing was 1.5 mm and 2.0 mm (15.19% and 20.41%) respectively.[20] Mardas and colleagues also report that nonmolar extraction sockets were preserved with the use of synthetic bone substitute or a bovine-derived xenograft combined with a collagen membrane; 1.1 mm (13.6%) and 2.1 mm (23.3%) width resorption was observed after 8 months of healing.[21] Similar findings regarding the preservation effectiveness of intrasocket grafting were presented by Wood and Mealey,[22] Pelegrine[14] and Borg and Mealey.[17] The results of those studies are comparable with the 87.61% width preservation rate found in the test group when using a micro-titanium stent rather than grafting material and/or barrier membrane.

The potential mechanism for the similar ridge width preservation effect of intrasocket grafting and the micro-titanium stent might be explained as follow. Bone graft material with osteoconductivity maintains the space for new bone formation by taking up the inner socket void, which is fully surrounded by a bony structure with the capability and cell sources for bone regeneration if the bone walls are intact. In the test group in our current study, the micro-titanium stent served as a rigid stent can also maintain the space by mechanically supporting the labial gingival tissue after buccal bundle bone resorption. This prevented the soft tissue from collapsing into the socket, where new bone regeneration was in process but lack sufficient mechanical strength to hold up the space against the potential pressure from the labial side. If the regeneration space can be well preserved and stably maintained, solid new bone formation can be expected without bone grafting materials.[23,24] Space maintenance might be the key factor for hard tissue preservation of the extraction socket, which can be achieved through "taking up" the space from the inner side with bone grafting materials or by "supporting" the labial soft tissue from the outside.

The full-thickness flap was elevated in the test group. For ethical reasons, a flapless procedure was carried out in the control group. Whether flap elevation results in additional ridge reduction after extraction is still controversial.[25,26] Comparing the significantly different residual bone width alterations of the two groups in the current study (87.61% versus 55.09%) after remodelling, the bone resorption caused by flap elevation was considered minimal. In addition, patients in the flap group (test group) exhibited much less bone resorption than did those in the flapless group (control group). Therefore, in the current study, raising a flap may not contribute to the different alveolar ridge resorption rates.

It is difficult to explain why the buccal side in the test group exhibited more vertical bone reduction (0.91 ± 0.43 mm versus 0.55 ± 0.39 mm in the control group). One possible explanation is that the coronal buccal points of the healed ridge in patients in the control group were far more close to the less reduced palatal ridge than were those in patients in the test group due to the extensive palatal shifting at the coronal level.

It is worth mentioning that the micro-titanium stent worked only as a pressure bearing device rather than a tissue exclusive membrane. At the time of implant placement surgery, the micro-titanium stent was found to be encapsulated in the labial soft tissue, which indicated that no barrier membrane effect was provided by the stent. More importantly, even the relatively rigid micro-titanium stent underwent slight deformation during the healing period. The middle portion of the stent, which overlaid the middle coronal buccal bone, did not stay in position and shifted palatally. The distortion of the micro-titanium stent implied the existence of soft tissue pressure against the coronal region during the healing period. Very few studies have mentioned the impact of soft tissue pressure on socket or bone remodeling. Mir-Mari and colleagues studied the volume stability of the augmented region with guided bone regeneration (GBR) technique during suturing of mucosal flaps.[27] They found that suturing of the mucosal flaps induced a considerable compressive forces on the coronal portion of the augmented site, which caused the displacement of particulated grafting materials and partial collapse of the collagen membrane.

In the test group in the current study, the most pronounced palatal shifting of the facial bone wall occurred at the middle level (1.21 ± 0.51 mm) compared with 0.53 ± 0.25 mm and 0.51 ± 0.42 mm at the crestal and apical levels. This result is inconsistent with the general trend of socket remodeling features, that is, the most pronounced horizontal bone reduction happened at the crestal region, with or without the intrasocket grafting procedure. Farmer and Darby found a 1.58 ± 1.25 mm ridge thickness loss at the crestal level and 1.04 ± 0.80 mm and 0.21 ± 0.58 mm at more apical levels in spontaneously healing sockets.[5] Lambert and colleagues grafted the extraction socket with bovine hydroxyapatite and found that the horizontal dimension of the crest decreased by 1.6 mm (20%) in the cervical regions (2 mm subcrestal), decreased moderately by 1 mm (12%) at the 5 mm subcrestal level and decreased very little, 0.5 mm (6%), at the apical level (8 mm subcrestal).[28] The results of an animal study by Araujo and Lindhe were also in agreement with this extraction socket remodeling feature.[6]

The different remodeling features induced by the introduction of the micro-titanium stent in the test group might be explained as follows. After the rapid resorption of thin facial bone wall,[6] the provisional matrix in the socket cannot maintain the space stably due to soft tissue pressure from the labial side, which leads to the palatal shifting of soft tissue and the subsequent reduction of alveolar bone width. The crestal region, which often has the most prominent shape and widest bone defect after bundle bone resorption has the most instable property and is prone to lose its volume.[5] However, the micro-titanium stent provided mechanical strength and counteracted the labial pressure, thereby greatly increasing tissue volume stability and resulting in better bone preservation at the crestal side.

The results of this investigation should be interpreted cautiously due to the lack of randomization and the small number of patients; however, this might be the first study to introduce the anti-pressure strategy, by using the micro-titanium stent, to preserve the alveolar ridge of the extraction socket of maxillary incisors. This method resulted in acceptable preservation effect and altered the remodeling features of the extraction socket. It also implies that soft tissue pressure from the labial side might contribute to the bone remodeling of extraction socket in the maxillary frontal area. Further studies are needed to verify this technique and the hypothesis on which it is based.

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SUPPORTING INFORMATION

Additional Supporting Information may be found in the online version of this article.