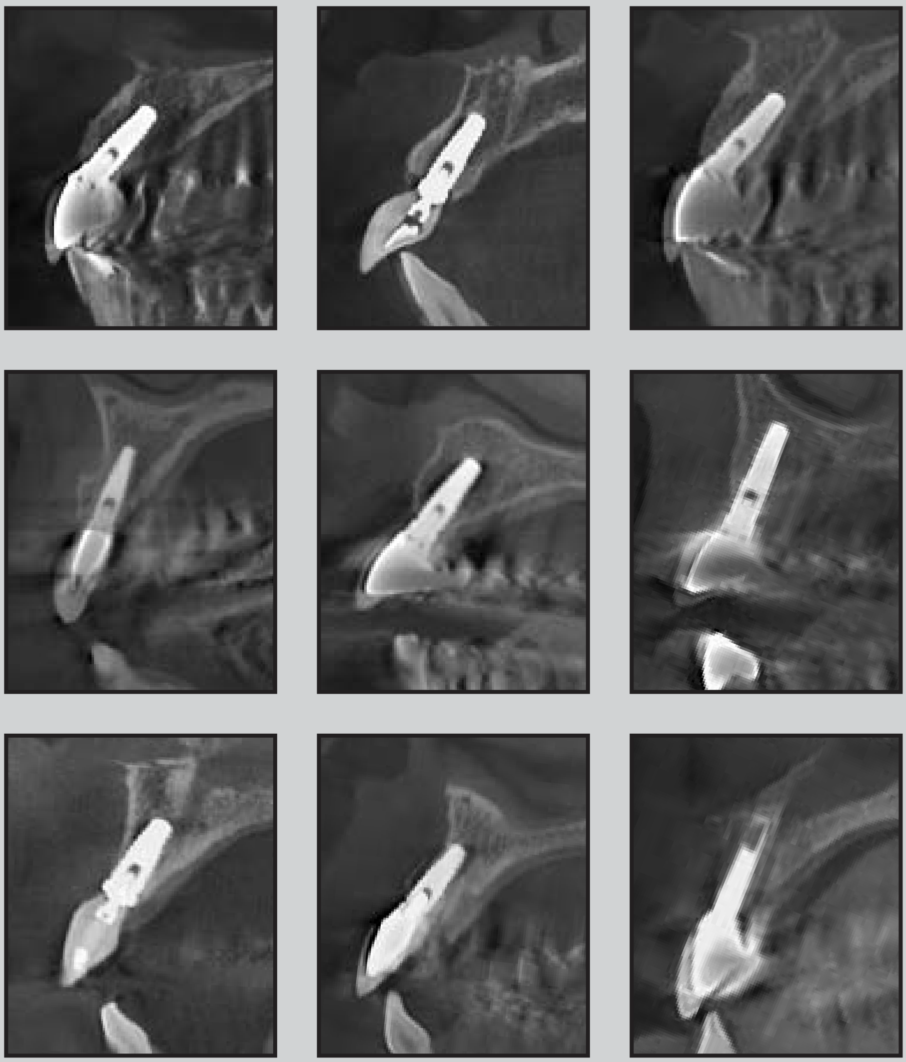

Dental Cone Beam Computed Tomography Analyses of Postoperative Labial Bone Thickness in Maxillary Anterior Implants: Comparing Immediate and Delayed Implant Placement

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This study aimed to evaluate the influence of labial alveolar bone thickness and the corresponding vertical bone loss on postoperative gingival recessions around anterior maxillary dental implants. Using cone beam computed tomography (CBCT) scanning, the temporal changes of three-dimensional images of alveolar bone were monitored to determine hard and soft tissue outcomes of two different implant placement techniques: delayed two-stage and immediate placement. Furthermore, for the delayed two-stage placement, guided bone regeneration was applied using either nonresorbable or resorbable membranes combined with anorganic bovine bone matrix. The comparative results suggested that gingival recessions were significantly lower in delayed two-stage placement, especially when using a nonresorbable membrane, compared to immediate placement, and labial bone thickness, measured by CBCT, offered an effectual indicator to assess gingival recession in the anterior region. (Int J Periodontics Restorative Dent 2011;31:215–225.)

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Implant placement in the esthetic zone should preserve the natural mucogingival appearance at the margin of the implant suprastructure. In responding to this challenge, implant placement techniques have met varying degrees of success. Immediate implant placement following tooth extraction, originally reported by Lazzara,[1] has advantages such as a short healing time, reduced number of surgeries (only one generally), and a relatively excellent esthetic outcome. On the other hand, labial gingival recession, which is caused by postoperative labial alveolar bone loss, has been reported as a drawback to this approach.[2–4] Araújo and Lindhe[5] reported that the average loss of alveolar bone in a canine model was 2.2 mm at 8 weeks following tooth extraction. Nevins et al[6] reported that human extraction sockets demonstrated a loss of more than 20% of the buccal alveolar bone without ridge preservation. Araújo et al[7] also reported that vertical resorption of the labial alveolar bone was approximately 2.6 mm in cases of immediate implant placement into the extraction sites. Therefore, they suggested that implant placement may not be preferentially applied to the immediate extraction socket because of such predictable bone resorption. Botticelli et al[8,9] compared the effects between immediate and delayed implant placement on alveolar bone loss using animal models as well as human subjects. They reported that both vertical and horizontal resorption of labial alveolar bone were greater in immediate implant placement than delayed implant placement. Grunder's clinical report[10] noted that an average gingival recession of 0.6 mm occurs on the labial aspect during the first year after implant placement using the delayed two-stage method. Other reports[11–15] also have indicated gingival recession at the labial aspect after completion of restorative procedures with the implant placed by the delayed two-stage technique. By evaluating the delayed two-stage method, Grunder et al[16] reported that labial alveolar bone thickness should be at least 2 mm to prevent gingival recession. Buser et al[17,18] reported that early implant placement with guided bone regeneration (GBR) was able to obtain stable esthetic facial soft and hard tissue contours. However, for immediate implant placement in the esthetic zone, no such estimate of alveolar bone thickness has been established.

Changes in labial alveolar bone following implant placement[19–21] appear to cause gingival recession or changes in the contour of the gingivae, which, in turn, can create esthetic problems. Therefore, it is critical to monitor the temporal changes of the labial alveolar bone structure after implant placement. This can only be accomplished by a device that provides a three-dimensional view of the hard tissue and do so in a noninvasive manner. The recently developed cone beam computed tomography (CBCT) scan for dental imaging meets these requirements easily, with the added benefit of decreased x-ray exposure. Therefore, using CBCT, the present study evaluated the effects of alveolar bone thickness and vertical loss on temporal changes in peri-implant soft tissue following implant placement in the maxillary anterior region by comparing the delayed two-stage and immediate implant placement techniques.

Method and materials

Study subjects and procedures

A total of 31 implants were placed in the maxillary anterior regions of 18 subjects (8 men, 10 women) whose ages ranged from 22 to 72 years. All subjects signed an informed consent form prior to the start of clinical procedures. The demographic characteristics of the patients are shown in Table 1. Acid-etched surface titanium implants (n = 27; Osseotite, Biomet 3i) and phosphate-enriched titanium oxide surface implants (n = 4; NobelReplace, Nobel Biocare) were used. One of the following three surgical approaches was applied to each implant: *(1)* group 1 = delayed two-stage technique using nonresorbable GBR membrane with a mixture of anorganic bovine bone matrix (ABBM; Bio-Oss, Geistlich) and freeze-dried bone allograft (FDBA; OraGRAFT, LifeNet Health), *(2)* group 2 = delayed two-stage technique using resorbable GBR membrane with the same graft materials as group 1, and *(3)* group 3 = immediate implant placement technique accompanied by autogenous bone graft (Figs 1 and 2). The abutments and implants were placed at the same time without occlusal loading.

Timing for definitive restoration

To promote efficient hard and soft tissue wound healing sufficiently for immediate implant placement, impressions for the definitive restorations were taken using a custom temporary impression coping 3 to 6 months after surgery. In patients who underwent two-stage implant placement, impressions for the definitive restorations were taken 2 to 4 months after stage-two surgery. The definitive restoration was achieved by placing ceramic crowns on top of zirconia or aluminum oxide abutments.

Table 1 Demographic data and clinical outcomes of patients

	Implant no.	Age, sex	Tooth no.*	Time since setting abutment (mos)	Width of labial alveolar bone (mm) Cervical section	Width of labial alveolar bone (mm) Middle section	Vertical bone resorption (mm)	Gingival recession (mm)
Group 1	1	49, M	11	17	2.53	2.14	0.00	0.00
	2	46, M	11	28	2.07	2.46	0.00	0.00
	3	46, M	12	28	2.74	2.13	0.00	0.00
	4	46, M	11	48	1.94	3.09	0.00	0.00
	5	36, F	12	48	2.30	3.73	0.00	0.00
	6	36, F	13	48	2.13	3.03	0.00	0.00
	7	40, F	11	10	3.26	3.33	0.00	0.00
	8	47, M	11	17	4.18	4.03	0.00	0.00
	9	56, F	12	25	1.46	2.29	0.00	0.00
	10	56, F	21	25	2.88	2.88	0.00	0.00
	11	56, F	22	25	1.63	2.19	0.00	0.00
	12	68, M	21	40	1.85	1.79	0.00	0.00
	13	69, F	11	21	2.30	3.45	0.00	0.00
	14	69, F	21	21	2.21	3.09	0.00	0.00
	15	69, F	13	21	0.80	1.35	1.12	1.00
	16	38, F	12	12	1.25	3.15	1.00	0.00
	Mean ± SD			27.12 ± 12.46	2.22 ± 0.81	2.76 ± 0.74	0.13 ± 0.36	0.06 ± 0.25
Group 2	17	45, F	22	14	1.18	1.74	0.00	0.00
	18	45, F	21	14	2.29	3.02	0.00	0.00
	19	53, F	11	6	1.74	2.14	0.00	0.00
	20	53, F	21	6	1.79	2.35	0.00	0.00
	21	66, F	13	18	1.01	1.13	1.26	1.00
	22	66, F	11	18	0.00	2.75	1.86	1.00
	23	66, F	21	18	1.18	1.74	0.00	1.00
	24	66, F	23	18	0.00	1.75	2.50	1.00
	Mean ± SD			14.00 ± 5.24	1.15 ± 0.82	2.08 ± 0.62	0.70 ± 1.02	0.50 ± 0.53
Group 3	25	38, F	12	36	0.00	1.86	2.23	1.00
	26	24, M	21	53	0.00	1.18	4.25	1.00
	27	48, M	11	51	1.74	1.43	0.00	0.00
	28	36, M	21	50	0.00	0.00	13.13	2.00
	29	34, F	21	57	0.00	0.95	3.15	1.50
	30	34, F	12	57	0.88	1.60	0.00	0.00
	31	51, F	11	25	0.71	1.29	0.00	0.50
	Mean ± SD			47.00 ± 12.01	0.48 ± 0.67	1.19 ± 0.60	3.25 ± 4.68	0.85 ± 0.75
Overall mean ± SD				28.22 ± 15.80	1.55 ± 1.06	2.23 ± 0.92	0.98 ± 2.51	0.35 ± 0.57

M = male; F = female; SD = standard deviation.
*FDI tooth-numbering system.

Fig 1 *Patient 1.*

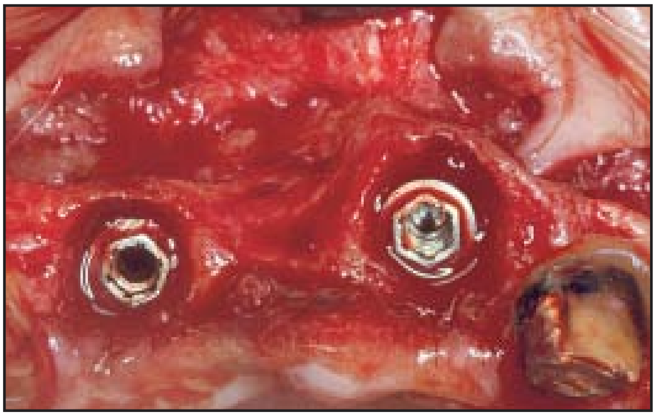


Fig 1a *A 34-year-old woman underwent immediate implant placement at the maxillary left central incisor and right lateral incisor sites. An autogenous bone graft was placed into 2.0-mm and 1.0-mm gaps, respectively.*

Fig 1b *Four years after receiving the definitive restorations, the abutment at the left central incisor site was exposed, a result of gingival recession.*

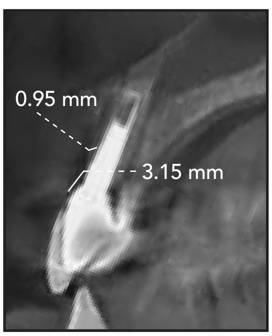


Fig 1c *Concurrent CBCT scan demonstrated vertical bone resorption of the labial bone (3.15 mm).*

Dental CBCT

Evaluations of labial alveolar bone thickness and corresponding vertical resorption were performed at least 6 months after setting the abutment using a dental CBCT scanner (3DX multi-image micro-CT; 3D Accuitomo, Morita). The time between setting the abutment and evaluation with the CBCT scanner ranged from 6 to 57 months (mean, 28.2 months). The focal planes of all CBCTs were adjusted to the center of the buccolingual aspect of the implant, as well as the mesiodistal (longitudinal) aspect. Then, the thickness of the labial bone was measured to within 1/100 mm, perpendicular to the implant surface at 1.5 mm (cervical width) and 5.0 mm (middle section width) from the implant platform on the image display of the CBCT using the distance measurement tool. Vertical bone resorption was measured from the implant platform to the alveolar ledge.

Fig 2 *Patient 2.*

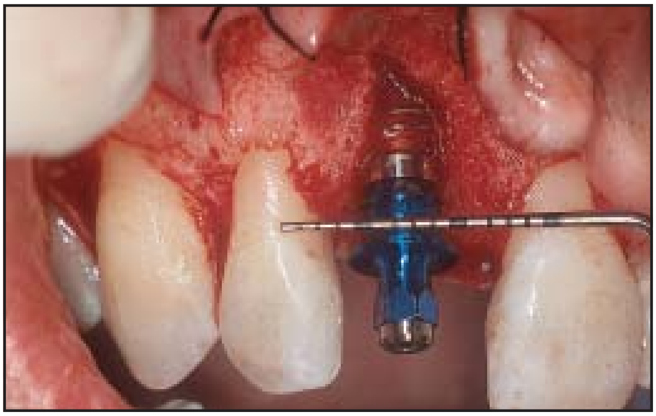


Fig 2a *A 45-year-old man underwent extraction of his maxillary right central incisor because of root fracture. Implant placement was performed 6 weeks after extraction to allow for soft tissue healing.*

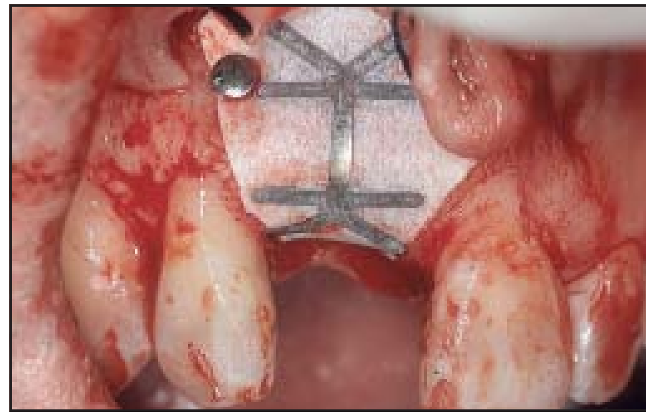


Fig 2b *GBR was performed using a 7:3 mixture of ABBM and FDBA combined with a nonresorbable titanium-reinforced membrane.*

Fig 2c *Sufficient horizontal augmentation of the labial alveolar bone (balcony) was observed.*

Fig 2d *An excellent esthetic outcome was obtained right after treatment.*

Fig 2e (right) *Radiograph taken 2.5 years after stage-two surgery.*

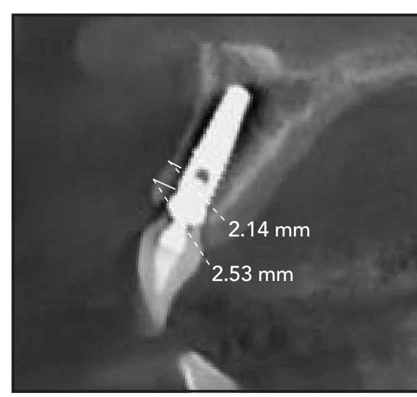


Fig 2f *CBCT taken 2.5 years after stage-two surgery. Labial alveolar bone thickness was sufficient, while its height was maintained at the level of the implant platform.*

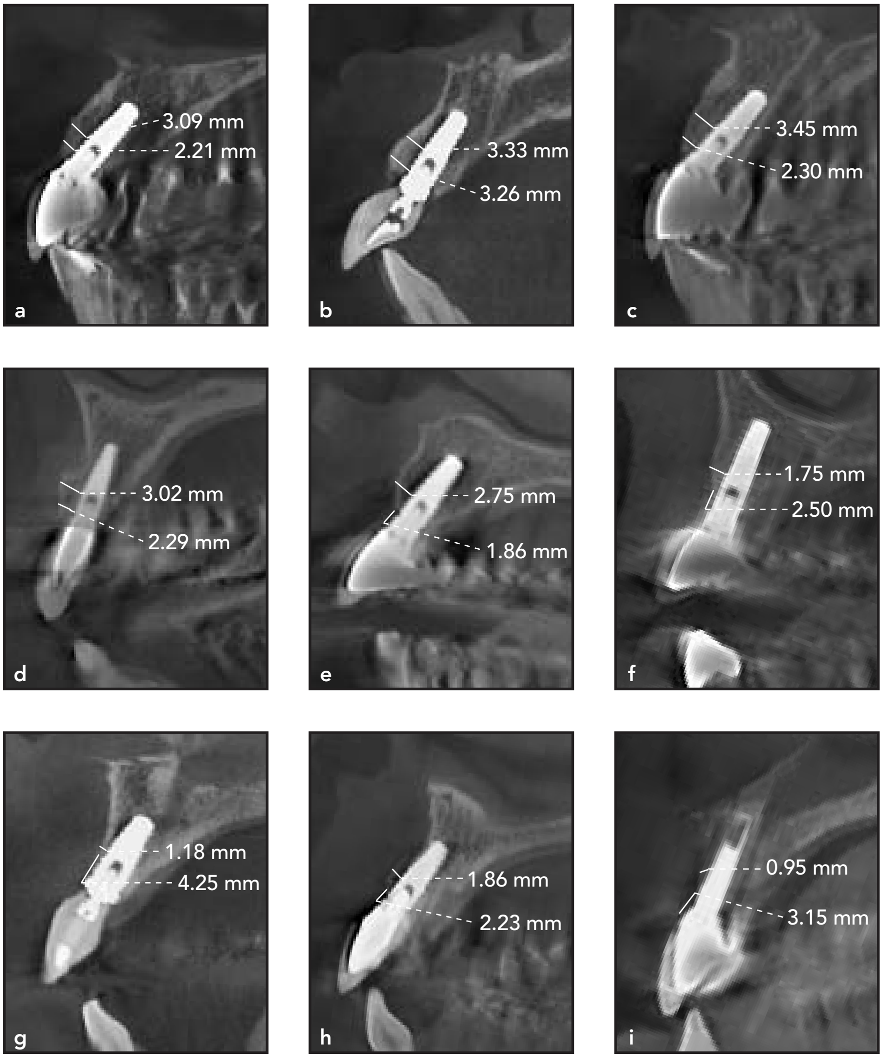
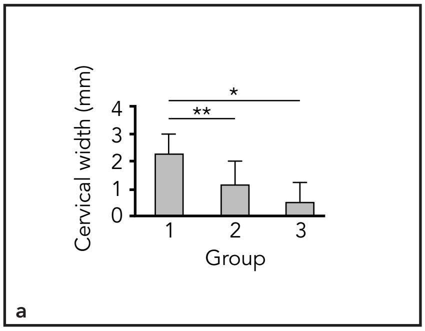
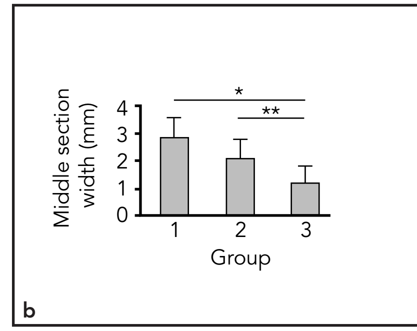


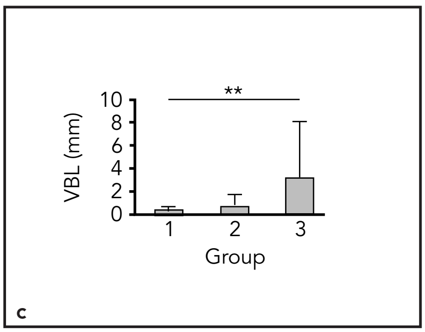
Fig 3 (a to c) *Group 1: Typical postoperative CBCT images. This method reliably creates thick labial bone because a titanium-reinforced membrane demarcates space for bone formation.* (d to f) *Group 2: These CBCT images represent prevalent results using a resorbable membrane. This method is less reliable for creating space for thick labial bone, since the softer collagen membrane can collapse easily from pressure exerted by soft tissue. Labial bone thickness is typically less than that in group 1. Vertical bone resorption or the risk of its future occurrence is therefore greater.* (g to i) *Group 3: Typical postoperative CBCT images. Labial bone thickness is much less and vertical bone resorption is significantly greater compared to group 1.*

Labial gingival recession

Labial gingival recession was measured using a digital camera at 0.5-mm rounding intervals, calculating the distance on the computer display in comparison to the actual crown length. These data were analyzed based on the immediate and delayed techniques. Different membrane types—nonresorbable and resorbable—were also investigated (Fig 3).







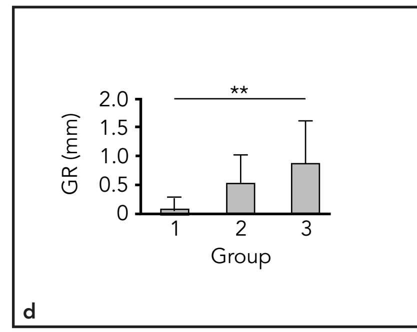


Fig 4 *Comparison of the levels of* (a) *cervical and* (b) *middle section labial alveolar bone width,* (c) *vertical bone loss* (VBL), *and* (d) *gingival recession* (GR) *among the different groups. *P < .01, **P < .05; Tukey-Kramer multiple comparison test.*

Results

The measurements of individual subjects' cervical width, middle section width, vertical bone loss, and gingival recession, as well as the means of these measurements in each group, are shown in Table 1 and Fig 4, respectively. Group 1 maintained the most sufficient esthetic mucogingival conditions based on minimal gingival recession supported by ample alveolar bone with little vertical bone loss (see Table 1). On the other hand, in group 2, 50% of sites showed measurable gingival recession and corresponding vertical bone loss, as well as decreased labial alveolar bone (see Table 1). In group 3, 71% of patients showed remarkable gingival recession (see Table 1). Thickness of labial alveolar bone at the cervical area of the implant (cervical width) for group 1 was significantly higher than that for groups 2 and 3 ($P < .05$, Tukey-Kramer multiple comparison test), whereas the difference between groups 2 and 3 did not meet the threshold of statistical significance (group 1, 2.22 ± 0.81 mm; group 2, 1.15 ± 0.82 mm; group 3, 0.48 ± 0.67 mm) (Fig 4a). Thickness of labial alveolar bone at the midpoint of the implant (middle section width) for group 3 was significantly lower than that for groups 1 and 2 ($P < .05$; group 1, 2.76 ± 0.74 mm; group 2, 2.08 ± 0.62 mm; group 3, 1.19 ± 0.60 mm) (Fig 4b). These results indicate that resorption of labial alveolar bone during the postoperative period appears to progress in an increasing order: group 1 ≤ group 2 ≤ group 3.

The level of vertical bone loss was significantly greater in group 3 than group 1 (Fig 4c). There was no significant difference in vertical bone loss between group 2 and groups 1 or 3 (group 1, 0.13 ± 0.36 mm; group 2, 0.70 ± 1.02 mm; group 3, 3.25 ± 4.68 mm). Very interestingly, gingival recession follows a similar overall pattern (group 1, 0.06 ± 0.25 mm; group 2, 0.50 ± 0.53 mm; group 3, 0.85 ± 0.75 mm) (Fig 4d).

Table 2	**Correlation between alveolar bone width and VBL or GR**	
	Correlation coefficient	***P***
Cervical width vs VBL	–0.548	< .01
Middle section width vs VBL	–0.582	< .001
Cervical width vs GR	–0.760	< .001
Middle section width vs GR	–0.686	< .001
VBL vs GR	0.784	< .001

VBL = vertical bone loss; GR = gingival recession.

Table 3 Sensitivity and specificity of three different measurements to detect gingival recession

Test	Cut-off point	Sensitivity	Specificity
Cervical width	< 1.2 mm	[10 / (10 + 0)] x 100 = 100.0%	[19 / (19 + 2)] x 100 = 90.5%
Middle section width	< 2.0 mm	[9 / (9 + 1)] x 100 = 90.0%	[17 / (17 + 4)] x 100 = 81.0%
VBL	≥ 1.0 mm	[8 / (8 + 2)] x 100 = 80.0%	[20 / (20 + 1)] x 100 = 95.2%

VBL = vertical bone loss.

There was a negative, but significant, correlation between vertical bone loss and cervical width, as well as middle section width (Table 2). Both cervical width and middle section width also showed a significant negative correlation to gingival recession (Table 2). Accordingly, as expected, vertical bone loss and gingival recession showed a significant positive correlation (Table 2). These data suggest that gingival recession that occurs after implant placement in the anterior region could be negatively associated with alveolar bone thickness as well as the level of alveolar bone loss at the labial aspect.

To evaluate the efficiency of CBCT scanning in the detection of gingival recessions, both the sensitivity and specificity of three different measurements (cervical width, cut-off level: 1.2 mm; middle section width, cut-off level: 2.0 mm; and vertical bone loss, cut-off level: 1.0 mm) were calculated and are shown in Table 3. Both sensitivity and specificity according to cervical width (100% and 90.5%, respectively), were higher than those of middle section width (90.0% and 81.0%, respectively). While specificity of vertical bone loss (95.2%) was higher than cervical width (90.5%), sensitivity was lower (80.0% and 100.0%, respectively). Overall, the measurement of cervical width using CBCT appeared to best detect gingival recessions. In other words, after implant placement in the anterior region, gingival recession seemed to be mitigated by a labial bone thickness of more than 1.2 mm at the cervical area of the implant.

Discussion

The thickness of the labial alveolar bone and its corresponding level of vertical resorption were measured in patients who underwent implant placement in the maxillary anterior region, using either an immediate or delayed two-stage placement, by CBCT, and the relationship between each measurement and gingival recession was analyzed. Gingival recession was minimal in sites where the labial alveolar bone thickness at the cervical area of the implant was approximately 1.2 mm or more at the postoperative measurement. Therefore, if the assumed threshold of 1.2 mm obtained at least 6 months after implant placement, as determined by CBCT, is added to the approximate 0.7 mm, which is the average bone resorption level concomitant to removal of the periosteum during the operation,[22] then the criterion of 2.0 mm appears to be satisfied (0.7 mm + 1.2 mm = 1.9 mm).

Because the periodontal ligament provides an adequate blood supply, the labial alveolar bone of natural teeth remains stable for a number of years, even when it is less than 1 mm wide.[23,24] Even in implants that lack periodontal ligament tissue, alveolar bone that has developed around the implant will supply enough blood as long as it is composed of cancellous bone containing a relatively large number of blood vessels. It is estimated that a labial alveolar bone width of more than 1.2 mm is required to induce cancellous bone beneath cortical bone, which, in turn, maintains long-term tissue stability.

Grunder et al[16] stated that the majority of esthetic implant cases required GBR to avoid gingival recession caused by alveolar bone resorption. Resorption of the alveolar ridge and changes in the position of the marginal gingiva may occur unless the labial alveolar bone thickness is approximately 2.0 mm. If the labial alveolar bone thickness is approximately 2.0 mm at the time of implant placement, approximately 0.7 mm of bone resorption will occur when removing the periosteum.[23] Therefore, the use of GBR should be based on a criterion that labial alveolar bone thickness is ≥ 2 mm at the time of implant placement. It is noted that GBR should be performed in many cases to maintain adequate labial alveolar bone height and the position of the marginal gingiva.

In the present study, immediate implant placement (group 3) was applied to sites showing intact labial bone. However, postoperative CBCT scans showed an average 3.25 mm of vertical bone resorption among the seven sites receiving immediate placement. The amount of vertical bone resorption may be sufficient to effect soft tissue esthetics. These results suggest that immediate implant placement may require technical modifications so that healthy hard tissue can be preserved, maintaining 2 mm of labial bone thickness after completion of restorative treatment.

A total of 24 implants were placed in the two groups undergoing two-stage delayed implant placement with GBR and the same graft materials (groups 1 and 2), and a trend of increased labial alveolar bone resorption was observed in group 2 compared to group 1 (Fig 4). These results indicate that the long-term stability of the peri-implant tissue was sufficiently retained by the technique using a combination of a nonresorbable membrane and ABBM + FDBA. Many studies have used only ABBM for bone grafting,[6,25] and this material clearly contributes to long-term hard tissue stability around the implant.[26] However, based on previous clinical experience using ABBM as the sole grafting material, residual ABBM granules were observed in patients after removal of their membranes at the 6-month recall, suggesting incomplete bone replacement. Therefore, to promote bone regeneration, a mixture of ABBM and FDBA, which has a swift absorption property and promotes bone replacement capacity, was employed in this study. Indeed, excellent results were obtained, showing that alveolar bone became sufficiently hard at the 6-month recall upon removal of the membrane.

Conclusion

The present study demonstrated that gingival recession was significantly lower using a delayed two-stage placement method compared to immediate placement, and vertical bone resorption and the resulting gingival recession can be mitigated if ≥ 2.0 mm of labial bone thickness is maintained in the anterior region for both implant placement methods (immediate and delayed). Most importantly, such minute measurement of alveolar bone width could only be achieved through CBCT, as applied in this study. Since these data were obtained from a relatively small number of subjects, clinical studies using a larger number of participants are required in the future.

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References

1. Lazzara RJ. Immediate implant placement into extraction sites: Surgical and restorative advantages. Int J Periodontics Restorative Dent 1989;9:332–343.
2. Kan JY, Rungcharassaeng K, Sclar A, Lozada JL. Effects of the facial osseous defect morphology on gingival dynamics after immediate tooth replacement and guided bone regeneration: 1-year results. J Oral Maxillofac Surg 2007;65(suppl 1):13–19 [erratum 2008;66:2195–2196].
3. Evans CD, Chen ST. Esthetic outcomes of immediate implant placements. Clin Oral Implants Res 2008;19:73–80.
4. De Rouck T, Collys K, Cosyn J. Immediate single-tooth implants in the anterior maxilla: A 1-year case cohort study on hard and soft tissue response. J Clin Periodontol 2008;35:649–657.
5. Araújo MG, Lindhe J. Dimensional ridge alterations following tooth extraction. An experimental study in the dog. J Clin Periodontol 2005;32:212–218.
6. Nevins M, Camelo M, De Paoli S, et al. A study of fate of the buccal wall of extraction sockets of teeth with prominent roots. Int J Periodontics Restorative Dent 2006;26:19–29.
7. Araújo MG, Sukekava F, Wennström JL, Lindhe J. Ridge alteration following implant placement in fresh extraction sockets: An experimental study in the dog. J Clin Periodontol 2005;32:645–652.
8. Botticelli D, Persson LG, Lindhe J, Berglundh T. Bone tissue formation adjacent to implants placed in fresh extraction sockets: An experimental study in dogs. Clin Oral Implants Res 2006;17:351–358.
9. Botticelli D, Berglundh T, Lindhe J. Hard-tissue alterations following immediate implant placement in extraction sites. J Clin Periodontol 2004;31:820–828.
10. Grunder U. Stability of mucosal topography around single-tooth implants and adjacent teeth: 1-year results. Int J Periodontics Restorative Dent 2000;20:11–17.
11. Small PN, Tarnow DP. Gingival recession around implants: A 1-year longitudinal prospective study. Int J Oral Maxillofac Implants 2000;15:527–532.
12. Small PN, Tarnow DP, Cho SC. Gingival recession around wide-diameter versus standard diameter implants: A 3- to 5-year longitudinal prospective study. Pract Proced Aesthet Dent 2001;13:143–146.
13. Bengazi F, Wennström JL, Lekholm U. Recession of the soft tissue margin at oral implants. A 2-year longitudinal prospective study. Clin Oral Implants Res 1996;7:303–310.
14. Cardaropoli G, Lekholm U, Wennström JL. Tissue alterations at implant-supported single-tooth replacements: A 1-year prospective clinical study. Clin Oral Implants Res 2006;17:165–171.
15. Oates TW, West J, Jones J, Kaiser D, Cochran DL. Long-term changes in soft tissue height on the facial surface of dental implants. Implant Dent 2002;11:272–279.

16. Grunder U, Gracis S, Capelli M. Influence of the 3-D bone-to-implant relationship on esthetics. Int J Periodontics Restorative Dent 2005;25:113–119
17. Buser D, Bornstein MM, Weber HP, Grutter L, Schmid B, Belser UC. Early implant placement with simultaneous guided bone regeneration following single-tooth extraction in the esthetic zone: A cross-sectional retrospective study in 45 subjects with a 2- to 4-year follow-up. J Periodontol 2008;79:1773–1781.
18. Buser D, Hart C, Bornstein MM, Grutter L, Chappuis V, Belser UC. Early implant placement with simultaneous GBR following single-tooth extraction in the esthetic zone: 12-month results of a prospective study with 20 consecutive patients. J Periodontol 2009;80:152–162.
19. Covani U, Cornelini R, Barone A. Buccolingual bone remodeling around implants placed into immediate extraction sockets: A case series. J Periodontol 2003;74:268–273.
20. Covani U, Bortolaia C, Barone A, Sbordone L. Buccolingual crestal bone changes after immediate and delayed implant placement. J Periodontol 2004;75:1605–1612.
21. Covani U, Cornelini R, Barone A. Vertical crestal bone changes around implants placed into fresh extraction sockets. J Periodontol 2007;78:810–815.
22. Wood DL, Hoag PM, Donnenfeld OW, Rosenfeld LD. Alveolar crest reduction following full and partial thickness flaps. J Periodontol 1972;43:141–144.
23. Kamijo M. Oral Anatomy, vol 1. Tokyo: Anatome, 1980:182.
24. Nobuto T, Yanagihara K, Teranishi Y, Minamibayashi S, Imai H, Yamaoka A. Periosteal microvasculature in the dog alveolar process. J Periodontol 1989;60:709–715.
25. Dahlin C, Simion M, Hatano N. Long-term follow up on soft and hard tissue following guided bone regeneration treatment in combination with a xenogeneic filling material: A 5-year prospective clinical study. Clin Implant Dent Relat Res 2010;12:263–270.
26. Maiorana C, Bertta M, Salina S, Santoro F. Reduction of autogenous bone graft resorption by means of Bio-Oss coverage. A retrospective study. Int J Periodontics Restorative Dent 2005;25:19–25.