

Research Article  
Implant Science



# Effectiveness of dental implantation with the partial split-flap technique on vertical guided bone regeneration: a retrospective study

Young-Dan Cho , Sungtae Kim , Young Ku

Department of Periodontology, School of Dentistry and Dental Research Institute, Seoul National University and Seoul National University Dental Hospital, Seoul, Korea



Received: Jul 14, 2021  
Revised: Oct 20, 2021  
Accepted: Oct 26, 2021

**\*Correspondence:**

Young Ku

Department of Periodontology, School of Dentistry and Dental Research Institute, Seoul National University and Seoul National University Dental Hospital, 101 Daehak-ro, Jongno-gu, Seoul 03080, Korea.

E-mail: guy@snu.ac.kr  
Tel: +82-2-2072-3182  
Fax: +82-2-744-0051

Copyright © 2021. Korean Academy of Periodontology  
This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<https://creativecommons.org/licenses/by-nc/4.0/>).

**ORCID iDs**

Young-Dan Cho   
<https://orcid.org/0000-0002-4694-5988>  
Sungtae Kim   
<https://orcid.org/0000-0001-6361-4104>  
Young Ku   
<https://orcid.org/0000-0001-5682-0604>

**Funding**

This work was supported by a grant from the Korea Health Technology R&D Project through the Korea Health Industry Development Institute (KHIDI), funded by the Ministry of Health & Welfare, Republic of Korea (H114C2681).

## ABSTRACT

**Purpose:** This study aimed to evaluate the effectiveness of the partial split-flap technique with a K-incision on vertical guided bone regeneration (vGBR) and to retrospectively analyze the clinical and radiographic outcomes of dental implantation using this approach.

**Methods:** In total, 78 patients who received 104 dental implants with vGBR, categorized as (1) pre-GBR and post-implantation and (2) simultaneous GBR and implantation, were enrolled. Data analysis was based on periapical radiographs, clinical photos, and dental records. The 2-sample *t*-test was used to compare the 2 surgical procedures.

**Results:** The baseline vertical bone level, augmented bone height (ABH), and treatment duration were significantly higher in the pre-GBR procedure group. The survival rates of the implants were 96.1% and 94.8% in implant- and patient-based analyses, respectively. In Cox regression analysis, high rates of implant failure were found in the presence of ABH of  $\geq 4$  mm, smoking, and diabetes.

**Conclusions:** Within the limitations of this retrospective study, the partial split-flap technique using a K-incision for vGBR showed stable clinical outcomes and favorable dental implant survival.

**Keywords:** Bone regeneration; Dental implants; Survival rate

## INTRODUCTION

A well-healed alveolar ridge is ideal for implant placement after tooth extraction; however, it is rarely present in periodontally compromised patients [1]. In cases of severe alveolar bone destruction, anatomical recovery with bone augmentation is necessary to maintain the continuity of the alveolar crest ridge [2,3]. Guided bone regeneration (GBR) is a helpful technique to enhance bone quantity both vertically and horizontally [4], while flap advancement is necessary to obtain primary closure for successful surgical outcomes and to reduce postoperative complications. Therefore, various protocols with new flap designs, including a coronally positioned flap, gingival tissue graft, pedicle flap, and double flap, have been introduced [5,6]. Although flap advancement could induce primary closure and cover the bone grafting site, one of the challenges encountered after primary closure is a decrease

**Author Contributions**

Conceptualization: Young-Dan Cho, Young Ku; Formal analysis: Young-Dan Cho, Sungtae Kim; Investigation: Young-Dan Cho, Sungtae Kim; Methodology: Young-Dan Cho, Young Ku; Project administration: Young Ku; Writing - original draft: Young-Dan Cho; Writing - review & editing: Sungtae Kim, Young Ku.

**Conflict of Interest**

No potential conflict of interest relevant to this article was reported.

in the width of the keratinized gingiva (KG) around the dental implant. This is because the buccal gingival flap needs to be pulled vertically as the releasing incision is made over the oral mucosa. For optimal dental implant restoration, not only adequate bone volume but also the presence of sufficient and stable soft tissues is important. Furthermore, the long-term success of implants depends on the balance between hard and soft tissues. Although the efficacy of retaining adequate KG width remains controversial [7,8], many studies have attempted to increase or preserve the KG width through peri-implant plastic surgery, including an apically positioned flap, free gingival graft, and prefabricated stent [9,10].

We previously reported a clinical case series on vertical GBR (vGBR) with the partial split-flap technique using a K-incision at the healed and low-level alveolar ridge [11]. This flap design allows soft tissue elongation, which may minimize the change of the buccal vestibular depth and maintain sufficient KG tissue during GBR. A Kirkland knife is used for a K-incision to split the gingiva into 2 parts. The elevated partial flap is sutured at both ends, the connective tissue portion in the intermediate layer is exposed, and re-epithelization is induced. Depending on the alveolar bone destruction pattern, a micro-screw or implant was used as a tenting pole to maintain the grafted space upon vertical bone augmentation, which was well-demonstrated in our pre-clinical study [12]. As a sequel to the case series [11] and the pre-clinical study [12], this study retrospectively evaluated the clinical and radiographic outcomes of patients who underwent dental implantation with the partial split-flap using a K-incision. The results of patients who were followed up for more than 3 years after the installation of implant prostheses are presented herein.

**MATERIALS AND METHODS**

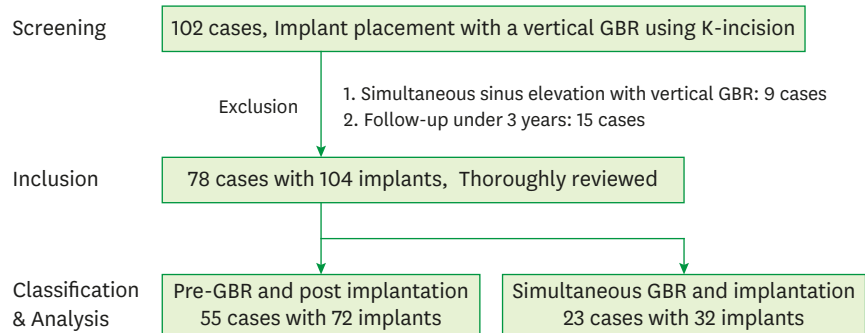
**Study design**

A total of 78 patients (age, 40–75 years) who underwent vGBR and implant placement between 2007 and 2016 with a total of 104 implants were analyzed in this retrospective study (Figure 1). This retrospective study was conducted in accordance with the Helsinki Declaration with approval from the Institutional Review Board (IRB No. S-D20200025) of the School of Dentistry, Seoul National University, Korea, and written according to the STrengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines. The requirement for informed consent of patients was waived because of the anonymity of the patient dataset and the simple investigation of data records. The data were analyzed by 2 periodontists (STK and YDC) using dental records, clinical photos, and radiographs of patients who underwent vGBR through a K-incision. These patients were followed up for more than 3 years (until 2020) after the installation of implant prostheses at Seoul National University Dental Hospital.

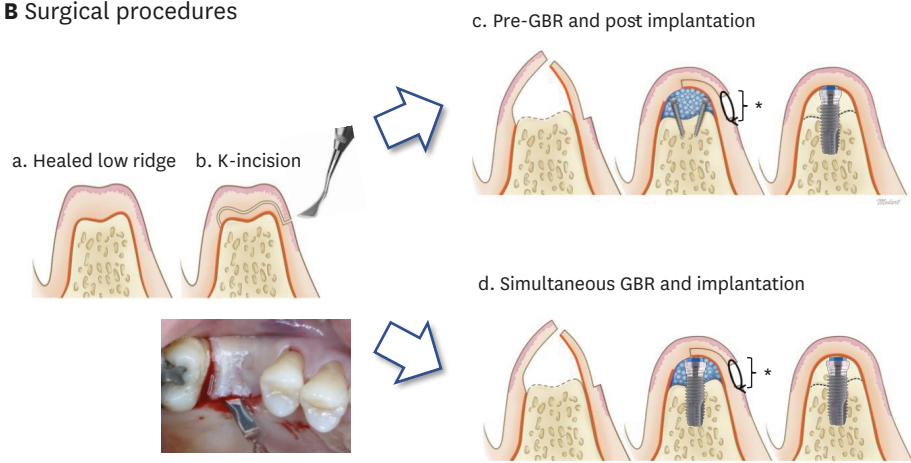
**Data screening and inclusion/exclusion criteria**

There were 102 cases of vGBR with a K-incision and implant placement by a single experienced periodontist (YK), with >3 years of follow-up after occlusal loading. In general, the number of cases was counted based on the bone-grafted region with a K-incision regardless of the number of implants. Twenty-four cases with simultaneous sinus elevation with vGBR (n=9) and follow-up periods of less than 3 years (n=15) were excluded from the initially screened cases. Finally, a total of 78 cases with 104 implants were included and thoroughly reviewed in this study. The cases were classified into the following 2 groups: group 1, pre-GBR and post-implantation (55 cases, including 72 implants); and group 2, simultaneous GBR and implantation (23 cases, including 32 implants) (Figure 1A).

**A Study flow**



**B Surgical procedures**



**Figure 1.** Diagram showing the study flow and surgical procedures used. (A) Study flow. (B) Surgical procedure: (a) vGBR using a K-incision was performed at the healed and low-level alveolar ridge; (b) The K-incision was made using a Kirkland knife to split the gingival flap into 2 equal parts; (c) Pre-GBR and post-implantation; and (d) Simultaneous GBR and implantation. Asterisk (\*) means the length of elongated soft tissue. The figures depicting the surgical procedure were partially adapted from Cho and Ku (2018) [11]. GBR: guided bone regeneration, vGBR: vertical guided bone regeneration.

**Surgical procedure**

After extraction of the periodontally compromised teeth, the extraction sockets had an average healing time of 3–4 months. vGBR using a K-incision was performed at the healed and low-level alveolar ridges (a in **Figure 1B**). The thickness of the gingiva was measured with a dental probe under local anesthesia, and a K-incision was applied if it was more than 3.0 mm. The K-incision was made using a Kirkland knife to split the gingival flap into 2 equal parts (b **Figure 1B**). In cases with severe vertical bone defects, wherein the implants had a risk of encountering anatomical structures, such as the maxillary sinus and inferior alveolar nerve, pin-retained GBR was performed (c in **Figure 1B**). If not, implant placement and vGBR were performed simultaneously (d in **Figure 1B**). The soft tissue was carefully divided into half its thickness using the K-incision to maintain adequate buccal vestibular depth and to secure the KG. Inorganic bovine bone mineral (OCS-B<sup>®</sup>; NIBEC, Jincheon, Korea) and a collagen membrane (Bio-Gide<sup>®</sup>; Geistlich Pharma AG, Wolhusen, Switzerland) were used for bone augmentation. A micro-screw (Jeil Medical Corp., Seoul, Korea) was used as a tenting pole to support the vertically augmented bone and membrane. With the K-incision, the soft tissue was elongated, as represented by the asterisk of c and d in **Figure 1B**. In all cases, RESTORE<sup>®</sup> RBM Implants (Keystone Dental, Lifecore Biomedical, Chaska, MN, USA) were placed. After the implant prostheses were installed, the patients were periodically followed up.

**Representative case description**

*Procedure of flap management with a K-incision*

The gingiva in the healed alveolar ridge with the vertical bone defect showed a concave, crestal appearance (**Figure 2A**). A partial split-flap with a K-incision was performed using a Kirkland knife (**Figure 2B**), and the implant was placed using vGBR (**Figure 2C**). Both flaps, which were well divided in half (arrows, **Figure 2C**), were sutured with passive tension, and the connective tissue on the palatal side was exposed (arrowhead, **Figure 2D**). Postoperatively, the soft tissue healed well, indicating adequate maintenance of vestibular depth and KG width (**Figure 2E**).

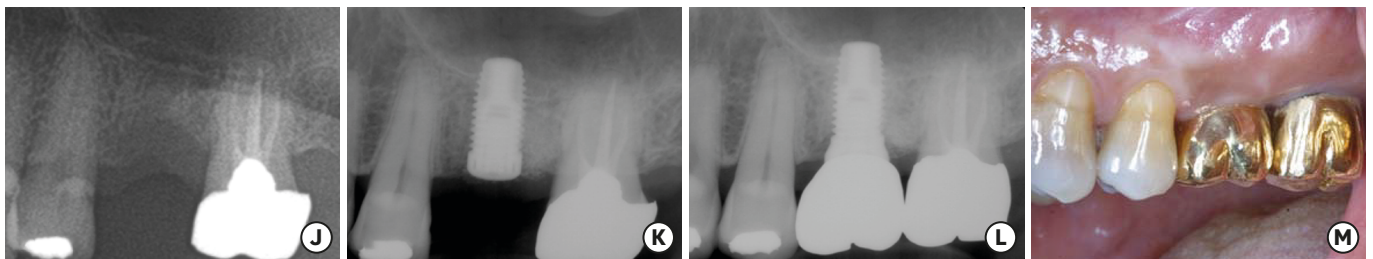
The procedure of soft tissue management with K-incision



Group 1. Pre-GBR and post-implantation



Group 2. Simultaneous GBR and implantation



**Figure 2.** Representative cases.

The procedure of soft tissue management with a K-incision: (A) Initial; (B) K-incision; (C) simultaneous GBR and implantation, arrow indicates a partial flap; (D) flap suture free of tension, arrowhead indicates the lower part of the partial flap; and (E) postoperative 5 months. Pre-GBR and post-implantation (Group 1): (F) 3 months after tooth extraction; (G) GBR; and (H and I) 3 years after occlusal loading. Simultaneous GBR and implantation (Group 2): (J) 3 months after tooth extraction; (K) GBR and implantation; and (L and M) 3 years after occlusal loading. GBR: guided bone regeneration.

#### *Pre-GBR and post-implantation*

The mandibular right first molar (#22; universal numbering system) of a 51-year-old man was extracted as it was compromised due to chronic periodontitis. Three months after tooth extraction, a severe vertical bone defect was observed in the radiograph (**Figure 2F**). First, micro-screw-retained vGBR with inorganic bovine bone and collagen membrane (**Figure 2G**) was performed, followed by micro-screw removal and implant fixture placement after 5 months. Three years after occlusal loading, the peri-implant bone was stable (**Figure 2H**), the gingival level was maintained harmoniously with the adjacent teeth, and an adequate KG was obtained (**Figure 2I**).

#### *Simultaneous GBR and implantation*

The maxillary left first molar (#14) of a 60-year-old man was extracted because of chronic periodontitis. Three months after tooth extraction, a vertical bone defect was noted (**Figure 2J**). Implant fixture installation and vGBR were performed simultaneously (**Figure 2K**). Three years after occlusal loading, the peri-implant bone condition was good (**Figure 2L**), and a healthy gingival status was achieved with an adequate gingival level and KG (**Figure 2M**).

### **Radiographic evaluation**

The periapical radiographs were taken using a film holder to maintain the same position. Radiographic measurements were conducted thrice, and the intrarater reliability was analyzed based on a 2-way mixed-effects model (single rater type, absolute agreement) [13], and the intraclass correlation coefficient was 0.912 ( $P < 0.001$ ). Radiographs obtained 3 months after tooth extraction were used as the baseline for vertical bone level evaluation (Supplementary Data 1A). A straight line between the crestal bones on the mesial and distal sides was used as a guide, and the perpendicular distance to the vertical bone defect was used to calculate the vertical bone level (V1). Similarly, the augmented bone height (ABH, V1–V2) and marginal bone loss (V3–V2) were also measured on radiographs obtained after surgery and after 3 years of follow-up, respectively. Changes in alveolar bone levels were analyzed on the radiographs using the ImageJ program (National Institutes of Health, Bethesda, MD, USA), and the values were corrected based on the length of adjacent teeth [14]. The crown-to-implant (C/I) ratio was calculated by dividing the crown length by the implant fixture length (Supplementary Data 1B).

### **Statistical analysis**

Statistical analyses were performed using the R statistical software (version 4.0.0, <http://www.R-project.org>). General descriptive statistics (mean  $\pm$  standard deviation) were used for countable values. The 2-sample *t*-test was used to compare the 2 surgical procedures. The survival rate of implants was estimated by Kaplan–Meier survival estimates. Cox regression analysis was used to determine the effects of variables on implant failure, as expressed using hazard ratio (HR) and 95% confidence interval (95% CI). In the statistical analysis, *P* values  $< 0.05$  were considered to indicate statistical significance.

## **RESULTS**

### **Implant characteristics**

Among the 104 implants, 72 were placed in group 1 (pre-GBR and post-implantation) and 32 implants were placed in group 2 (simultaneous GBR and implantation). The characteristics of the implants are presented in detail in **Table 1**.

**Table 1.** Implant characteristics (n=104)

Group	Group 1 (n=72)	Group 2 (n=32)
Implant diameter (mm)		
Narrow (<3.75)	1	2
Regular (4.0)	53	21
Wide (5.0)	18	9
Implant length (mm)		
Short (8)	8	3
Medium (10–11.5)	64	29
Location		
Premolar	14	7
Molar	58	25
Maxilla	39	14
Mandible	33	18
Prosthetic type		
Single	42	26
Splinted	30	6

GBR: guided bone regeneration, Group 1: pre-GBR and post-implantation, Group 2: simultaneous GBR and implantation.

**Table 2.** Comparisons between the 2 procedures

Variables	Group 1	Group 2	P value
Baseline vertical bone level (mm)	6.43±1.06	4.12±1.25	0.011 <sup>a)</sup>
Augmented bone height (mm)	5.14±1.63	3.37±1.97	0.023 <sup>a)</sup>
Marginal bone loss (mm)	1.95±0.36	1.52±0.42	0.115
Duration from GBR to prosthesis delivery (d)	285.40±52.13	183.21±25.42	0.017 <sup>a)</sup>
Crown-to-implant ratio	1.22±0.09	1.35±0.13	0.086

GBR: guided bone regeneration, Group 1: pre-GBR and post-implantation, Group 2: simultaneous GBR and implantation.

<sup>a)</sup>The difference was significant when  $P < 0.05$ .

### Comparison between the procedures

The data for the 2 surgical procedures were compared using the independent 2-sample *t*-test. A comparison of the implantation procedures (**Table 2**) indicated that the baseline vertical bone level after tooth extraction (6.43±1.06 mm) and ABH (5.14±1.63 mm) were significantly higher in group 1 than in group 2. The treatment duration from GBR to prosthesis delivery was longer in group 1 than in group 2. There were no significant differences in the marginal bone loss and C/I ratio.

### Implant survival and Kaplan–Meier estimates

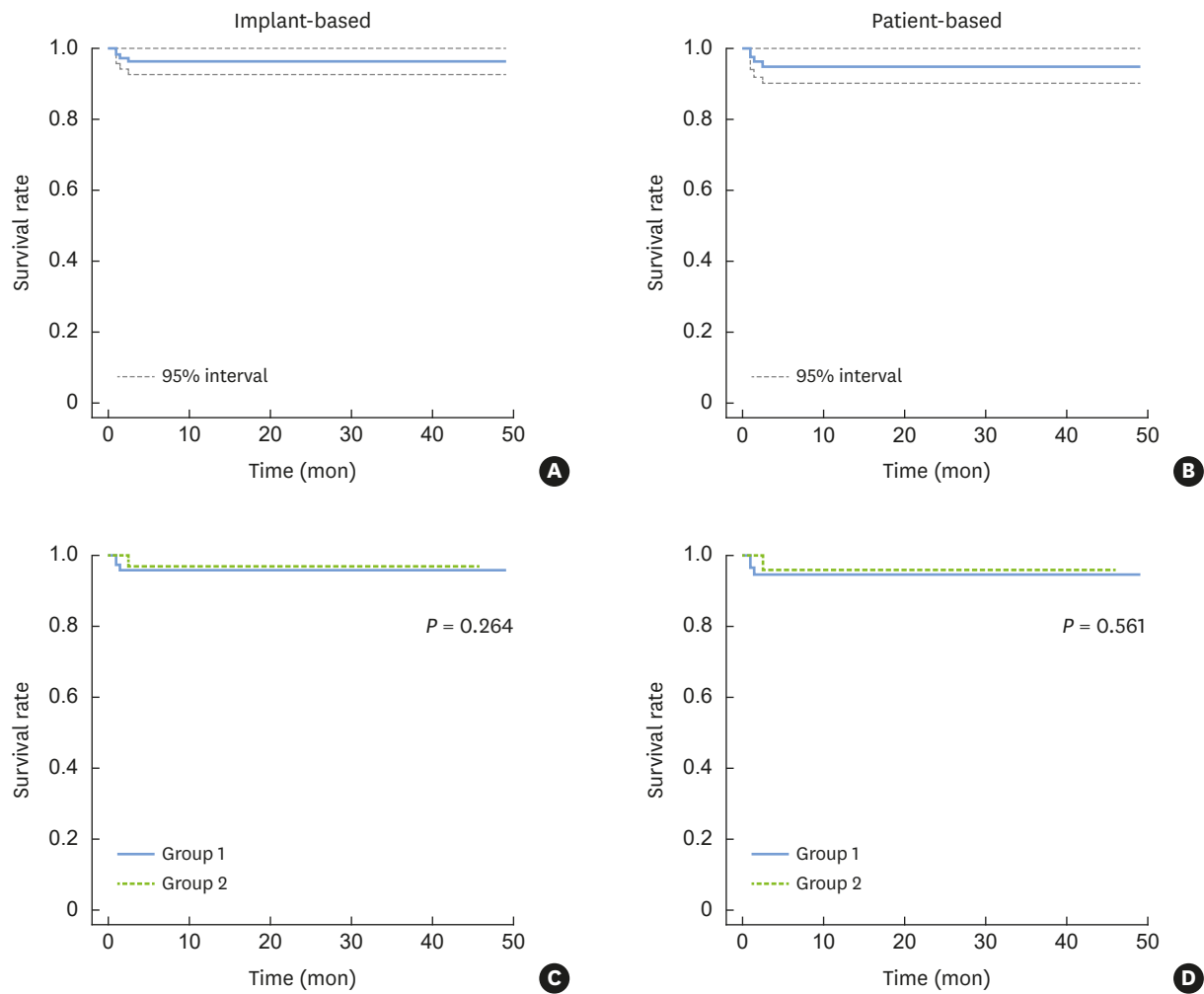
Among the 104 implants, 4 failed owing to osseointegration failure before occlusal loading (**Table 3**). The estimated Kaplan–Meier survival rates of implants based on the implants and patients were 96.1% (**Figure 3A**) and 94.8% (**Figure 3B**), respectively. According to the surgical procedure, the Kaplan–Meier survival rates in group 1 and group 2, estimated based on the implants, were 95.8% and 97.2% (**Figure 3C**), respectively, while those estimated based on the patients were 94.4% and 95.7%, respectively (**Figure 3D**). There was no statistically

**Table 3.** Case list of failed implants (n=4)

No.	Patient-related				Implant-related				
	Age (yr)	Sex	MS	Smoking	Group	Location <sup>a)</sup>	ABH	Diameter (mm)	Length (mm)
1	54	F	DM	No	1	14	5.41	4.0	8.0
2	63	M	HT, DM	Yes	1	15	5.03	4.0	10.0
3	57	M	N	Yes	1	3	5.65	5.0	10.0
4	55	F	DM	No	2	19	4.09	4.0	10.0

MS: medical status, DM: diabetes mellitus, HT: hypertension, ABH: augmented bone height.

<sup>a)</sup>Universal numbering system.



**Figure 3.** Kaplan-Meier cumulative survival rate. The estimated survival rate of implants based on the implants (A) and patients (B). The estimated survival rate of implants in group 1 (C) and group 2 (D).

significant difference between group 1 and group 2 in either the implant-based ( $P=0.264$ ) or patient-based ( $P=0.561$ ) analyses.

### Cox regression analysis

The reason for failure in all cases was osseointegration failure. A Cox regression analysis showed that implant failure was not affected by age, sex, or the surgical procedure (**Table 4**).

**Table 4.** Cox regression analysis for implant failure

Variable <sup>a)</sup>	Implant failure		
	HR	95% CI	P value
Age ( $\geq 60$ vs. $<60$ )	0.8	0.4–1.3	0.580
Sex (female vs. male)	1.1	0.9–1.6	0.854
Surgical procedure (group 1 vs. group 2)	2.9	1.2–8.1	0.245
ABH ( $\geq 4$ vs. $<4$ )	3.8	0.7–10.3	0.142
Smoking vs. non-smoking	5.4	1.5–20.5	0.018 <sup>b)</sup>
Diabetes vs. non-diabetes	6.3	1.7–19.2	0.031 <sup>b)</sup>
Hypertension vs. non-hypertension	1.9	0.6–6.3	0.231

HR: hazard ratio, CI: confidence interval, ABH: augmented bone height.

<sup>a)</sup>Comparison variable, <sup>b)</sup>

$P < 0.05$ , statistically significant.

However, an ABH  $\geq 4$  mm (HR, 3.8; 95% CI, 0.7–10.3;  $P=0.042$ ) and external factors such as smoking (HR, 5.4; 95% CI, 1.5–20.5;  $P=0.018$ ) and diabetes (HR, 6.3; 95% CI, 1.7–19.2;  $P=0.031$ ) significantly increased the risk of implant failure.

## DISCUSSION

This retrospective 3-year follow-up study evaluated the clinical and radiographic outcomes of patients who underwent dental implantation with a partial split-flap using a K-incision. The presence of sufficient gingiva with a thickness of 3.0 mm or more in vGBR is a good indication for a K-incision. The estimated clinical advantage of a K-incision is to maintain vestibular depth and KG width because the K-incision does not exceed the mucosa; however, its limitation is that clinicians require advanced skills to split the gingival flap.

In this study, we found that the use of a K-incision might minimize mucogingival junction disruption, preserving KG after GBR (**Figures 1 and 3**). Although the healing period for the split-flap area with the K-incision was slower than that with the full-thickness incision, along with a risk of flap tears in the thin gingival areas, the soft-tissue healing pattern was favorable. The significance of keratinized or attached gingiva remains controversial in periodontology and implantology. Some studies have suggested that keratinized or attached gingiva is not a critical factor for maintaining gingival health [15]. However, other studies have reported that insufficient keratinized mucosa is associated with a higher risk of inflammation [16]. In essence, the KG acts as a physical barrier to the oral bacteria, lessens the pulling force from the lip or frenum, and provides a deep vestibule, which enables maintenance of oral hygiene [17,18]. Halperin-Sternfeld et al. [19] reported that inadequate vestibular depth around the implant was associated with peri-implant bone loss and mucosal recession. Other studies also supported the importance of KG and vestibular depth for favorable oral hygiene [20]. A partial split-flap to induce secondary epithelialization does not require a secondary donor site and additional biomaterials, but has a higher likelihood of relapse due to wound contraction [21]. Furthermore, a thin flap (less than 1.0 mm) has risks such as tissue tearing, sloughing, and necrosis, resulting in the exposure of graft material [22]. A conventional staged approach with a free gingival graft has increased stability in the re-established KG and vestibule but exhibited some disadvantages, such as unpleasing esthetics with an unharmonious tissue profile and high patient morbidity [23].

The dental records investigated in this study did not show peri-implantitis, and the extent of marginal bone loss was favorable considering that the accepted criteria for implant success are 1–1.5 mm in the first year after occlusal loading and  $<0.2$  mm annually thereafter (**Table 2**) [24].

Short implant placement or sinus elevation with bone grafts could be the first choice of intervention at sites of vertical bone defects because of the convenient treatment process and the reasonable survival rate [25,26]. In this condition, implant placement is simple; however, the fixture platform is located lower than the surrounding ridge position, which induces a hypsodont-shaped restoration with a high C/I ratio resembling a horse tooth [11]. This creates a deep periodontal pocket and insufficient KG surrounding the implant prosthesis and proximal to the mucosa, which further weakens the tight gingival seal of the implant. As a result, this may obstruct the continuity of the alveolar ridge, while complicating the maintenance of peri-implant gingival health, eventually leading to peri-implant disease and bone loss [27,28]. Therefore, reconstruction of the original alveolar ridge shape using vertical



and/or horizontal bone grafts is essential. However, even if this partial-split technique helps to some extent in reconstruction of the ridge, there may be limitations to its clinical indication because restoration of missing teeth can take a long time (**Table 2**).

Four cases of implant failure are presented in **Table 3**. All cases were caused by a lack of osseointegration within 5 months before prosthesis installation. In all 4 cases, the ABH was over 4.0 mm, demonstrating that ABH influences implant failure (**Table 4**). A large amount of bone augmentation with xenografts under unfavorable recipient conditions with severe bone defects might be a risk factor in patients who undergo pre-GBR and post-implantation. This could be attributed to its absence of osteoinductive properties and susceptibility to infection in comparison to autologous bone [29]. In addition, the patients' health condition and smoking might also influence implant failure (**Table 4**). Among the patients who experienced implant failure, 2 patients were smokers and 3 patients had diabetes mellitus (DM) (**Table 3**). DM is a highly prevalent chronic disease [30], and various studies have attempted to understand the influence of DM on the osseointegration and survival of dental implants [31,32]. Generally, pre-clinical studies in DM-induced animals have reported a high failure rate of dental implants [33]; however, the results of clinical studies remain inconsistent. Some studies reported no significant difference in the implant failure rate between non-DM and DM patients [34,35]. Other studies reported a higher failure rate in DM patients than in those without DM, especially in the first year of functional loading, suggesting that microvascular conditions in patients with DM might be a possible causal factor [36,37]. Smoking was also found to be a risk factor for implant failure because of its detrimental effect on early osseointegration [38] and the risk of peri-implantitis [39,40]. Based on our results and those of other studies, an adequate amount of bone graft and controlled health conditions are important for the success of dental implants with GBR. As a retrospective study, this investigation had limits in evaluating the effectiveness of the K-incision. Due to the inherent limitations of a retrospective study, clinical parameters could not be measured according to a precise schedule and several pieces of information were lacking because of insufficient records. Therefore, a prospective study is being planned to provide further support for our observations in this study.

Within the limitation of this retrospective study, we concluded that the partial split-flap technique using a K-incision was helpful for extending the soft tissue coverage of the grafted area for vGBR. A large amount of vertical bone grafting and patients' systemic health condition could affect the risk of implant failure. Further long-term studies and randomized clinical investigations with larger patient cohorts are recommended to prove the clinical value of the K-incision.

## REFERENCES

1. Jivraj S, Chee W. Treatment planning of implants in posterior quadrants. *Br Dent J* 2006;201:13-23. [PUBMED](#) | [CROSSREF](#)
2. Buser D, Dula K, Belser U, Hirt HP, Berthold H. Localized ridge augmentation using guided bone regeneration. 1. Surgical procedure in the maxilla. *Int J Periodontics Restorative Dent* 1993;13:29-45. [PUBMED](#)
3. Buser D, Dula K, Belser UC, Hirt HP, Berthold H. Localized ridge augmentation using guided bone regeneration. II. Surgical procedure in the mandible. *Int J Periodontics Restorative Dent* 1995;15:10-29. [PUBMED](#)
4. McAllister BS, Haghighat K. Bone augmentation techniques. *J Periodontol* 2007;78:377-96. [PUBMED](#) | [CROSSREF](#)

5. Fugazzotto PA. Maintaining primary closure after guided bone regeneration procedures: introduction of a new flap design and preliminary results. *J Periodontol* 2006;77:1452-7.  
[PUBMED](#) | [CROSSREF](#)
6. Hur Y, Tsukiyama T, Yoon TH, Griffin T. Double flap incision design for guided bone regeneration: a novel technique and clinical considerations. *J Periodontol* 2010;81:945-52.  
[PUBMED](#) | [CROSSREF](#)
7. Moraschini V, Luz D, Velloso G, Barboza EDP. Quality assessment of systematic reviews of the significance of keratinized mucosa on implant health. *Int J Oral Maxillofac Surg* 2017;46:774-81.  
[PUBMED](#) | [CROSSREF](#)
8. Lin GH, Chan HL, Wang HL. The significance of keratinized mucosa on implant health: a systematic review. *J Periodontol* 2013;84:1755-67.  
[PUBMED](#) | [CROSSREF](#)
9. Baltacıoğlu E, Bağış B, Korkmaz FM, Aydın G, Yuva P, Korkmaz YT. Peri-implant plastic surgical approaches to increasing keratinized mucosa width. *J Oral Implantol* 2015;41:e73-81.  
[PUBMED](#) | [CROSSREF](#)
10. Park JC, Yang KB, Choi Y, Kim YT, Jung UW, Kim CS, et al. A simple approach to preserve keratinized mucosa around implants using a pre-fabricated implant-retained stent: a report of two cases. *J Periodontal Implant Sci* 2010;40:194-200.  
[PUBMED](#) | [CROSSREF](#)
11. Cho YD, Ku Y. Guided bone regeneration using K-incision technique. *J Periodontal Implant Sci* 2018;48:193-200.  
[PUBMED](#) | [CROSSREF](#)
12. Lee C, Kim S, Kim J, Namgung D, Kim K, Ku Y. Supplemental periodontal regeneration by vertical ridge augmentation around dental implants. A preclinical *in vivo* experimental study. *Clin Oral Implants Res* 2019;30:1118-25.  
[PUBMED](#) | [CROSSREF](#)
13. Koo TK, Li MY. A guideline of selecting and reporting intraclass correlation coefficients for reliability research. *J Chiropr Med* 2016;15:155-63.  
[PUBMED](#) | [CROSSREF](#)
14. Draenert FG, Sagheb K, Baumgardt K, Kämmerer PW. Retrospective analysis of survival rates and marginal bone loss on short implants in the mandible. *Clin Oral Implants Res* 2012;23:1063-9.  
[PUBMED](#) | [CROSSREF](#)
15. Kennedy JE, Bird WC, Palcanis KG, Dorfman HS. A longitudinal evaluation of varying widths of attached gingiva. *J Clin Periodontol* 1985;12:667-75.  
[PUBMED](#) | [CROSSREF](#)
16. Bouri A Jr, Bissada N, Al-Zahrani MS, Faddoul F, Nouneh I. Width of keratinized gingiva and the health status of the supporting tissues around dental implants. *Int J Oral Maxillofac Implants* 2008;23:323-6.  
[PUBMED](#)
17. Marquez IC. The role of keratinized tissue and attached gingiva in maintaining periodontal/peri-implant health. *Gen Dent* 2004;52:74-8.  
[PUBMED](#)
18. Monje A, Blasi G. Significance of keratinized mucosa/gingiva on peri-implant and adjacent periodontal conditions in erratic maintenance compliers. *J Periodontol* 2019;90:445-53.  
[PUBMED](#) | [CROSSREF](#)
19. Halperin-Sternfeld M, Zigdon-Giladi H, Machtei EE. The association between shallow vestibular depth and peri-implant parameters: a retrospective 6 years longitudinal study. *J Clin Periodontol* 2016;43:305-10.  
[PUBMED](#) | [CROSSREF](#)
20. Deeb GR, Deeb JG, Agarwal V, Laskin DM. Use of transalveolar sutures to maintain vestibular depth and manipulate keratinized tissue following alveolar ridge reduction and implant placement for mandibular prosthesis. *J Oral Maxillofac Surg* 2015;73:48-52.  
[PUBMED](#) | [CROSSREF](#)
21. Hillerup S. Healing reactions of relapse in secondary epithelization vestibuloplasty on dog mandibles. *Int J Oral Surg* 1980;9:116-27.  
[PUBMED](#) | [CROSSREF](#)
22. Vagarinho J, Sardinha S, Alves R. An unusual complication in plastic periodontal surgery. *Case Rep Dent* 2020;2020:8824246.  
[PUBMED](#) | [CROSSREF](#)
23. Lim HC, An SC, Lee DW. A retrospective comparison of three modalities for vestibuloplasty in the posterior mandible: apically positioned flap only vs. free gingival graft vs. collagen matrix. *Clin Oral Investig* 2018;22:2121-8.  
[PUBMED](#) | [CROSSREF](#)

24. Misch CE, Perel ML, Wang HL, Sammartino G, Galindo-Moreno P, Trisi P, et al. Implant success, survival, and failure: the International Congress of Oral Implantologists (ICOI) Pisa Consensus Conference. *Implant Dent* 2008;17:5-15.  
[PUBMED](#) | [CROSSREF](#)
25. Al-Johany SS. Survival rates of short dental implants ( $\leq 6.5$  mm) placed in posterior edentulous ridges and factors affecting their survival after a 12-month follow-up period: a systematic review. *Int J Oral Maxillofac Implants* 2019;34:605-21.  
[PUBMED](#) | [CROSSREF](#)
26. Omran MT, Miley DD, McLeod DE, Garcia MN. Retrospective assessment of survival rate for short endosseous dental implants. *Implant Dent* 2015;24:185-91.  
[PUBMED](#) | [CROSSREF](#)
27. Lee KJ, Kim YG, Park JW, Lee JM, Suh JY. Influence of crown-to-implant ratio on periimplant marginal bone loss in the posterior region: a five-year retrospective study. *J Periodontal Implant Sci* 2012;42:231-6.  
[PUBMED](#) | [CROSSREF](#)
28. Garaicoa-Pazmiño C, Suárez-López del Amo F, Monje A, Catena A, Ortega-Oller I, Galindo-Moreno P, et al. Influence of crown/implant ratio on marginal bone loss: a systematic review. *J Periodontol* 2014;85:1214-21.  
[PUBMED](#) | [CROSSREF](#)
29. Yamada M, Egusa H. Current bone substitutes for implant dentistry. *J Prosthodont Res* 2018;62:152-61.  
[PUBMED](#) | [CROSSREF](#)
30. Mealey BL, Ocampo GL. Diabetes mellitus and periodontal disease. *Periodontol 2000* 2007;44:127-53.  
[PUBMED](#) | [CROSSREF](#)
31. de Araújo Nobre M, Maló P, Gonçalves Y, Sabas A, Salvado F. Dental implants in diabetic patients: retrospective cohort study reporting on implant survival and risk indicators for excessive marginal bone loss at 5 years. *J Oral Rehabil* 2016;43:863-70.  
[PUBMED](#) | [CROSSREF](#)
32. Dubey RK, Gupta DK, Singh AK. Dental implant survival in diabetic patients; review and recommendations. *Natl J Maxillofac Surg* 2013;4:142-50.  
[PUBMED](#) | [CROSSREF](#)
33. Hasegawa H, Ozawa S, Hashimoto K, Takeichi T, Ogawa T. Type 2 diabetes impairs implant osseointegration capacity in rats. *Int J Oral Maxillofac Implants* 2008;23:237-46.  
[PUBMED](#)
34. Erdogan Ö, Uçar Y, Tatlı U, Sert M, Benlidayı ME, Evlice B. A clinical prospective study on alveolar bone augmentation and dental implant success in patients with type 2 diabetes. *Clin Oral Implants Res* 2015;26:1267-75.  
[PUBMED](#) | [CROSSREF](#)
35. Peled M, Ardekian L, Tagger-Green N, Gutmacher Z, Machtei EE. Dental implants in patients with type 2 diabetes mellitus: a clinical study. *Implant Dent* 2003;12:116-22.  
[PUBMED](#) | [CROSSREF](#)
36. Daubert DM, Weinstein BF, Bordin S, Leroux BG, Flemming TF. Prevalence and predictive factors for peri-implant disease and implant failure: a cross-sectional analysis. *J Periodontol* 2015;86:337-47.  
[PUBMED](#) | [CROSSREF](#)
37. Oates TW Jr, Galloway P, Alexander P, Vargas Green A, Huynh-Ba G, Feine J, et al. The effects of elevated hemoglobin A<sub>1c</sub> in patients with type 2 diabetes mellitus on dental implants: survival and stability at one year. *J Am Dent Assoc* 2014;145:1218-26.  
[PUBMED](#) | [CROSSREF](#)
38. Bezerra Ferreira JD, Rodrigues JA, Piattelli A, Iezzi G, Gehrke SA, Shibli JA. The effect of cigarette smoking on early osseointegration of dental implants: a prospective controlled study. *Clin Oral Implants Res* 2016;27:1123-8.  
[PUBMED](#) | [CROSSREF](#)
39. Naseri R, Yaghini J, Feizi A. Levels of smoking and dental implants failure: A systematic review and meta-analysis. *J Clin Periodontol* 2020;47:518-28.  
[PUBMED](#) | [CROSSREF](#)
40. Cho YD, Kim PJ, Kim HG, Seol YJ, Lee YM, Ryoo HM, et al. Transcriptome and methylome analysis of periodontitis and peri-implantitis with tobacco use. *Gene* 2020;727:144258.  
[PUBMED](#) | [CROSSREF](#)