Long-Term (> 15 Years) Postrestorative Outcomes of Surgical Crown Lengthening Associated with Early Postsurgical Physiologically Oriented Crevicular Repreparation (POCR) Technique in Esthetic Areas

Renzo Guarnieri, MD, DDS

Surgical crown lengthening (SCL) is indicated to reestablish the biologic width and to increase the extent of supragingival tooth structure for restorative or esthetic purposes. The present study aimed to evaluate the postrestorative conditions and positional changes of the periodontal tissues following SCL 15 years or more after surgery. Moreover, an early postsurgical physiologically oriented crevicular tooth repreparation (POCR) approach for surgical and restorative phases of the SCL procedure is described. Eighteen patients who needed SCL to gain retention necessary for prosthetic treatment, or previous prosthetic margins, were included. During surgery, the bone level was reduced based on the future prosthetic margin and predetermined biologic width; flaps were placed at the bony crest. Relined temporary acrylic resin crowns were delivered 7 to 10 days postsurgery, and definitive crowns were delivered 9 months postsurgery. Patients were examined at baseline (BSL); at 3, 6, and 9 months postoperatively; and at each yearly recall visit. The following parameters were evaluated: Plaque and Gingival Indices, free gingival margin, width and thickness of the keratinized gingiva, probing depth, attachment level, bone level, direct bone level, and biologic width. Sixteen patients completed the study. No significant change in the position of the free gingival margin and periodontal parameters were seen from 9 months to > 15 years. Biologic width at 9 months was smaller compared to BSL (~0.06 ± 0.02 mm) and gradually increased during the follow-up period, almost reaching the initial levels at the examinations > 15 years later. The described SCL technique obtained a consistent 3-mm gain of coronal tooth structure and was successful in maintaining stable periodontal tissue conditions, reestablishing the biologic width to its original vertical dimension after 15 years. Int J Periodontics Restorative Dent 2021;41:845–854. doi: 10.11607/prd.4857

Utilizing surgical crown lengthening (SCL) as an adjunct to restorative dentistry has long been proposed to provide proper tooth preparation and retention of prosthetic restorations and to reestablish the biologic width (BW) at a more apical position.1 Its main goal is to gain supracrestal tooth length by placing restorative margins at an appropriate level, avoiding violation of the BW, which may result in bone resorption, gingival recession, gingival inflammation, or hypertrophy.2–5 Surgical techniques for crown lengthening include gingivectomy, apically positioned flap surgery (APF), and APF with osseous reduction.6,7 Most researchers agree that a minimum distance of at least 3 mm (1 mm of supracrestal connective tissue attachment, 1 mm of junctional epithelium, and 1 mm for sulcus depth) is required from the osseous crest to the final restorative margin following crown lengthening.8 These measurements stem from histologic descriptions of the dentogingival complex conducted by Gargiulo et al,9 who identified the subcomponents of the dentogingival junction as the connective tissue attachment (mean length: 1.07 mm) and the epithelial attachment (mean length: 0.97 mm), and by Vacek et al,10 who reported mean lengths of 0.77 mm for the connective-tissue attachment and 1.14 mm for the...
epithelial attachment. In relation to the average length of the dentogingival junction (approximately 2 mm), Ingber et al suggested that an additional 1 mm be added coronal to the 2-mm dentogingival junction as an optimal distance between the bone crest and restorative margins. Moreover, it has also been suggested that at least 4 mm of dental structure should be exposed above the soft tissue margin, and that at least 1 mm of dentin wall coronal to the crown and a 360-degree collar of the crown (also called the “ferrule effect”) should be present to prevent failure. When SCL is performed for prosthetic reasons, gingivectomy and APF without osseous reduction are often not sufficient to obtain these conditions, and APF with osseous surgery is the most common technique used to increase the extent of supragingival tooth structure and to provide adequate distance from the osseous crest to the anticipated restorative margins. The timing of the surgical and restorative phases when SCL is used for prosthetic reasons is still under discussion. Determining the minimum time needed to achieve gingival margin stability is critical in ensuring minimal treatment delays and an adequate continuity of care while allowing for adequate healing to produce optimal, long-term functional and esthetic results from prostheses. Some clinicians suggested a reprefparation during crown-lengthening surgery and, after apical flap repositioning, an immediate relining of temporary crowns. Others proposed an apically positioned flap with osseous surgery, without intrasurgical preparation and without changing the natural emergence profile of the abutments, and reprefparation and relining of the temporary crown at 3 weeks. Still, others suggested refraining from any intrasurgical tooth preparation and waiting at least 6 to 12 weeks for restorative treatment because of the possibility of gingival recession during the postoperative healing phase. These mentioned studies on SCL report conflicting results. Moreover, they followed the positional changes of the periodontal tissues immediately after surgery and during healing without reporting long-term outcomes. Although a number of surgical and restorative procedures have been described in the literature to create an esthetic and harmonious appearance, very few have studies also focused on the timing of surgical and restorative phases and on the influence of timing on the long-term stability of the soft tissue. Thus, many questions remain unanswered. The present study aimed (1) to provide and describe an early postsurgical physiologically oriented crevicular reprefparation (POCR) protocol for the surgical and restorative phase in esthetic cases requiring crown-lengthening surgery and (2) to evaluate the postrestorative conditions and positional changes of the periodontal tissues during the 15 years (and longer) after surgery.

Materials and Methods

The present prospective study was performed in a private dental center, and all surgical and restorative procedures were performed by the same clinician (R.G.). Because all patients were treated as part of routine periodontal and restorative treatment, the study was granted an exemption by the local institutional review board. Each included patient was asked to sign an informed consent form, and the study was conducted in compliance with the Declaration of Helsinki. Eighteen periodontally healthy patients aged 46 to 62 years (mean age: 54 years) who required SCL to gain retention in maxillary frontal sites with insufficient supracrestal tooth structure necessary for prosthetic treatment, or with previous prosthetic margins, were enrolled.

A review of medical and dental histories and a clinical examination demonstrated no systemic or local contraindications to surgical treatment. Prior to surgery, patients had their teeth professionally cleaned and received oral hygiene instructions. For each patient, preliminary extraoral and intraoral photographs were taken, as well as full-mouth radiographs, to define the treatment planning. High-precision impressions of the maxilla and mandible were taken together with silicone at the intercuspal position to develop master split-cast models. In addition, smile lines were assessed for esthetic reasons, and wax-ups were analyzed to evaluate the spaces, shapes, and dimensions of teeth. A full-arch acrylic resin stent was fabricated for each patient, and grooves were created at appropriate sites to standardize probe placement, angulation, and measurements.
Measurements were obtained using a standardized UNC-15 periodontal probe and rounded up to the nearest millimeter. The following clinical parameters were obtained at six sites (buccal, lingual, mesiobuccal, mesiolingual, distobuccal, and distolingual) around each tooth requiring crown lengthening, and these measurements were taken at baseline (BSL), at 3 (T3), 6 (T6), and 9 (T9; delivery of definitive crowns) months postsurgery, and at each subsequent year control visit (T[number of years postsurgery]):

- Plaque Index (PI)
- Gingival Index (GI)
- Attachment level (AL): The reference stent to the base of the pocket
- Probing depth (PD): calculated by subtracting the free gingival margin (FGM) measurement from the AL measurement
- Keratinized tissue width (KTW): the distance from the most coronal point on the gingival margin to the mucogingival junction (at the buccal aspect of each tooth requiring SCL)
- Keratinized tissue thickness (KTT): measured after the experimental area was anesthetized, by means of no. 30 K-file inserted through the soft tissue until touching the bony crest, measured at the midpoint of the vertical line representing the KTW
- Bone level (BL): measured via transgingival probing
- BW: calculated by subtracting the BL measurement from the AL measurement

- Direct bone level (DBL): measured from the reference stent to the BL after flap reflection

Appendix Table 1 (available in the online version of this article, at quintpub.com/journals) shows the exact sequence of measurements. Each patient entered a periodontal maintenance program (at an individualized interval of 3 to 6 months) that included plaque staining followed by reinstruction and remotivation, professional tooth cleaning and mechanical debridement, and polishing using rubber cups and polishing paste.

Surgical and Prosthetic Procedures

Figures 1 to 8 show schematic views of the described surgical and restorative techniques. The surgical technique consisted of inverse beveled submarginal and intrasulcular incisions (IN) are made to allow elevation of a full-thickness buccal flap and a thinned palatal flap. After removing secondary flaps, osteoplasty and ostectomy (OST) are performed. Intrasurgical new preparation (NP) of the abutments is performed, adding a feather-edge to the preexisting preparation, ending 2 mm vertically from the new bone crest level.
Fig 3  Clinical situation immediately postsurgery. CO = coagulum; NP = new preparation; PDL = periodontal ligament.

Fig 4  Clinical situation 7 to 10 days after surgery. The existing provisional restorations are relined to obtain a new seal at the level of new preparation, which is located inside the gingival sulcus (at least 2 mm from the bone crest) after surgery. NJE = new immature junctional epithelium; NIE = new immature epithelium; GT = granulation tissue in maturation phase; NC = new connective tissue in maturation phase; PDL = periodontal ligament.

Fig 5  During the healing phase, the intrasulcular portion of the temporary crown’s margin supports the gingival margin circumferentially, allowing maturation of the junctional epithelium and the connective tissue, which will adapt to the new emergence profile. NMJE = new mature junctional epithelium; NME = new mature epithelium; NC = new connective tissue; PDL = periodontal ligament.

Fig 6  Nine months after surgery, one retraction cord is positioned in the sulcus to allow the “displacement” of the junctional epithelium, and the preparation is re-finished, taking extreme care not to damage the junctional epithelium. NP = new preparation; F = fiber; NMJE = new mature junctional epithelium; NME = new mature epithelium; NC = new connective tissue; PDL = periodontal ligament.

Fig 7  After removing the epithelium displacement cord, definitive high-precision impressions are made. IMP = impression material; NMJE = new mature junctional epithelium; NME = new mature epithelium; NC = new connective tissue; PDL = periodontal ligament.

Fig 8  New situation 9 months after surgical crown lengthening, at the delivery of definitive crowns. NMJE = new mature junctional epithelium; NME = new mature epithelium; NC = new connective tissue; PDL = periodontal ligament.
maintaining a scalloped, parabolic bony contour to follow the desired contour of the overlying gingiva (Figs 9a and 9b). An extra 2 mm were added to the previously calculated, existing BW to determine the amount of supracrestal tooth structure needed for placement of the juxtagingival prosthetic margins. Following osseous surgery, intrasurgical preparation of the abutments was performed with end cutting burs, adding a feather-edge to the preexisting preparation, ending 2 mm vertically from the new bone crest level. For the remaining 2 mm of abutment visible from the bone crest, no modification of the natural emergence profile was made. Both the buccal and palatal flaps were apically positioned at the bony crest and stabilized by single vertical mattress sutures (Fig 9c). The existing temporary restorations were cemented with calcium hydroxide coating cement, which would also have filled the space between the shape of the new abutment preparation and the crowns themselves. Extreme care was taken to remove all excess cement apical to the restoration margins (Fig 9d). A periodontal dressing was used (Coe-Pak, GC).

The prosthetic procedure, as previously described, began during the surgical phase with the creation of a feather-edge to the existing preparation, without modification of the natural emergence profile of the remaining 2 mm of abutments. At suture removal (9 to 10 days postsurgery), the existing provisional restorations were removed and relined to obtain a new seal at the level of the feather-edge (which is located inside the gingival sulcus, at least 2 mm from the bone crest) after surgery. The new contours and emergence profiles of the crown’s intrasulcular portion were created following the original abutment anatomy (the 2-mm area coronal to the bone crest was not modified) using a thin, flat tool (Fig 10a).

After isolating the abutment with glycerin, the existing crown was relined with fluid acrylic resin. During the resin’s hardening phase, the thin, flat tool follows the internal portion of the gingival margin, using the rounded end to lean on the edge of the abutment’s natural emergence profile, which was not modified in the 2-mm area coronal to the bone crest (Fig 10b). Once it is relined, the crown shows two distinct margins: an internal one (with the feather-edge) and an external one (which follows the external portion of the gingival margin). Excess material was removed. After polishing, the crown—with the new angular component positioned in the sulcus, still in maturation phase—was cemented, respecting the BW. During the next healing phase, the intrasulcular portion of the temporary crown’s
margin supports the gingival margin circumferentially, allowing matura-

tion of the junctional epithelium and of the connective tissue, which will

adapt to the new emergence profile. Because the relined provisional
crowns must remain in situ over the next 6 to 9 months, alginate or high-

precision material impressions can be taken during the same appoint-

ment to build a second series of relievable provisional restorations,

which could be used in the event of breakage or deterioration (Fig 10c).

New appointments were scheduled for monthly check-ups to evaluate

the growth of the interdental papil-

lae and the stability of the gingival

margins until the final restorative

phase, which was never scheduled

prior to 9 months postsurgery.

Nine months after surgery, de-

finite, high-precision impressions

were taken for final restorations. Be-

fore impression-taking and under in-

traoperative microscopic control (at

×20 to ×25 magnification), one re-

traction cord was positioned in the

sulcus to allow the “displacement”

of the junctional epithelium (Fig

11a). Using a 12-blade cutter, the

existing preparation was re-finished,

taking extreme care not to damage

the junctional epithelium (Figs 11b

and 11c). After removing the cord of

epithelium displacement, the defini-
tive, high-precision impressions were


Statistical Analysis

Means were obtained for each pa-
tient site to evaluate differences

from BSL to T3, T6, T9, and T(number

of years postsurgery). Using these

means as the response variables,

repeated-measures analysis of vari-

ance was used to determine wheth-
er there was an overall effect. Tukey

test for multiple comparisons was

used to determine which sites had
greater changes.

Results

Sixteen patients completed this

study, and no complications re-

lated to the surgery or prosthetic

treatment were observed. During

the study period, there were no

significant changes in PI or GI at

treated sites. The mean PI and GI

ranged from 0.41 to 0.52 and 0.24
to 0.43, respectively. Appendix Ta-

ble 2 presents the mean FGM, AL,

PD, KTT, KTW, BL, and BW mea-

surements at BSL, T3, T6, T9, and

T(number of years postsurgery).

Changes in FGM, AL, PD, KTT, KTW,

BL, and BW between BSL and T9

and T(number of years postsurgery)

are presented in Appendix Table 3.

At T3, T6, T9, and T(number of years

postsurgery), the displacement of

the FGM was 3.38 ± 0.21 mm, 3.50 ±

0.21 mm, 3.44 ± 0.18 mm, and

3.47 ± 0.24 mm, respectively. At all
sites, there was a statistically significant difference in the apical displacement of FGM from BSL to T3, T6, and T9, while there was no significant change in the position from T9 to T(number of years postsurgery). At T3, T6, T9, and T(number of years postsurgery), the mean AL in treated sites was 10.78 ± 1.14 mm, 10.62 ± 0.76 mm, 10.64 ± 0.92 mm, and 10.51 ± 1.12 mm, respectively. There was no statistically significant change in AL from T3 to T9, while a statistically significant change was observed between T9 and T(number of years postsurgery). At all sites, the PD from BSL to T3 increased, was almost unchanged between T3 and T9, and then statistically significantly decreased to T(number of years postsurgery). The mean distance from the reference stent to the BL at BSL for treated sites was 9.18 ± 1.81 mm. The change in DBL before and after osseous resection at treated sites was 3.56 mm. The change in BL at T9 was 3.72 ± 0.58 mm and at T(number of years postsurgery) was 3.74 ± 0.79 mm. There was no statistically significant change in the BL from T9 to T(number of years postsurgery). At all treated sites, BW at T9 was smaller than at BSL (mean: −0.06 ± 0.02 mm), whereas it gradually increased during the follow-up until almost reaching initial

Fig 11  (a) Before making a definitive impression, an intraoperative microscopic control (×20 or ×25 magnification) is used to position one cord in the sulcus, allowing the “displacement” of the junctional epithelium. (b) Under intraoperative microscopic control, it is possible to perfectly control the limit of the first preparation. (c) Intraoperative microscopic control is used again to re-finish the existing preparation using a 12-blade cutter, taking extreme care not to damage the junctional epithelium. (d) The impression material is easily able to match the high-precision impression. (e) Under intraoperative microscopic control, it is possible to control the intrasulcular extension of the crown’s metallic margins.

Fig 12  (a) Clinical situation at delivery of the definitive crowns. (b) Clinical situation > 15 years after surgical crown lengthening. The reinforced gingival attachment can be noted.
levels at an examination 15 or more years postsurgery. The mean value of KTW at BSL, T6, and T(number of years postsurgery) was 5.21 ± 1.09 mm, 5.16 ± 1.12 mm, and 5.24 ± 0.113 mm, respectively. At all treated sites, no significant difference was found from BSL to T9 and to T(number of years postsurgery). The mean value of KTT at BSL, T9, and T(number of years postsurgery) was 0.87 ± 1.17 mm, 0.91 ± 1.09 mm, and 1.44 ± 0.24 mm, respectively. The change of KTT between T9 and T(number of years postsurgery) was statistically significant.

Discussion

Considering individual variations in BW dimensions and the possible unwanted effects of minimal surgical osseous reduction,17,18 there is a general consensus that a minimum distance of 3 to 4 mm is required from the osseous crest to the final restorative margins.8,16 In the present study, the magnitude of the existing BW (previously calculated as more than 2 mm) was used to determine the amount of osseous reduction to perform. Results related to the first healing period (< 9 months) are clinically superimposable to the results documented histologically.19-21 They are also in agreement with data reported in a clinical study by Lanning et al22 (BW reductions of 0.3 mm and 0.07 mm at 3 and 6 months, respectively). Several studies2-5,23-29 demonstrated compromised healing associated with the subgingival level compared to the supragingival level of crown margin preparations. However, it must be emphasized that the term “subgingival” is too generic and does not allow a precise definition of the margin positioning; it could be related to margins extending within the gingival crevice, but also beyond—for example, into the junctional epithelium, if not into the supracrestal connective tissue. Maynard and Wilson30 proposed dividing the periodontium into three dimensions: superficial physiologic, crevicular physiologic, and subcrevicular physiologic. The superficial physiologic dimension represents the free and attached gingiva surrounding the tooth, while the crevicular physiologic dimension represents the gingival crevice, extending from the FGM to the junctional epithelium. The subcrevicular physiologic space is analogous to the BW described by Gargiulo et al,9 consisting of the junctional epithelium and connective tissue attachment. Nevins and Skurow31 stated that when subgingival margins are indicated, the restorative dentist must not disrupt the junctional epithelium or connective tissue apparatus during preparation and impression-taking. According to the previously mentioned considerations, all prosthetic procedures in the present study were performed with the aid of an operating microscope set at either ×25 or ×30 magnification. This allowed maximum control of the sulcular depth reached in each phase of the prosthetic procedure, achieving the primary objective of not exceeding the apical limit (1 mm from the gingival margin), which is space occupied by the junctional epithelium (Fig 11).

The maturation of BW after surgery is accompanied by a coronal regrowth of interdental papillae (called soft tissue rebound), a phenomenon that lasts more than 1 year after surgery.18 Many surgical and restorative factors influence the coronal regrowth of the interdental papillae,18,32-35 including the already-mentioned distance of restorative margins from the bone crest, the patient biotype, the amount of interdental bone loss, the distance from the contact point to the bone crest, and the shape of the roots. Moreover, to permit functional gingival stimulation, the artificial crown should follow the original anatomy of the tooth;35 furthermore, buccal and lingual crown contours should be “flat,” not “fat,” (usually < 0.5 mm wider than the cemento-enamel junction), and no variations in crown contour beyond 1 mm should be performed.35 These considerations underline the importance of careful presurgical, surgical, and restorative evaluations to obtain satisfactory results, optimizing the control of potential rebound (1) through possible further modifications of the convergence of provisional interproximal surfaces and the position of the contact points, and (2) by waiting at least 9 months after surgery before definitive prosthetic management.

One interesting result of the present study is related to KTT. In 92% of treated sites, it showed a significant increase between T9 and T(number of years postsurgery) averaging 0.73 mm. The observed thickening of the marginal keratinized gingival tissue had a clinically
“reinforced gingival attachment” aspect (Fig 12), presenting an extreme resistance to mobilization, with PD almost 0 mm. Because the reestablishment of attached epithelium and connective tissue after SCL began at 1 week postsurgery and reached functional maturity between 6 and 9 months postsurgery,18 none of the prosthetic procedures should disrupt tissue integrity during this period. The early postsurgical POCR technique used in the present study is extremely conservative in the postsurgical aspect of periodontal tissues and allows, by means of the interaction between the preparation and restoration gingiva, the gingival tissue to thicken and adapt to new crown forms, resulting in a reinforced gingival attachment tissue stimulation.

Conclusions

Within the limitations of the present study, outcomes showed that the surgical and restorative techniques used in SCL obtained a consistent 3-mm gain in coronal tooth structure and reestablished the BW to its original vertical dimension, all without significant changes in the position of the FGM from 9 months to 15 or more years.

Acknowledgments

The author declares no conflicts of interest.

References


### Appendix Table 1  Sequence of Measurements

<table>
<thead>
<tr>
<th>Examination/Follow-up</th>
<th>FGM</th>
<th>AL</th>
<th>PD</th>
<th>KTT</th>
<th>KTW</th>
<th>BL</th>
<th>BW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline, prior to surgery</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
</tr>
<tr>
<td>After flap reflection, prior to surgery</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
</tr>
<tr>
<td>After flap reflection and surgery</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
<td>FGM</td>
</tr>
<tr>
<td>3 mo</td>
<td>1.27 ± 1.17</td>
<td>4.24 ± 0.52</td>
<td>9.18 ± 1.81</td>
<td>2.26 ± 0.14</td>
<td>5.21 ± 1.09</td>
<td>4.86 ± 1.12</td>
<td>4.88 ± 1.26</td>
</tr>
<tr>
<td>6 mo</td>
<td>2.56 ± 0.52</td>
<td>10.62 ± 0.76</td>
<td>2.86 ± 0.84</td>
<td>3.24 ± 0.61</td>
<td>4.86 ± 1.12</td>
<td>4.88 ± 1.26</td>
<td>4.88 ± 1.26</td>
</tr>
<tr>
<td>9 mo</td>
<td>1.27 ± 1.17</td>
<td>4.24 ± 0.52</td>
<td>9.18 ± 1.81</td>
<td>2.26 ± 0.14</td>
<td>5.21 ± 1.09</td>
<td>4.86 ± 1.12</td>
<td>4.88 ± 1.26</td>
</tr>
<tr>
<td>≥ 15 y</td>
<td>1.27 ± 1.17</td>
<td>4.24 ± 0.52</td>
<td>9.18 ± 1.81</td>
<td>2.26 ± 0.14</td>
<td>5.21 ± 1.09</td>
<td>4.86 ± 1.12</td>
<td>4.88 ± 1.26</td>
</tr>
</tbody>
</table>

FGM = free gingival margin; KTT = keratinized tissue thickness; KTW = keratinized tissue width; AL = attachment level; PD = probing depth; BL = bone level; BW = biologic width.

Sequence of measurements and calculations obtained at baseline, during surgery, and at the 3-month, 6-month, 9-month, and ≥ 15-year examinations.

### Appendix Table 2  Clinical Parameters Obtained During Follow-up

<table>
<thead>
<tr>
<th>Examination</th>
<th>FGM</th>
<th>AL</th>
<th>PD</th>
<th>KTT</th>
<th>KTW</th>
<th>BL</th>
<th>BW</th>
</tr>
</thead>
<tbody>
<tr>
<td>BSL</td>
<td>4.36 ± 0.18</td>
<td>6.92 ± 0.85</td>
<td>2.56 ± 0.52</td>
<td>1.27 ± 1.17</td>
<td>5.21 ± 1.09</td>
<td>9.18 ± 1.81</td>
<td>2.26 ± 0.14</td>
</tr>
<tr>
<td>T3</td>
<td>7.54 ± 0.21</td>
<td>10.78 ± 1.14</td>
<td>3.24 ± 0.61</td>
<td>4.86 ± 1.12</td>
<td>4.86 ± 1.12</td>
<td>4.88 ± 1.26</td>
<td>4.88 ± 1.26</td>
</tr>
<tr>
<td>T6</td>
<td>7.76 ± 0.24</td>
<td>10.62 ± 0.76</td>
<td>2.86 ± 0.84</td>
<td>4.86 ± 1.12</td>
<td>4.86 ± 1.12</td>
<td>4.88 ± 1.26</td>
<td>4.88 ± 1.26</td>
</tr>
<tr>
<td>T9</td>
<td>7.80 ± 0.16</td>
<td>10.64 ± 0.92</td>
<td>2.84 ± 0.58</td>
<td>1.31 ± 1.09</td>
<td>5.16 ± 1.28</td>
<td>12.84 ± 1.41</td>
<td>2.20 ± 0.36</td>
</tr>
<tr>
<td>T15+</td>
<td>7.83 ± 0.22</td>
<td>10.51 ± 1.12</td>
<td>2.68 ± 0.16</td>
<td>2.04 ± 0.84</td>
<td>5.24 ± 1.41</td>
<td>12.92 ± 1.59</td>
<td>2.41 ± 0.22</td>
</tr>
</tbody>
</table>

Follow-up times: T3 = 3 months postoperative; T6 = 6 months postoperative; T9 = 9 months postoperative; T15+ = ≥ 15 years postoperative.

FGM = free gingival margin; AL = attachment level; PD = probing depth; KTT = keratinized tissue thickness; KTW = keratinized tissue width; BL = bone level; BW = biologic width.

Data presented are the mean distances from the reference stent to the clinical reference points at different follow-ups. Values are presented in millimeters as mean ± SD. KTW and KTT were measured directly without the reference stent. PD and BW are calculated measurements.

### Appendix Table 3  Changes in Clinical Parameters from Baseline to the 9-Month and Final Examinations

<table>
<thead>
<tr>
<th>Examination</th>
<th>FGM</th>
<th>AL</th>
<th>PD</th>
<th>KTT</th>
<th>KTW</th>
<th>BL</th>
<th>BW</th>
</tr>
</thead>
<tbody>
<tr>
<td>T9</td>
<td>3.44 ± 0.18</td>
<td>3.72 ± 0.48</td>
<td>0.28 ± 0.14</td>
<td>0.04 ± 0.09</td>
<td>-0.05 ± 0.08</td>
<td>3.66 ± 0.69</td>
<td>-0.06 ± 0.02</td>
</tr>
<tr>
<td>T15+</td>
<td>3.47 ± 0.24</td>
<td>3.59 ± 0.62</td>
<td>0.12 ± 0.16*</td>
<td>0.77 ± 0.52*</td>
<td>0.03 ± 0.01*</td>
<td>3.74 ± 0.54</td>
<td>0.15 ± 0.03*</td>
</tr>
</tbody>
</table>

Follow-up times: T9 = 9 months postoperative; T15+ = ≥ 15 years postoperative. Clinical parameters: FGM = free gingival margin; AL = attachment level; PD = probing depth; KTT = keratinized tissue thickness; KTW = keratinized tissue width; BL = bone level; BW = biologic width.

Values are presented in millimeters as mean ± SD. For FGM, AL, and BL, data presented are the mean distances from the reference stent. KTW and KTT were measured directly without the reference stent. PD and BW are calculated measurements.

* *P < .05*