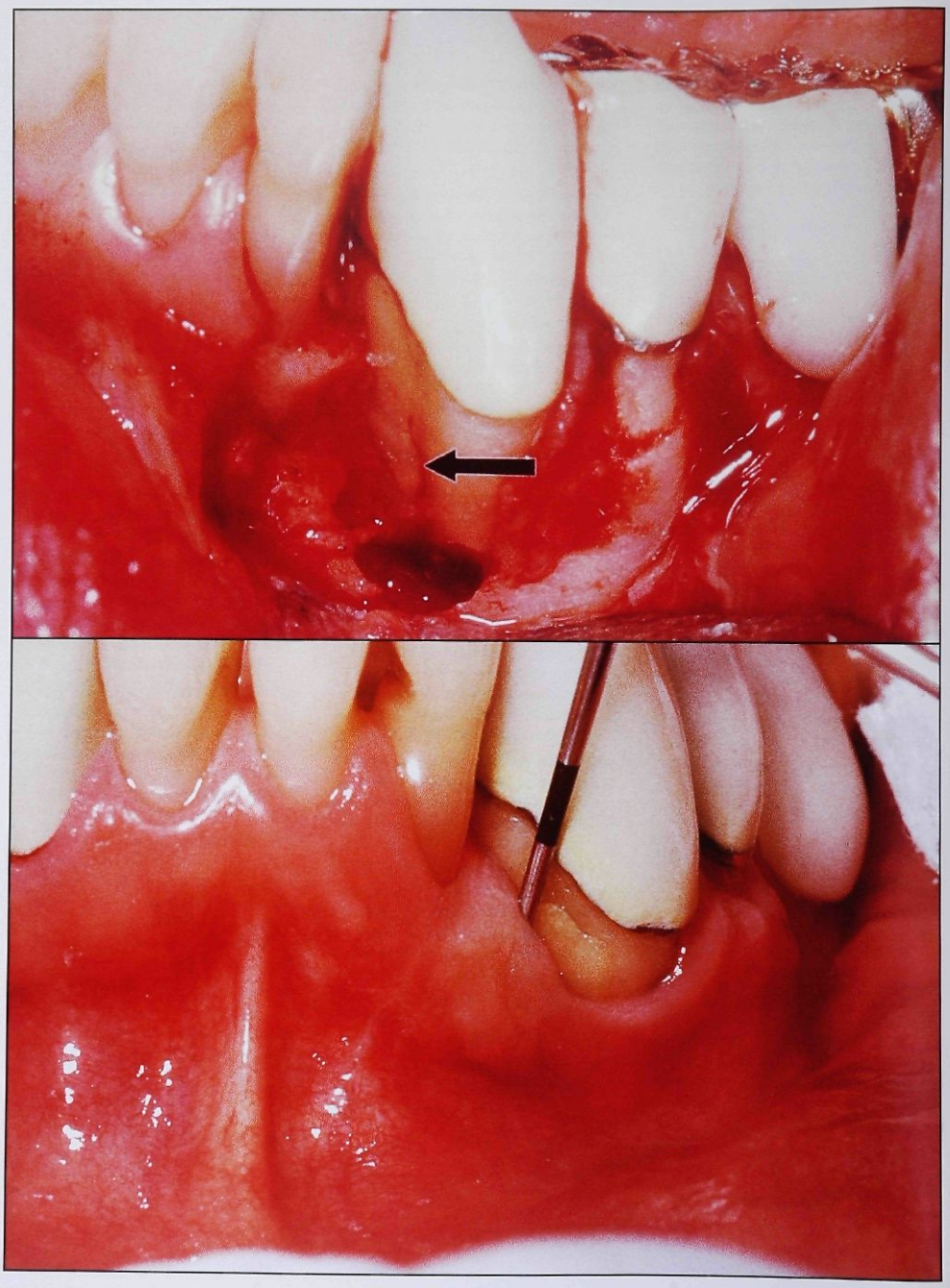

Resin-Ionomer and Hybrid-Ionomer Cements: Part II. Human Clinical and Histologic Wound Healing Responses in Specific Periodontal Lesions

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Twenty-five subjects with a total of 50 subgingival restorations participated in this study. At the beginning of the investigation, nine teeth that were considered hopeless because of the extent of their pathology were selected for extraction to evaluate histologically the restorations and their effect on the adjacent tissues. The purpose of this article is to demonstrate the responses to the clinical applications as well as to the placement of resin-ionomers in subgingival lesions. Clinical and histologic evidence of epithelial and connective tissue adherence to resin-ionomer restorative materials was observed during the healing process. (Int J Periodont Rest Dent 1997;17:75–87.)

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Recently, modified resin-glass-ionomer formulations were placed as subgingival restorative materials to restore teeth that were previously considered hopeless and/or nonrestorable.[1] Root lesions that require subgingival restorations may include cases involving root resorption, fractured roots, erosive lesions, endodontic perforations, and deep carious root lesions. Part I of this series described the ideal characteristics, according to the author, of a subgingival restorative material for the repair of such defects, as well as the differences between several restorative materials that are potentially suitable for this purpose. To delineate and more carefully define the wound healing responses of the periodontium following these subgingival restorative procedures, clinical and histologic evidence of repair of the periodontal complex is necessary.[2] Therefore, the purpose of this article is to describe the clinical

applications and placement of resin-ionomer restorative materials in subgingival lesions and to present the histologic wound healing that follows these therapeutic procedures.

Method and materials

Twenty-five subjects in need of a total of 50 restorations participated in this study. All subjects were informed of their oral condition, and all received a thorough oral and written explanation of the procedures to be performed. After a subject received this information and before the procedure was started, an informed consent document was signed. Clinical documentation included a complete-mouth periodontal chart, radiographs, 35-mm color slides, assessment of gingival inflammation based on the presence or absence of redness and bleeding on probing, and the measurement of a Plaque Index.[9]

Measurement of probing depth was made parallel to the long axis of the tooth with a specially fabricated pressure-sensitive probe calibrated to 10 g of force. All probing measurements were rounded off to the nearest millimeter. Bleeding on probing was assessed as either present (+) or absent (–) within 30 seconds after probing ((+) = 1, (–) = 0). Redness of the gingiva was assessed as either present (+) or absent (–) ((+) = 1, (–) = 0). Gingival recession was measured from the cementoenamel junction (CEJ) and/or other fixed reference points that were available. Change in attachment level was determined from the changes in probing depth, and gingival recession measurements were taken at baseline and postoperatively. All measurements were rounded off to the nearest millimeter.

Preoperative preparation consisted of scaling and polishing, as well as instruction in the Bass method of tooth brushing, the use of unwaxed dental floss, and the Perio-aid (Butler). A period of 4 weeks was allowed for patients to develop skills in plaque removal before the experimental procedures commenced. It should be noted that although the subjects achieved Plaque Index scores of one or below at the end of this period, few subjects maintained that level for the duration of the investigation.

Two resin-ionomer restorative materials, Dyract (restorative A, DeTrey/Dentsply) and Geristore (restorative B, DenMat), and one hybrid-ionomer material, Photac-Fil (restorative C, ESPE Premier) were used to restore the dental lesions. All materials were used according to their manufacturer's instructions. Since all of the dental lesions in these investigations were subgingival, a full-thickness

mucoperiosteal flap was reflected prior to restoration of the lesion. To control the hemorrhage from the periodontal ligament and alveolar bone, a 30% hydrogen peroxide solution on a cotton pellet was applied to the surgical site for 5 seconds to achieve hemostasis. An alternative method would have been to use the Stabident System (Fairfax Dental) with a local anesthetic containing a vasoconstrictor. This technique was designed to allow local anesthetic to be injected directly into the alveolar process with resulting vasoconstriction and anesthesia. Once the restorations were in place, they were finished with a fine-grit diamond only, and no attempt was made to polish the restored surface. When the subgingival lesion had invaded the pulp canal, the pulp was extirpated and a gutta percha point was placed into the root canals to maintain the patency of the canal prior to the placement of the restorative material. The root canal fillings were completed subsequent to the subgingival restoration.

The mucoperiosteal flaps were replaced and sutured with a 4-0 silk suture. A periodontal dressing (Coe-Pack, GC America) was placed for the first postoperative week. No antibiotics were prescribed or administered. The use of antimicrobial mouth rinses was optional after the first week. Subjects were recalled weekly for the first 4 weeks, and then on a monthly basis for the first postoperative year, and every 3 months thereafter for an assessment of periodontal condition.

Prior to performing the restorative procedures, a total of nine teeth that had been diagnosed as hopeless by the patients' dentists were selected for extraction to undergo histologic evaluation. All of the patients selected for the histologic part of these studies were immediate denture patients who were referred by their general dentists. Of the nine teeth, three teeth were selected for treatment with each product. At the end of 3 months, these restored teeth with adjacent tissues were removed with the ridge-preserving technique previously described to histologically evaluate restoration-tooth-tissue interfaces.[2] The biopsies were fixed in 70% alcohol and embedded in methyl methacrylate for microscopic examination. Serial sections were cut at 10 to 15 µm, and every tenth section was stained with either hematoxylin and eosin, toludine blue, or mineralized bone stain (MIBS). All stained sections were studied under the light microscope.

Clinical case reports

Representative case reports from the 25 subjects and 50 restorations evaluated for this study are presented below.

External root resorption

External resorptive lesions were classified by Mesaros and Wayman[3] according to the following etiology: periapical inflammation, reimplantation of teeth, tumors and cysts, trauma, impaction of teeth, and idiopathic conditions. The following two cases are descriptive of the physiologic resorptive process that takes place as a result of inflammatory resorption.[2] These cases may be characterized by intense inflammation with areas of bowl-shaped resorption of the cementum and dentin.

Fig 1a (left) *Clinical photograph depicting the extent of the destruction of the root and crown. The root was destroyed approximately 2 mm apical to the alveolar crest.*

Fig 1b (left) *Clinical photograph of the root and crown restored with a resin-ionomer restorative material. The restorative material was placed approximately 2 mm subcrestal, and a new bone-restoration space had to be created with a thin, fine-grit diamond.*

Fig 1c (right) *Radiograph taken 1.5 years postoperative.*

Fig 1d *Clinical photograph taken 1.5 years postoperative. Note the lack of gingival inflammation adjacent to the resin-ionomer material and that the clinical crown and root were restored with the resin-ionomer material only. The tooth has been in function without a post-and-core build-up and a crown restoration.*

Case 1

A 31-year-old man presented with a root resorptive lesion on the lingual surface of his canine. Radiographic evidence and surgical exposure revealed that the lesion extended approximately 2.0 mm apical to the alveolar crest. An endodontic access opening was made in the crown, and the pulp was extirpated. A full-thickness mucoperiosteal flap was reflected to expose the resorptive lesion in the root surface. A round carbide bur was used to establish a solid tooth surface to receive the restoration (Fig 1a). A gutta-percha point was placed in the root canal to keep the canal accessible for the projected endodontic procedure. The restorative material was placed approximately 2 mm subcrestal to include the entire resorptive lesion (Fig 1b). A thin, fine-grit diamond was used to create a restoration-bone space and finish the margin of the restoration. The flap was replaced. At 1.5 years postoperative, the tissue appeared clinically healthy and well adapted to the root surface (Figs 1c and 1d). No redness and/or bleeding on probing was present. Probing assessment demonstrated minimal sulcus depth, which suggested tissue attachment to the restoration.

Case 2

A 41-year-old woman presented with a root resorptive lesion on the labial surface of her anterior tooth. A flap was reflected, and a lingual access opening was made in the crown to extirpate the pulp. A gutta-percha point was placed in the root canal to preserve and maintain patency of the root canal for endodontic therapy (Fig 2a). The resin-ionomer restorative material was then placed to restore the lesion in the root (Fig 2b). The restoration was finished with a fine-grit diamond, and the flap was sutured coronal to the alveolar crest (Fig 2c). At the end of 1 year a noticeable lack of gingival inflammation and minimal sulcus depth were apparent adjacent to the resin-ionomer material (Fig 2d).

Fig 2a *Clinical photograph depicting root resorption destruction of the facial root surface. Note the gutta-percha point in the root canal to maintain canal patency. The root canal was completed subsequent to sealing of the root surface with the resin-ionomer restorative material.*

Fig 2b *Clinical photograph illustrating the resin-ionomer restoration in the root resorptive lesion. The restoration was finished with a fine-grit diamond bur.*

Fig 2c *Clinical photograph of the tissue flap sutured over the resin-ionomer. Note the distance between the CEJ and the coronal edge of the flap.*

Fig 2d *Clinical photograph taken 1 year postoperative. Note the shallow sulcular depth, lack of gingival inflammation, and change in flap position over the resin-ionomer restoration when compared to Fig 2c.*

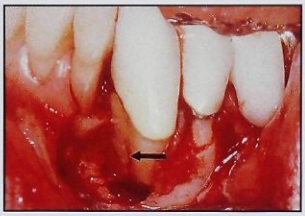


Fig 3a *Clinical photograph depicting massive destruction of alveolar bone and a split root* (arrow).

Fig 3b *Clinical photograph illustrating the apex (retrofil) and labial split root restored with a resin-ionomer material. The surface of the restorative material was finished with a fine-grit diamond bur.*

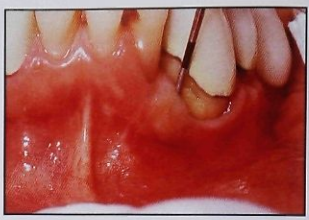


Fig 3c *Eighteen-month postoperative photograph depicting a shallow gingival sulcus adjacent to the restored root surface.*

Root fracture

Acute or chronic trauma may result in vertical crown and root fractures. The defect may be a partial or complete fracture involving the crown and/or root.[4] Fractures have frequently been associated with extensive dental treatment. The following case describes a vertical fracture repair.

Case 3

A 52-year-old woman presented for periodontal treatment on a mandibular canine with a deep pocket and labial fistula. Clinical probing revealed extensive pocket formation mesiofacially. Radiographic evidence indicated that the tooth had been endodontically treated. Upon reflection of the tissue, it was noted that the labial root was fractured vertically (Fig 3a). The fractured area and the apical foramen of the root canal were restored with a resin-ionomer material (Fig 3b). Eighteen months postoperative a shallow gingival sulcus adjacent to the restored root surface was noted, and the labial fistula was no longer present (Fig 3c). The tissue was not inflamed, although plaque could be observed at the gingival margin.

Restoration of caries under existing crowns

Caries may occur at or apical to the margin of a single crown and/or bridge abutment. Usually the treatment of choice is to remove the crown and/or bridge, restore the caries (possibly preform a periodontal surgical crown lengthening procedure) and replace the crown and/or bridge. The aforementioned can be a costly dental option for the patient. Advancement in adhesive dentistry and studies on the biocompatibility of resin-ionomer materials can now offer the patient a more cost-effective alternative.

Case 4

A 48-year-old man presented with deep caries under a crown, a furcation involvement, and a necrotic pulp on a right mandibular right first molar. The molar was the distal abutment for a three-unit bridge. The patient could not afford to have the bridge replaced, but did consent to having endodontic treatment and a resin-ionomer restoration placed to restore the carious lesion. Since certain resin-ionomer cements bond to both gold and dentin, this treatment concept seemed like a reasonable alternative. Subsequent to endodontic therapy, a full-thickness flap was reflected to expose the extent of the carious lesion (Fig 4a). The caries was removed, and a resin-ionomer restoration was placed on the root and under the crown. The flap was replaced to its former position and sutured. Figure 4b demonstrates that the gingival complex and the existing bridge has responded favorably for 3 years with no signs of recurrent caries, periodontal inflammation, or separation of the restoration from the gold crown.

Fig 4a *Clinical photograph of a mandibular right first molar bridge abutment depicting root caries and a furcation involvement.*

Fig 4b *Three-year postoperative clinical photograph illustrating the favorable response of the crown and gingival complex to the resin-ionomer restoration with no signs of breakdown.*

Histologic case reports

Representative case reports from the nine histologic tissue specimens evaluated for this study are presented below.

Root perforation

Unfortunately, iatrogenic injuries such as root perforations during endodontic procedures and/or preparation for post-and-core build-up may occur in clinical practice even with diligent care. The following case depicts a simulated root perforation that was repaired with a resin-ionomer restoration.

Case 5

After flap reflection, a root perforation was simulated on the labial surface of a central incisor of a 55-year-old man, who was scheduled for an immediate denture by his general dentist. The endodontic procedure was completed prior to tissue reflection. A resin-ionomer restoration was placed on the labial surface of the tooth to repair the lesion, finished with a fine-grit diamond, and the tissue was sutured into place. Three months later, during the placement of the immediate denture, the labial aspect of the tooth and adjacent tissue was taken for histologic assessment. Histologically, it was apparent that the tissue was adherent to the resin-ionomer used to repair the root perforation (Figs 5a and 5b).

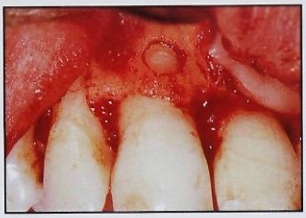


Fig 5a *Clinical photograph of a central incisor with a simulated root lesion that could have been created by an endodontic post perforation, accidental endodontic perforation, or a retrofil endodontic procedure. The perforation was restored with a resin-ionomer material to evaluate the wound healing.*

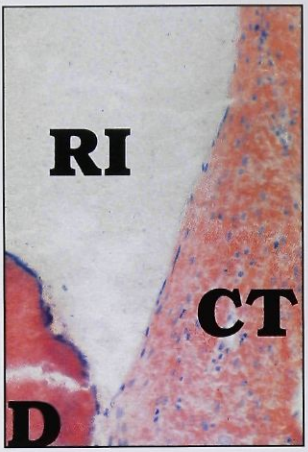


Fig 5b *Micrograph showing the fibroblasts and connective tissue* (CT) *next to the resin-ionomer restoration* (RI) *in dentin* (D) *and the absence of inflammatory cells.*

Facial root restoration

Recent advances in restorative dentistry have allowed facial lesions to be esthetically restored. However, concerns have been raised when soft tissue coverage is also desired. The following case describes the placement of a resin-ionomer restoration in such a lesion and the subsequent placement of tissue over the restorative material.

Case 6

A 46-year-old woman who was scheduled for the placement of a maxillary denture by her general dentist presented with supragingival and subgingival root caries and soft tissue dehiscences on the labial surfaces of a lateral incisor and first premolar. The canine was missing. A flap was reflected so the teeth could be adequately restored with a resin-ionomer restoration (Fig 6a). After restoring the teeth, the flap was positioned coronally to cover the entire restored root surface. Three months postoperative, the probing depths were shallow, and gingival inflammation (ie, redness and/or bleeding on probing) was not evident even in the presence of bacterial plaque (Fig 6b). The labial aspects of the teeth and adjacent tissues were removed for histologic evaluation of the lateral incisor and first premolar prior to the extractions and placement of an immediate maxillary denture by her general dentist. The histologic sections of the lateral incisor and first premolar exhibited a mean soft tissue coverage over the resin-ionomer restoration of 7.02 mm, which consisted of a mean sulcus depth of 1.07 mm, a mean epithelial attachment of 1.82 mm, and a mean connective tissue adhesion of 4.13 mm. The histologic sections revealed bacterial plaque adjacent to the gingival sulcus and a lack of inflammatory cells adjacent to the plaque and sulcus (Fig 6c). This lack of inflammatory cells could also be observed in high-power micrographs of the junctional epithelium adjacent to the resin-ionomer material (Fig 6d). Higher-power micrographs illustrate the close adhesion of the fibroblasts and connective tissue to the resin-ionomer restoration (Fig 6e).

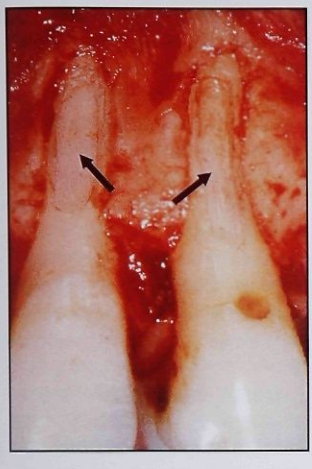


Fig 6a *Clinical photograph of a lateral incisor and first premolar. Note the labial root surfaces are restored with a resin-ionomer material* (arrows).

Fig 6b *Clinical photograph of Fig 6a 3 months postoperative depicting soft tissue coverage over the resin-ionomer material placed on the facial root lesions. Note the presence of bacterial plaque near the marginal gingiva.*

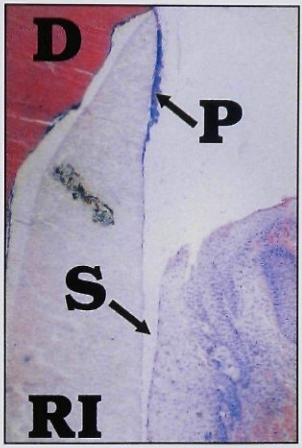


Fig 6c *Micrograph of a tissue block of the the lateral incisor in Fig 6a taken 3 months postoperative. Note bacterial plaque* (P) *on the resin-ionomer restoration* (RI) *in the dentin* (D) *next to the shallow gingival sulcus* (S), *and the relative lack of inflammatory cells in the gingival tissues adjacent to the plaque and sulcus. (Original magnification* × *50.)*

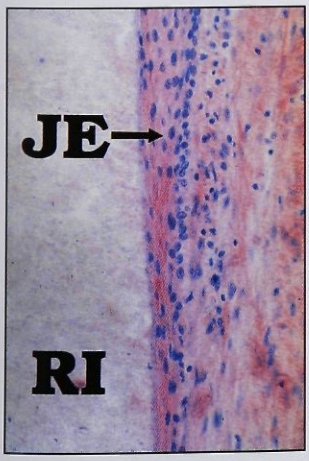
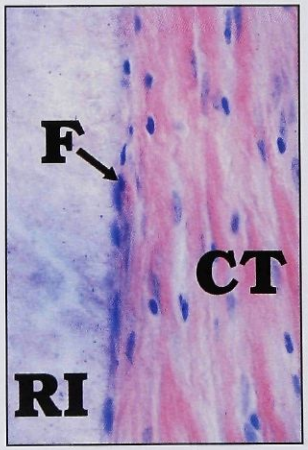


Fig 6d (left) *High-power micrograph depicting the junctional epithelium* (JE) *adjacent to the resin-ionomer restoration* (RI). *Note the lack of inflammatory cells. (Original magnification* × *250).*

Fig 6e (right) *Higher-power micrograph depicting fibroblasts* (F) *and connective tissue* (CT) *adjacent to the resin-ionomer restoration* (RI). *(Original magnification* × *500.)*



Clinical discussion

The subgingival lesions restored in this study were traditionally considered to be unrepairable by many dentists. Based on the findings of this study, subgingival restorations may now be placed in a more routine fashion, because the materials tested exhibited dentin bonding capabilities and biocompatibility to surrounding tissues.

Results indicate that, except for the nine predetermined teeth that were extracted and the four restorative A fillings that debonded, all of the teeth restored subgingivally continue to be in function after periods of 1 to 3 years. Although the patients were required to obtain a Plaque Index of 1 or below to begin the study, the mean PI exceeded this level subsequent to the restorative procedures (Table 1). All of the restorative materials exhibited fluoride release, which may have altered the nature of plaque surrounding the restorations. Gingival inflammation, as assessed by redness and/or bleeding on probing, was minimal after healing (Tables 2 and 3). Probing depths are listed in Table 4. The mean gains in attachment level after 1 year are indicated in Table 5.

Certain resin-ionomer restorative materials possess properties that are biocompatible with periodontal tissues. This biocompatibility may be related to the antimicrobial activity of the fluoride release of resin-ionomer materials that affects the composition of the bacterial plaque and plaque biochemistry by altering carbohydrate metabolism (see Fig 6c).[5] All of the cases demonstrated minimal signs of clinical inflammation (redness and/or bleeding on probing, Tables 2 and 3) in the healing areas, even in the presence of plaque. It was interesting to note that although the plaque score increased over the postoperative course (Table 1), gingival inflammation decreased (Tables 2 and 3).

Postoperative gingival recession was minimal for all procedures. At 1 year postoperative, the mean gingival recession was 0.42 mm. Also at 1 year postoperative there were significant decreases in probing depths and gain in attachment with all three materials tested (Tables 4 and 5). Although restorative A had 0.51 mm more probing depth than material B and 0.59 mm more probing depth than material C, there were no significant differences in the gain of soft tissue attachment values with any of the materials tested. Further study will report on the differences in biocompatibility to bone tissue.

It was also interesting to note the positive correlation between redness and bleeding on probing at 1 year postoperative (Tables 2 and 3). When the soft tissue was advanced coronally over restored subgingival lesions (ie, coronally positioned flaps to cover exposed root surfaces), the clinical probing depths were minimal and the gingival tissues appeared to adhere to the repaired root surfaces (Table 6). Preoperative and postoperative probing depths were similar; however, the postoperative gain in clinical attachment was 4.25 ± 0.43 mm over preoperative values. The postoperative change in marginal gingiva (coronal advancement) was 4.00 ± 0.71 mm.

Certain restorative materials have the ability to reduce and/or eliminate the incidence of microleakage. The resin-ionomer restorative material may act as a seal to minimize any internal or external bacterial contamination between the restorative margin on the tooth and the surrounding tissues, thereby facilitating the health of the gingival complex.

Crown lengthening was not performed in any of the cases where the lesion extended to or below the crest of the bone. The teeth were restored to full functionality while maintaining an esthetic result.

Table 1 Plaque Index (mean ± SD)

	Restorative		
	A	B	C
Preoperative	0.86 ± 0.35	0.68 ± 0.47	0.80 ± 0.40
3 mo	1.29 ± 0.59	1.09 ± 0.51	1.60 ± 0.49
6 mo	1.54 ± 0.63	1.05 ± 0.51	1.57 ± 0.49
1 y	1.30 ± 0.61	1.10 ± 0.46	1.29 ± 0.70

Table 2 Gingival inflammation (mean ± SD)

	Restorative		
	A	B	C
Preoperative	0.92 ± 0.26	0.77 ± 0.42	0.90 ± 0.30
3 mo	0.29 ± 0.45	0.09 ± 0.29	0.10 ± 0.30
6 mo	0.14 ± 0.35	0.05 ± 0.22	0.14 ± 0.35
1 y	0.08 ± 0.27	0.05 ± 0.22	0.14 ± 0.35

Table 3 Bleeding on probing (mean ± SD)

	Restorative		
	A	B	C
Preoperative	0.92 ± 0.26	0.82 ± 0.39	0.90 ± 0.30
3 mo	0.36 ± 0.48	0.39 ± 0.47	0.40 ± 0.49
6 mo	0.23 ± 0.42	0.05 ± 0.22	0.14 ± 0.35
1 y	0.08 ± 0.27	0.05 ± 0.22	0.14 ± 0.35

Table 4 Probing depth (mean ± SD)

	Restorative		
	A	B	C
Preoperative	6.14 ± 0.83	5.55 ± 0.75	5.10 ± 0.70
3 mo	3.07 ± 0.46	2.45 ± 0.66	2.20 ± 0.40
6 mo	3.15 ± 0.53	2.58 ± 0.67	2.71 ± 0.45
1 y	3.30 ± 0.61	2.79 ± 0.83	2.71 ± 0.88

Table 5 Mean attachment level gains after 1 year

	Restorative		
	A	B	C
Mean	2.14	2.27	2.20
SD	0.74	0.79	0.75

SD = Standard deviation.

Table 6 Clinical measurements for soft tissue coverage over resin-ionomers

	Mean	SD
Preoperative probing depth	2.5	0.50
Postoperative change in marginal gingiva (coronal attachment)	4.0	0.71
3-month postoperative probing depth	2.25	0.43
Attachment level gain	4.25	0.43

SD = Standard deviation

Table 7 Histologic measurements of soft tissue coverage over resin-ionomer at 3 months postoperative (mm)

	Mean
Sulcus depth	1.07
Length of epithelial at attachment	1.82
Connective tissue adhesion	4.13

Histologic discussion

Histologic findings suggest epithelium and connective tissue adherence to the resin-ionomer restorative materials during the wound healing process. Cases presented in this report indicate that it may be possible to restore the junctional epithelium and connective tissue adhesion to resin-ionomer restorations and deter crown lengthening procedures that may result in adverse esthetics and/or more complicated oral hygiene procedures. With crown lengthening procedures it is usually necessary to expose sufficient tooth by the removal of bone to allow the restoration to be placed without impingement on the biologic width.[6,7] Table 7 shows the mean values of serial sections taken from histologic biopsy specimens.

It is interesting to note the comparison of the clinical measurements (Table 6) and histologic measurements (Table 7). The combined histologic measurements of sulcus depth and epithelial attachment are 2.89 mm, and the clinical probing depth was 2.25 mm. The histologic connective adhesion was 4.13 mm compared to the 4.25 mm clinical attachment gain. Additional histologic studies are warranted to confirm the new attachment and/or adhesion between the resin-ionomer restorative materials and the periodontal tissues noted in this study.

Conclusions

1. The author suggests that resin-ionomers need to possess the following physical characteristics to be used as an ideal subgingival restorative material: biocompatibility, dual-cure set, adhesiveness, fluoride release, radiopacity, compactness, surface hardness, insolubility in oral fluids, absence of microleakage, low coefficient of thermal expansion, and low cure shrinkage.
2. Epithelial and connective tissue adhesion was observed during the wound healing process with restoratives A, B, and C.
3. The physical properties of certain resin-ionomer restorative materials allowed lost crown and root structures to be replaced functionally and esthetically in place of traditional crown lengthening, post-and-core build-up, and complete-crown procedures.

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