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Gingival response to a new multipurpose dental adhesive: A histologic study in dogs

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The biocompatibility of cementing materials is a prerequisite for any dental procedure. In this study, the tolerance of gingival tissue to an advanced fourth-generation dental adhesive (High-Q-Bond) was tested in dogs. The results from High-Q-Bond adhesive were compared with those obtained from Superbond C&B adhesive. Buccal class V subgingival cavities were restored with either High-Q-Bond or Superbond C&B adhesive. Untreated teeth served as normal intact controls. The teeth with the attached buccal gingivae were extracted and processed for histologic examination. The histologic observations showed an inflammatory response in the gingiva of the Superbond C&B adhesive-treated teeth, whereas the High-Q-Bond fillings exhibited no noticeable adverse effect on the gingival tissue. (J Prosthet Dent 1996; 76: 379-85.)

During cementing procedures, contact between cementing agents and the gingiva is inevitable. The biocompatibility of these materials with both the dental pulp and the gingiva is a prerequisite for any such dental application. Thus, the tolerance of the dental tissues to these materials should be established before their clinical use.

Many dental adhesives have been shown to be safe for dental pulp.[1] However, the adhesive agents polymethyl methacrylate (PMMA), found in restorative unfilled acrylic resins, and bisphenylglycidylmethacrylate (bis-GMA), found in restorative composites, caused mild to severe pulp irritation.[2] Proper clinical precautions such as the use of a protective liner and adequate thickness of dentin can prevent pulp inflammation.[2]

Well-polished acrylic resins are not toxic and do not irritate the gingival. Clinically, composites do not cause gingival problems unless subgingival rough and porous material is in contact with the gingiva.[3] To the best of our knowledge, no previous reports on the biocompatibility of fourth-generation dental adhesives for gingiva have been published.

High-Q-Bond adhesive (HQB; BJM Laboratories Ltd., Or Yehuda, Israel) is a dentin-bonding agent[4] that belongs to the fourth generation of dental adhesives. It is composed of acrylic monomers methyl methacrylate (MMA) cross-linked with a multifunctional agent (trimethylolpropane-triacrylate), an adhesion promoter (glycidoxypropyltrimethoxysilane), a comonomer - aliphatic polyester (urethane acrylate), and initiators for the autopolymerizing process (dimethyl-p-toluidine and benzoyl peroxide). The HQB composition also includes PMMA, inorganic fillers, and coupling agents. According to the manufacturer, HQB provides high tensile bond strength and can be used for bonding to various substrates such as dentin, enamel, noble and base metal alloys, amalgam, porcelain, and composite.

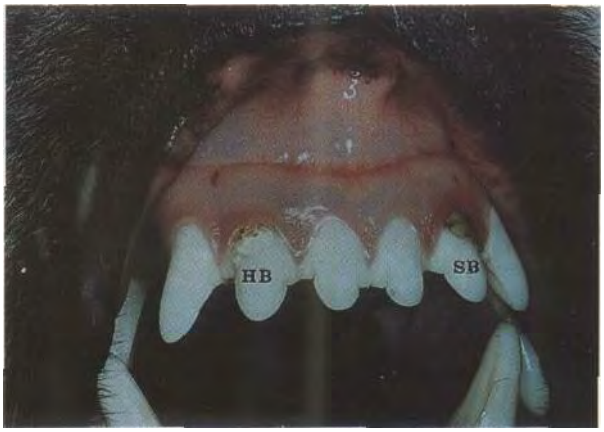

Fig. 1. Macroscopic view of maxillary incisors in dog after cavity filling with SB and HQB *(HB)*. Conspicuous inflammation around SB filling.

Superbond C&B adhesive (SB; Sun Medical Co. Ltd., Kyoto, Japan) is also a fourth-generation multipurpose autopolymerizing adhesive[5,6] composed of an MMA/ PMMA base and 4-methacryloxy ethyl trimellitate monomer (4-META) and catalyzed by tri-N-butylborane (TBB). This cement is extremely durable and displays extraordinary bond strengths to enamel, dentin, metals, porcelain, and dental resins.[6]

The first adhesive material in dentistry was MMA, polymerized with TBB. Surface treatment involved phosphoric acid etching,[7] and adhesion was obtained by me-

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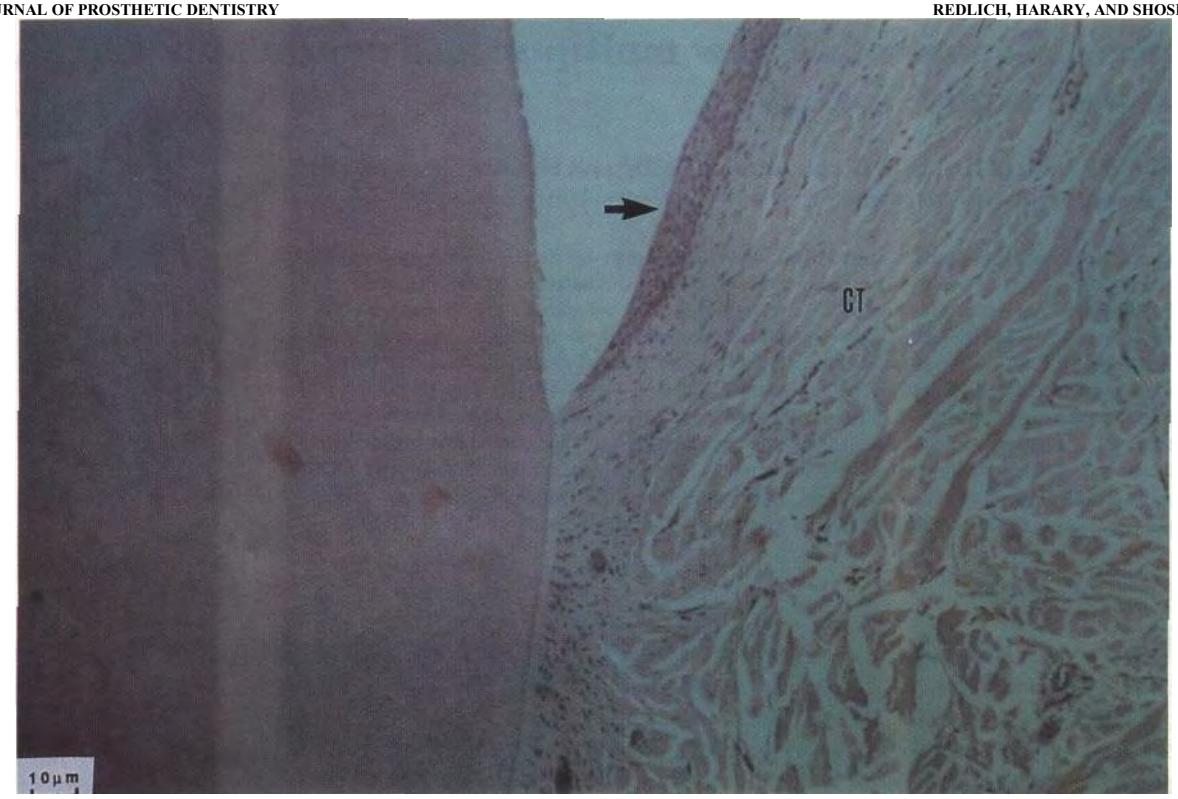

Fig.2. Photomicrograph of intact control section of incisor gingiva shows sulcular epithelium *(arrow)* and connective tissue stroma *(CT).* (Original magnification x 125.)

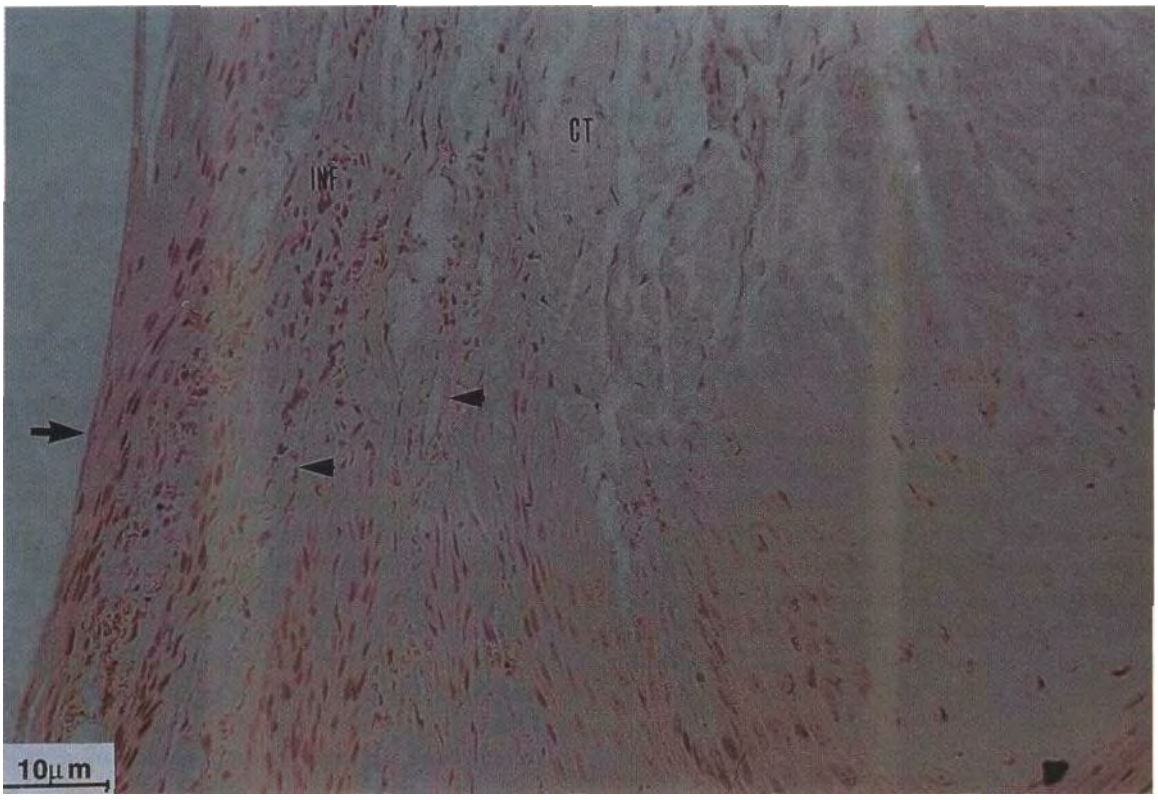

Fig.3. Photomicrograph of sulcular epithelium *(arrow)* and underlying connective tissue stroma *(CT)* in SB-treated tooth after 6 days shows subepithelial inflammatory foci *(INF)* and dilated blood vessels *(arrowheads).* (Original magnification x 320.)

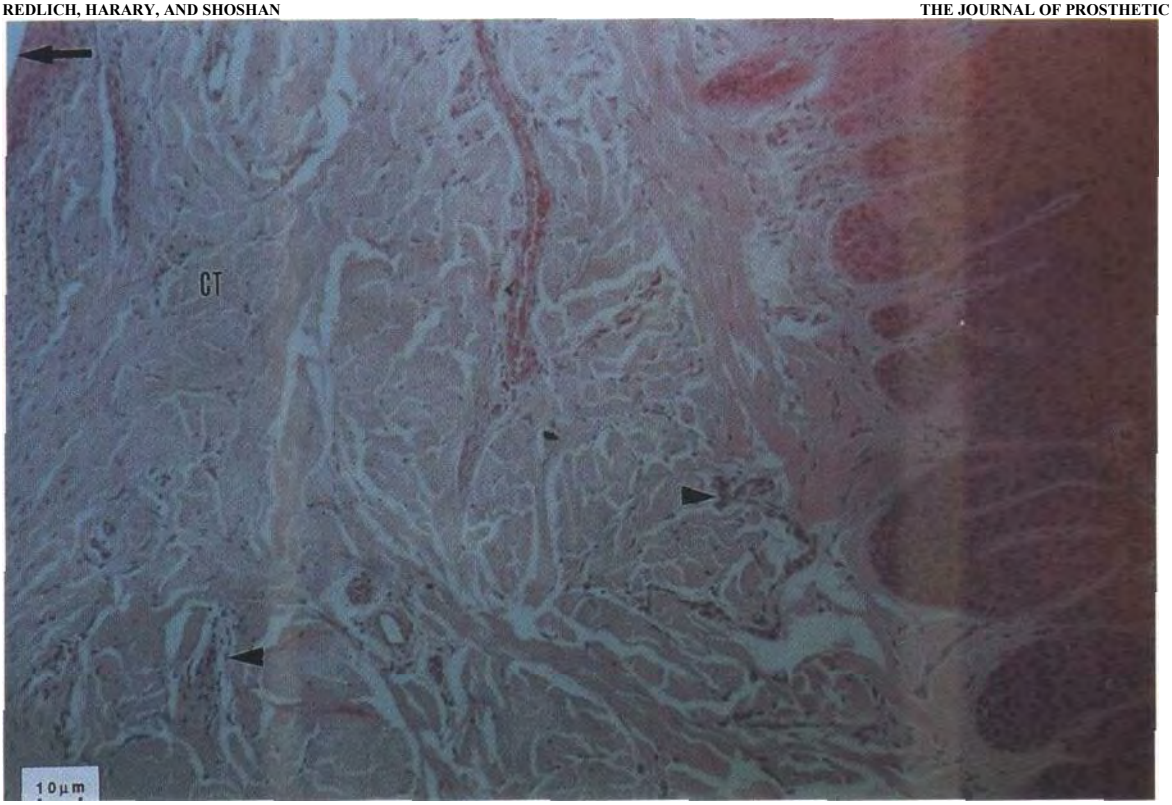

Fig.4. Photomicrograph of sulcular epithelium *(arrow)* and underlying connective tissue stroma *(CT)* in HQB-treated tooth after 6 days shows normal-appearing stroma with solitary focus of mild inflammation *(arrowhead).* (Original magnification x 125.)

chanical interlocking after adhesive infiltration into the dental surface.

A second generation of adhesives was offered for enamel or dentin.[8] The adhesive agents bis-GMA and tetraethylglycidylmethacrylate were responsible for ionic bonding to the calcium in the hydroxyapatite of the tooth surface. Surface preparation included either pretreatment of the smear layer by mild agents or a complete removal of the smear layer by acids.

The major adhesive agents of the third generation were N-totylglycineglycidylmethacrylate, maleic acid/2-hydroxy-ethylmethacrylate (HEMA) system, and 4-META." Molecules of 4-META were responsible for obtaining adhesion between the curing polymer system and any hydrophilic surface. The fourth-generation bondings have multipurpose adhesion capability to enamel, dentin amalgam, porcelain, and various alloys.[10,11]

The purpose of this study was to examine the results obtained for canine gingival tissue reaction to SB and HQB, which also indicated the biocompatibility of these multipurpose adhesives.

MATERIAL AND METHODS

The study protocols with the animals were approved by the Animal Care and Use Committee of the Hebrew University of Jerusalem and followed the National Institutes of Health guidelines on the care and use of laboratory animals.

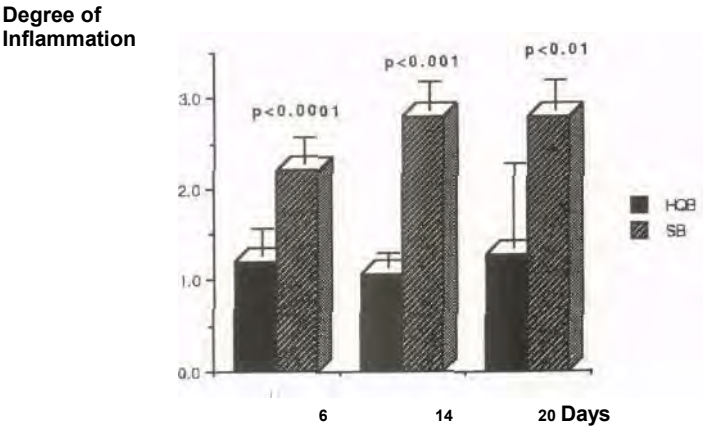

Fig. 5. Inflammatory response of gingival to HQB and SB, expressed as mean ± SD.

A total of 12 class V subgingival cavities were created on the buccal aspect of maxillary bilateral second incisors in six dogs. In each dog one cavity was restored with HQB and the second cavity with SB prepared according to manufacturers' recommendations. To minimize bacterial contamination, the teeth were brushed with a toothbrush every second day.

The adhesives were tested in dogs because of (1) the similarity between canine and human gingiva,[12,13] (2) conve-

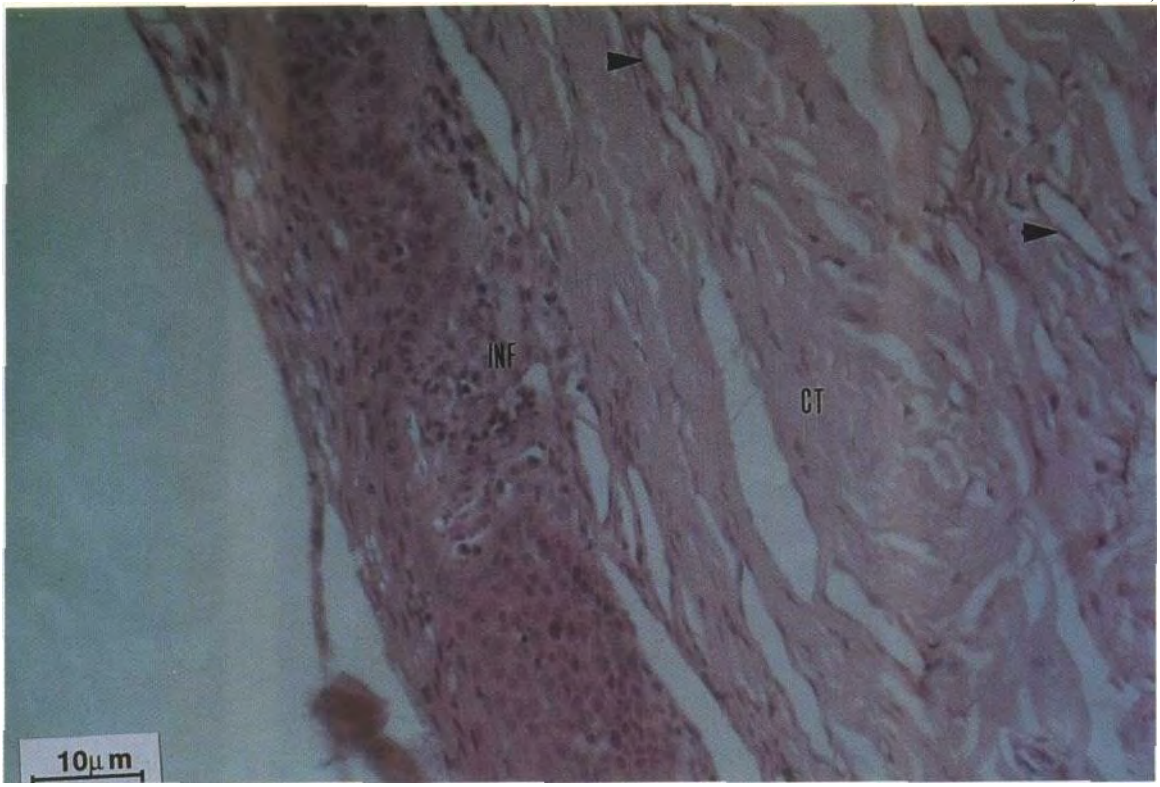

Fig.6. Photomicrograph of connective tissue stroma *(CT)* in SB-treated tooth after 14 days shows subepithelial inflammatory foci *(INF)* and dilated blood vessels *(arrow-heads)*. (Original magnification x 320.)

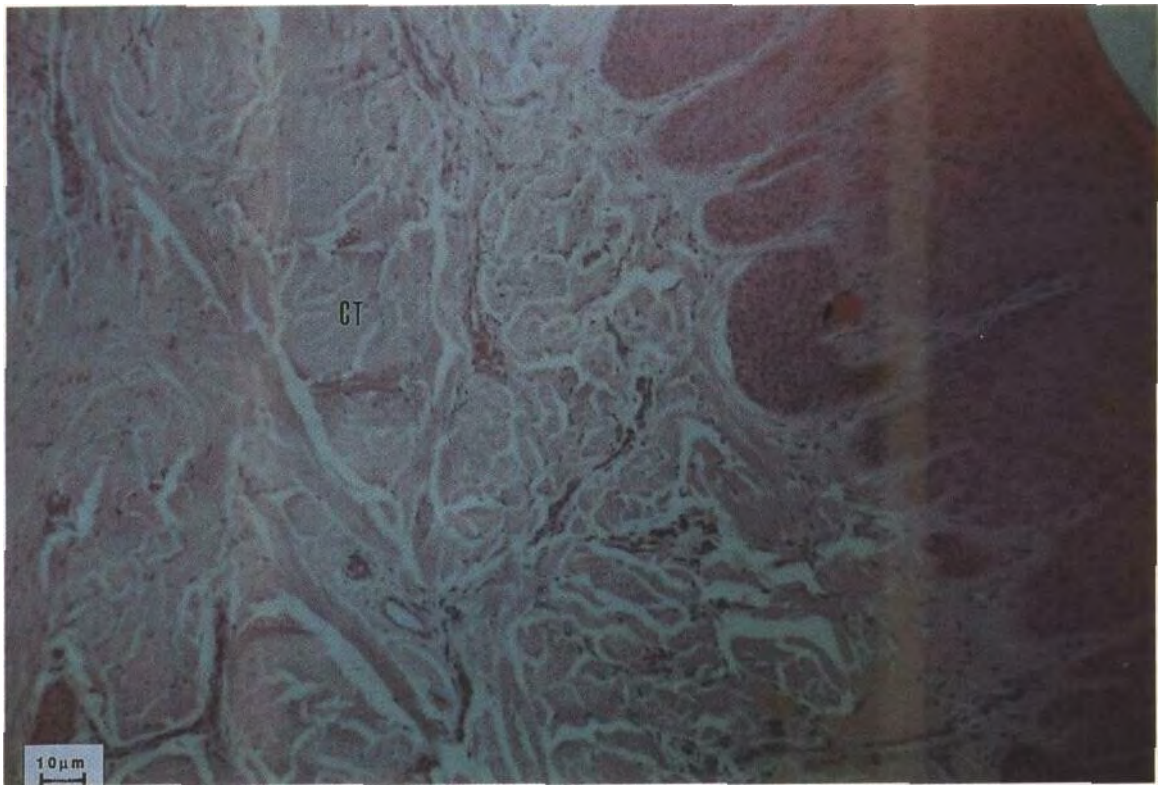

Fig.7. Photomicrograph of underlying connective tissue stroma *(CT)* in HQB-treated tooth after 14 days shows normal-appearing stroma. (Original magnification x 125.)

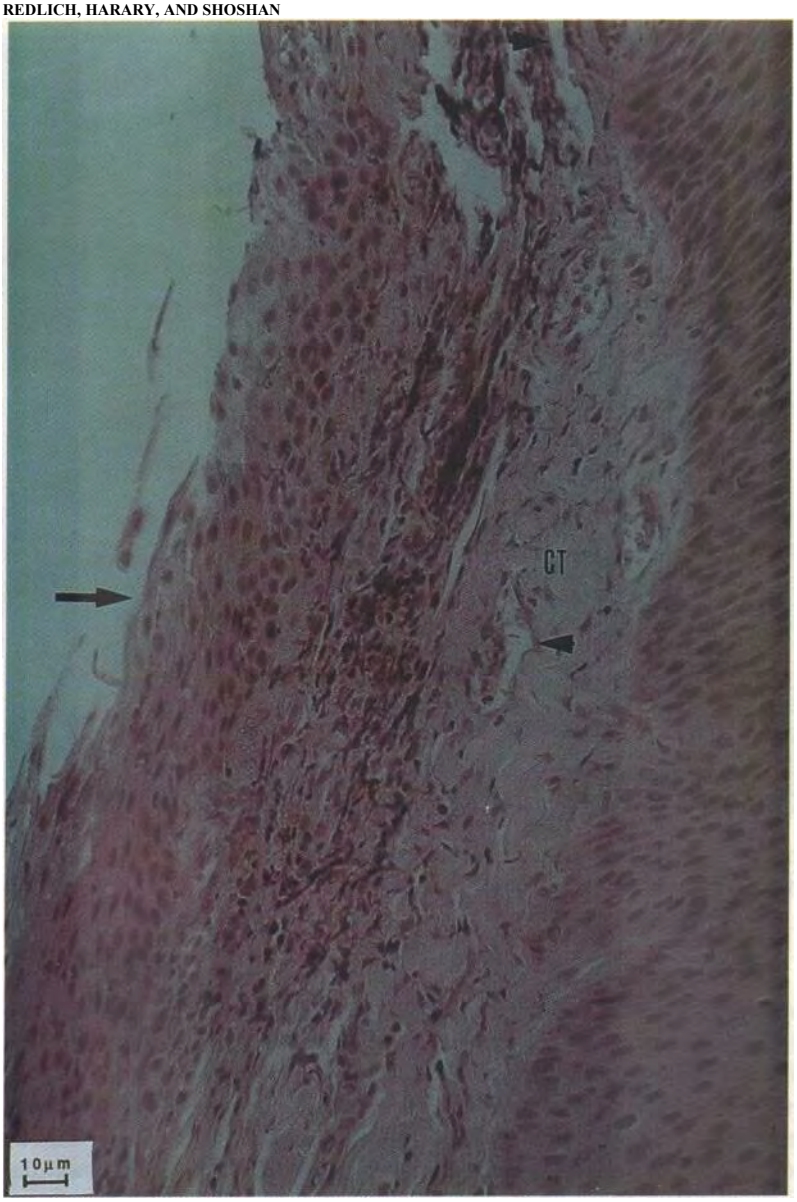

Fig.8. Photomicrograph of sulcular epithelium *(arrow)* and underlying connective tissue stroma *(CT)* in SB-treated tooth after 20 days shows subepithelial inflammatory foci and dilated blood vessels *(arrowhead)*. (Original magnification x 125.)

nience in dental procedures, and (3) the possibility of controlling the contact between the adhesives and the gingiva.

The treated teeth with the attached buccal gingiva were extracted 6, 14, and 20 days after being restored. Thus four cavities were obtained for examination at each time point. Free and attached gingiva from intact teeth served as the controls.

The samples were fixed in 4% phosphate-buffered neutral formalin solution and subsequently demineralized with EDO solution (DuPage Kinetic Laboratories Inc., Plainfield, 111.). They were then dehydrated, embedded in paraffin, and cut at a thickness of 6 um. The sections were stained with hematoxylin and eosin for histologic examination.

The results were evaluated by three examiners in a "blind" manner, namely without knowing the source of the sections examined. The score given by each examiner was based on the analysis of five sections. The sections were scored as follows, according to the inflammatory status: 0, no inflammation; 1, mild inflammation (solitary inflammatory foci); 2, moderate inflammation (subepithelial inflammatory foci); 3, severe inflammation (extending into the stroma, and dilated blood vessels).

The statistical comparisons between the different degrees of inflammation were made with the Wilcoxon signed-ranks test. A p value of 0.05 or less was considered to be statistically significant.

RESULTS

Macroscopically, well-preserved contours of gingival tissue adjacent to both SB and HQB restorations were

Fig.9. Photomicrograph ofsulcular epithelium *(arrow)* and underlying connective tissue stroma *(CT)* in HQB-treated tooth after 20 days shows normal-appearing stroma and mild subepithelial inflammation *(INF).* (Original magnification x 125.)

observed for all extraction times. However, although only a slight halolike pink discoloration was visible around the HQB restorations, indicating a mild inflammatory reaction, dark-red inflamed gingiva was conspicuously present in the SB-restored teeth (Fig. 1). Histologic examination of the intact controls revealed normal features of all components of dog gingiva (Fig. 2).

However, for the treated teeth, conspicuous differences between the HQB and SB adhesive groups were noted. After 6 days, inflammatory cells at the subepithelial region of the sulcular epithelium and dilated blood vessels in the gingival stroma were observed in the SB-treated teeth (Fig. 3). In the teeth treated with HQB adhesive, the dominant feature was that of normal tissue with only a solitary inflammatory focus (Fig. 4). The extent of inflammation was 2.2 for SB adhesive (0.29 mean [SD], 21.8 mean ranks) and 1.2 for HQB adhesive (0.29 mean [SD], 9.2 mean ranks) *($p < 0.0001$)* (Fig. 5).

After 14 days, subepithelial inflammation and dilated blood vessels were dominant in the gingival stroma of the SB-treated teeth (Fig. 6). However, after HQB adhesive treatment the gingival stroma and the subepithelium were practically without any noticeable inflammation or vascular abnormality (Fig. 7). The extent of inflammation was 2.8 for SB adhesive (0.3 mean [SD], 22.8 mean ranks) and 1.13 for HQB adhesive (0.15 mean [SD], 8.2 mean ranks) ($p < 0.001$). The extent of inflammation in SB-treated teeth was significantly greater after 14 days than after 6 days *($p < 0.001$)* (Fig. 5), but for the HQB-treated teeth the extent of inflammation remained the same at all extraction time points (Fig. 5).

After 20 days, extensive inflammatory response was seen in the stroma of the free and attached gingiva of the SB-treated teeth accompanied by dilated blood vessels (Fig. 8). The HQB adhesive restorations had no noticeable effect on the gingival tissue, which resembled that of the intact control except for a mild inflammatory subepithelial infiltration (Fig. 9). The extent of inflammation was 2.8 for SB adhesive (0.32 mean [SD], 23.1 mean ranks) and 1.27 for HQB (0.93 mean [SD], 8.4 mean ranks) ($p < 0.01$) (Fig. 5). The extent of inflammation in SB-treated teeth was significantly greater after 20 days than after 6 days *($p < 0.001$)* (Fig. 5).

DISCUSSION

This study demonstrated that the prolonged presence of HQB and SB in the gingival sulcus used as class V subgingival fillings caused mild to severe gingival inflammation, respectively. The inflammatory response of the gingiva to both SB and HQB adhesives is most likely the result of the cavity preparation, mechanical irritation caused by the cements, and the presence of MMA.[14]

The different tissue response to these cements as shown in this study is most likely related to the difference in their chemical composition. Thus it was assumed that the severe gingival reaction in the SB-treated teeth was a result of the use of TBB as a polymerization catalyst. During polymerization reaction, the TBB reacts with oxygen in the air and water and oxidizes into peroxide.[15] To reduce the hazardous effect of TBB, the SB contains modified, partially preoxidized TBB. Nevertheless, the presence of peroxide may be the trigger to the conspicuous gingival inflammation that was observed in the teeth treated with SB adhesive. Thus the minimal tissue irritation by HQB adhesive is explained by the fact that it does not contain TBB.

It is important to note, however, that to avoid the exposure of the oral environment to the cements both manufacturers do not recommend the use of SB or HQB adhesives as restorative materials.

CLINICAL IMPLICATIONS

An intensive cleaning of the sulcus is necessary after dental adhesives are used because debris is likely to be subgingivally retained. Excess cement must be removed before setting because hardening of the cement makes the removal of the debris very difficult.

CONCLUSIONS

Within the limits of this study, the following conclusions were drawn.

1. Both SB and HQB dental adhesives caused gingival inflammation when used as restorative materials for subgingival cavities in dogs.
2. HQB adhesive was superior to SB adhesive because it elicited conspicuously less inflammation.
3. Proper clinical handling of dental adhesives will ensure their safety and biocompatibility.

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