

Establishing Clinical Guidelines to Ensure Optimized Pulp Therapy Outcomes: Utilization of Biologically Based Data



Charles F. Cox, DMD, PhD, FADI
Vice Chairman, Section of Restorative & Pulp Biology
Department of Restorative Dentistry
UCLA - School of Dentistry
10833 Le Conte Ave., Los Angeles, CA 90059-1668
(310) - 825 - 6909, office
ccox@dent.ucla.edu

“New opinions are always suspected, and usually opposed, without any other reason but because they are not already common.” From An Essay concerning Human Understanding (John Locke 1690)

An often-asked question during our young years was, which came first, the chicken or the egg? For our profession, a similar academic question might be, which came first, direct or indirect pulp capping—save the pulp or save the tooth? Literature suggests that by removing severely decayed dentin our emerging dental profession of the 1700’s became more focused on treating mechanical carious pulp exposures than removal of soft cariously infected, affected dentin for so-called indirect capping, which came along later.

This article attempts to briefly review the historical and scientific timeline of pulp therapy, attempting to separate fiction from published science. Hopewell Smith (1898) was one of our first colleagues to report on the unique capacity of the dental pulp to heal and provide a “bacteriometric” seal (Ruby 2000). Today’s literature continues to validate those data. And yet, our current literature still continues to debate the optimum clinical treatment of an exposed pulp. For example, many still think that calcium hydroxide

(Ca(OH)₂) is the only suitable agent for direct pulp capping—we shall examine that consideration in detail.

DIRECT PULP CAPPING & HEALING: WITHOUT CALCIUM HYDROXIDE

In the late 1800’s, clinicians literally utilized metal-caps covered with chlora-percha as a temporary “stopping” agent to clinically treat an exposed pulp—today, our profession is still searching for a uniform clinical treatment protocol to treat an exposed pulp. To add to the mystery, many colleagues have learned only a passive knowledge of the stormy history of pulp therapy. After all, dentistry basically evolved from patients need for immediate relief of their acute pain long before the establishment of our “modern” restorative, esthetic focused profession. Today, we hear about minimally invasive dentistry, but is pulp therapy included within a portion of that restorative consideration?

...the unique capacity of the dental pulp to heal and provide a “bacteriometric” seal. (1898)

In his academic thesis, Rowe (1965a) reported that the dental literature from 1839 to 1875 contained roughly 120 papers dealing with pulp therapy. Since then, thousands of articles have reported many viewpoints on pulp healing and treatment procedures, often with divergent views (see Carvahlo 2000 for a review), which

only serve to confuse today’s clinicians understanding for treatment procedures.

In 1826, Koecker recommended that an exposed pulp be cauterized with a red-hot wire before covering with gold leaf and the cavity filled with gold. Others suggested the exposure be treated with opium, camphor, or aromatic

(continued on page 2)

Nuts & Bolts Clinical Discovery

A New Adhesive: “Clearfil Protect Bond”

Nanako “Nancy” Iwamoto, D.D.S., Ph.D.
Technical Planning Department
Dental Materials Division, Kuraray Medical, Inc.

Before Clearfil Protect Bond, the main objective of adhesive systems was to provide adhesion between the tooth structure and the restorative material. With the introduction of self-etching systems, the objective expanded to include the elimination of postoperative sensitivity. Now with Clearfil Protect Bond, a new class of adhesive, two other functions are provided, antibacterial cavity-cleansing and fluoride release.

The FDA recently approved the “antibacterial cavity cleansing effect” for Clearfil Protect Bond, the world’s first product in this new class of adhesives. The ingredient that provides the antibacterial cavity cleansing effect is a new monomer called MDPB. This new functional monomer developed by Kuraray Medical, Inc. is included as part of the primer of Clearfil Protect Bond.

Why have an Antibacterial Cavity Cleansing Effect?

Self-etching systems combine dentin conditioning and bonding in two simple steps. In the first step, priming, the acidic component of the primer dissolves the smear layer and incorporates this dissolved layer into the mixture as it demineralizes the dentin. In today’s practice of very conservative tooth structure removal, it is possible and perhaps likely that a few bacteria remain in the infected dentin. Therefore, it seems advantageous to assure a complete antibacterial cavity cleansing effect prior to adhesive restoration of teeth, especially if that antibacterial cavity cleansing effect takes place in the

(continued on page 7)

INSIDE THIS ISSUE



■ **Continuing Education Credit material in this issue.**

Take the free exam at
www.dentrek.com/kuraray.asp

oils of clove or cassia before closure. In 1874, Hirschfeld described her pulp therapy as using stamp paper moistened with carbolic, due to her understanding of employing a strong antiseptic to eliminate bacterial infection. Shortly afterwards, Hopewell Smith reported that an exposed aseptic pulp was capable of healing (1898). These data have been strongly revalidated by Massler (1967a, 1967b), Brännström et al. (1962, 1969, 1971, 1978) (Snuggs et al. 1993), and others referenced in this article.

Hopewell Smith, in 1898, reported that an exposed aseptic pulp was capable of healing.

before the clinicians started their intended treatment procedures.

“Whether the cavity shall be filled temporarily or permanently depends upon the constitutional conditions and the state of the pulp at the time of treatment. The judicious operator should have made careful selection of the case to be treated and will decide from the clinical evidence whether the prognosis will be promising or not; clinicians with limited experience of immediate dressing are cautioned not to attempt a permanent restoration.

Careful records should be methodically preserved, noting pre-existing conditions, and the controlling symptoms. Should subsequent irritation occur, a new diagnosis may be formed and a new course of treatment formed, and recorded in red ink. Fill the cervical portion of the cavity with gutta-percha, carrying it over the metal cap, then close the filling with zinc phosphate cement. In this way, with occasional renewal, the temporary work may be left for at least a year or more, with cases carried forward from ten to fifteen years. The restoration may be permanently closed after five years when no irritation had reappeared. In many instances, recovery was observed by secondary deposits of dentinal tissues, occluded with a bony tissue.”

The pulp biology histology from the late 1800's up to today have identified this “bony tissue” as a dentin bridge. Again, you must consider that hard tissue formation (osteo-dentin a.k.a. dentin bridging) was observed against metal caps, non-calcium hydroxide agents! This published counsel from Jack over 100 years ago remains as a valuable clinical guideline today!

EARLY DENTAL LITERATURE: TO SAVE THE PULP OR THE TOOTH

When and from whom did the descriptive terminology “direct pulp cap” actually arise? It came from the clinical placement of small metal caps over an exposed pulp (Jack, 1900). Alternatives to metal caps were placement of an asbestos disk rendered antiseptic in various ways, or by placing paper disks coated on the pulp side with chlora-percha. Following accidental exposure, Jack recommended that pain control be treated by application of tincture of calendula, a rubber dam applied, hemorrhage controlled, and the exposure disinfected with a cotton pledget saturated with hydro-naphthol, acetanilin or formalin, remaining in place during preparation of the metal cap. Burchard (1900) suggested “an immediate dressing should be

antiseptic, possess some anesthetic value, an incorporation of zinc oxide would provide a mild therapeutic action as an appropriate dressing.”

Jack indicated (1900) that metal caps were “best when made from platinum,” however tin was acceptable, their purpose was to provide thickness and concavity over the exposure, so as to protect the subjacent tissue from pressure from intruding into the exposed tissue. Clinical placement of a metal cap, should ensure that its round or oval borders pass beyond the pulp-exposure wall, and the plastic cement be allowed to flow over and around the margins of the metal cap and allowed to firmly set. Coverings were mixtures of carbolic acid, oil of cloves and zinc oxide or a mixture of oxysulfate or

oxychloride of zinc, each mixed in a “plastic paste” and laid over the metal cap or exposure without producing pressure to the pulp. Burchard (1900) classified temporary stopping agents as adhesive or non-adhesive. Adhesives were composed of pink base-plate gutta-percha, Burgundy pitch, white wax, and calcium carbonate or zinc oxide, placed to temporarily fill the cavities for several days. The non-adhesive agent was mixed without Burgundy pitch. Jack (1900) indicated an important “principal of equal importance was to prevent compression of the pulp tissue from the capping material allowing its immediate contact with the pulp.” His reasoning was “if the least amount of space be permitted to exist between the capping agent and pulp, the space would fill with

fluids, and pus and gases will form with consequent compression of the pulp.”

GERMICIDES, ANTISEPTICS, DISINFECTANTS & COAGULANTS TO TREAT THE EXPOSED DENTAL PULP

In 1900, the common clinical understanding was that cavity treatment involving an exposure was treated by the application of a therapeutic agent: as either a germicide, an antiseptic or disinfectant, each differing in degree, each having the power to destroy pathogens, as a coagulant (e.g. zinc chloride) or non-coagulant (e.g. NaOCl). Since the late 1950's, NaOCl has resurfaced as the antiseptic of choice for disinfecting mechanical and carious pulp exposures.

In the late 1800's, oxidizing agents such as Labarraque's solution, a chlorinated soda, had fallen into general disuse along with hyposulfites. At that time electrolytic products of seawater called electrozone and meditrina (hypochlorites) were utilized for disinfection. During World War I, the successful use of NaOCl resurfaced as

...studies continue to show pulp healing and bridge formation following direct capping of exposed pulps with an antimicrobial adhesive system.

EARLY ENDODONTIC TREATMENT

In 1824, Hudson was one of the first clinicians to describe, “stuffing the cavity of one tooth from the ends of its roots with gold” for which he received a ten-dollar fee. In the later decades, Johnston (1884) recommended the use of iodoform cement containing carbolic, eugenol, and “indifferent porous powder saturated with formaldehyde vapour” to fill root canals. Gysi's recommended his triopaste, which contained a 17% paraformaldehyde and arsenic as a devitalizing agent-today's biological acceptance is quite different, as the American Association of Endodontists strongly recommend that permanent teeth NOT be treated with formalin containing agents (AAE 1989). In 1964, Rowe noted that since the early 1900's, primary teeth had been routinely treated with formalin containing materials. However today, pediatric dental specialists have yet to find or accept an alternative non-toxic formalin-containing pulp therapy agent. It seems as though pediatric specialists have failed to demonstrate any difference in the biological pulp response between primary and permanent teeth. Opinions between specialties continue to differ, in spite of the biological data reporting the hazards of formalin containing agents.

HISTORICAL DENTAL RECORDS

The interested reader is encouraged to read the academic thesis of Rowe (1965a) for a historical review of materials used for pulp therapy. He developed a bridge between the recorded historical timeline by sorting out pulp therapy documentation into a scientific timeline. Somewhere, in antiquity, reside the actual records of direct pulp therapy, specifically, the technical procedures and materials to treat an exposed pulp. A report by Lufkin (1938) suggests that Philip Pfaff (1746) a dentist to King Frederick of Prussia first mentioned capping an exposed pulp before inserting a filling.

PRE-EXISTING CLINICAL DIAGNOSIS ARE NECESSARY

Jack (1900) suggested that early diagnostic criteria must be comprehensive and well defined

Dakin's solution (1915) becoming the antiseptic of choice in most medical, surgical procedures. From an endodontic viewpoint, the ultimate antiseptic is biomechanical removal of that portion of the infected pulp tissue, which should not be confused with a chemotherapeutic lavage with one of several agents and procedures ranging from cotton pellets with mechanical pressure and saline, LASER irradiation, electrosurgery, hydrogen peroxide, anesthetic solutions, slurry of Ca(OH)₂, ferric sulfate, formocresol, glutaraldehyde, and camphor to name a few. It must be mentioned that both formocresol and glutaraldehyde are toxic and mutagenic agents, yet today, these agents are still used by clinicians worldwide with seeming impunity of their biological consequences.

HEMORRHAGE CONTROL AND DIRECT CAPPING

The clinical and medical-scientific history of NaOCl began in the early 1900's. It gained use as an endodontic adjuvant in the 1950's and has again gained clinical credibility as a pulp lavage agent. The academic community has yet to accept any one clinical procedure or agent, which is accepted as the most "ideal" lavage for hemorrhage control in preparation for direct pulp capping or pulpotomy. Hafez et al. (2000, 2002) reviewed the publications of biologically based data confirming several histological facts—that NaOCl simultaneously removes operative debris, the organic biofilm and provides cavity disinfection.

Hermann (1930) is reported (after Pfaff) to have introduced the use of a CaOH₂ as a clinical procedure to supposedly stimulate pulp healing and dentin bridge formation. Since then, clinicians have opined on several misconceptions (namely, only Ca(OH)₂ containing agents possess the unique capacity to stimulate reparative or dentin bridge formation. For some colleagues, the clinical "gold standard" for direct capping remains placing a CaOH₂ agent—unfortunately some clinicians still hold fast to that opinion. These ideas were refuted when Cox et al. (1987) demonstrated that pulp healing and dentin bridge formation would routinely occur against a spectrum of low pH agents such as silicate cement and a zinc phosphate cement in the absence of calcium or hydroxyl ions (Figs. 1, 2). These data reinforced the many studies of Brännström and colleagues — that the dental pulp possesses an inherent capacity to heal, in the absence of bacterial inflammation (see Brännström 1981 for review).

Cox and colleagues were first to demonstrate histological evidence of pulp healing and dentin bridge formation against an auto cured adhesive system (1987) (Fig. 3). White et al. (1994) revalidated these data. Mechanical pulp exposures were direct-capped with a fourth generation adhesive system, showing soft tissue healing and dentin bridge formation directly adjacent to the adhesive resin interface, forming a true biomimetic scaffold for the repair process and bridge formation. ISO studies (Sudo et al. 1959, Katoh et al. 1978, Fusayama 1987, Hosoda et al. 1991, Cox et al. 1992, 1994, 1999, Akimoto et al. 1998, Hafez et al. 2000, 2002) have demonstrated that hemorrhage control with NaOCl is the most important agent to complete lavage for successful healing and bridge formation (Fig. 4). These studies continue to show pulp healing and bridge formation following direct capping of exposed pulps with an antimicrobial adhesive system (Fig. 5).

Other ISO adhesive studies (Cox et al. 1999, Hafez et al. 2000, 2002) have demonstrated that bacterial microleakage remains the prime factor causing pulp inflammation and necrosis. Studies (Cotton 1974, Brännström and Vojinovic 1976, Brännström et al. 1979, Brännström 1981) have long shown that bacteria are recognized as the most insidious insult, which jeopardizes successful pulp therapy. The classic gnotobiotic rat study of Kakahashi et al. (1963), often overlooked in the literature demonstrated dentin bridging against a pH spectrum of materials, including food debris, when exposures are maintained under completely sterile conditions. These same data were again reinforced by Kozlov and Massler (1966) in a parallel study.

CHALLENGING QUESTIONS: SUPPORTING DATA TO ENHANCE YOUR CLINICAL OUTCOMES

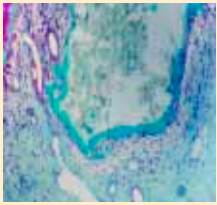
It remains an academic accountability to harmonize the concepts and treatment modalities for pulp therapy—to prevent your confusion over conflicting viewpoints, which confront your understanding of the clinical treatment for exposed and pulpotomized pulps. Questions often asked are—does a small exposure increase the odds for a suitable healing response? Will large exposures fail to heal? If saliva contamination occurs to the exposure interface, should I complete immediate pulpectomy? Does acid etchant kill the pulp? Is disinfection necessary? Do adhesives cause pulp death? How

(continued on page 4)

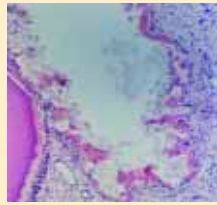
SUGGESTED CLINICAL PROTOCOL FOR SUCCESSFUL CAVITY AND PULP LAVAGE FOR DIRECT CAPPING OF AN EXPOSED PULP

By Charles F. Cox, DMD, PhD, FADI

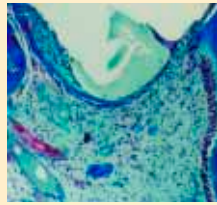
1. Place a small drop of caries detector (e.g. Kuraray Caries Detector) onto the cavity as directed with an appropriate small sponge or cotton pellet, rinse thoroughly and remove excess fluid with high evacuation. **DO NOT DRY.** Remove the dark stained (red-purple) infected dentin. It is **RECOMMENDED** that you to use a large (#8 or #10) round bur at slow speed revolution. A too heavy and forceful hand instrumentation may often unroof the underlying dentin, leaving a large exposure, forcing carious debris into the subjacent pulp—with damage. If a mechanical bur carious pulp exposure does occur, rinse with sterile water and gently remove the adjacent carious dentin with rotary instrumentation taking care to prevent pushing additional carious debris into the subjacent pulp tissue.
2. Flush the exposure site with sterile water and gently cover the exposure with a small cotton pellet only immediately saturated with a 5% solution of medical grade NaOCl for 20-30 seconds. Remove the pellet and gently flush the exposure site with sterile water. If hemorrhage persists, reapply a fresh cotton pellet dampened with 5% NaOCl and leave until hemorrhage is controlled and remove as described above. This is essential!
3. Place a small cotton pellet fresh dampened with a 2% to 5% NaOCl over the exposure and then place an acid etchant of your choice onto the dentin walls and floor **AROUND THE NaOCL SATURATED COTTON PELLETT**, avoiding the exposed pulp. Acidic solutions will only cause new hemorrhage and biofilm contamination. Remove the pellet with high-speed evacuation and gently rinse with sterile water. Gently air disperse the cavity from approximately 10-cm. Gently apply a bond coat onto the cavity dentin around the cotton pellet, as recommended to avoid pulp hemorrhage and lightly air disperse from 10 cm.
4. The choice of a direct capping agent remains the choice of the attending clinician. If you so choose to use a Ca(OH)₂ agent, you must provide a "bacteriometric" seal to prevent long-term complications as discussed above.
5. If you so choose to use an adhesive system for direct capping, place the two-step self-etching bonding system onto the dentin, allowing it to gently flow over the exposure site taking care to avoid recurring hemorrhage. Light cure for 3-5 seconds so as to prevent pulp damage from an abrupt increased temperature rise from rapid polymerization. This will also prevent polymeric shrinkage from the pulp-dentin interface. Be aware that **NO** hemorrhage should occur around the dentin-pulp interface.
6. Place thin increments of an antimicrobial adhesive over the area and again use a short ramped light cure sequence. Complete the restoration to contour and finish to functional anatomy with your choice of instrumentation.
7. To enhance the "bacteriometric" nature of the final restoration, acid etch the enamel-restoration cavosurface interface with phosphoric acid, rinse gently, air dry and seal with the an antimicrobial bonding resin to seal any interfacial gap.



1. A 7µm section through a non-inflamed monkey tooth (#31) following mechanical exposure and direct capping with a commercial acidic silicate cement and a "bacteriometric" ZnOE seal after 21-days. Silicate particles are seen above center with a new green-stained dentin bridge adjacent to the entire silicate interface. An edge of remaining dentin (purple-green) is seen at the extreme upper left. New odontoblastoid cells are seen along the pulp interface with viable pulp tissue beneath. No Ca(OH)₂ agent was present. 100X magnification. Masson-trichrome stain.



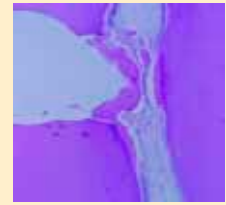
2. A 7µm section through a non-inflamed monkey tooth (#12) following a mechanical exposure and direct capping with a zinc phosphate (ZnPh) acidic cement and a "bacteriometric" ZnOE seal after 21-days. Some ZnPh cement particles are seen mid-center with a new pink-stained dentin bridge along the entire ZnPh cement interface. An edge of remaining dentin (purple-green) is seen extreme upper left. New odontoblastoid cells are seen along the pulp interface with viable pulp tissue beneath. No Ca(OH)₂ agent was present. 100X magnification. Hematoxylin and eosin stain.



3. A 7µm section through a non-inflamed monkey tooth (#23) following a mechanical exposure and direct capping with an early (1987) auto-cured adhesive system and its companion composite resin system with a "bacteriometric" ZnOE seal after 21-days. No NaOCl was employed with this tooth-leaving small operative (green stained) dentin chips in the subjacent pulp. The clear area above is the space left from removal of the composite following demineralization for histological processing. A new green-stained dentin bridge is seen running horizontally across the slide directly adjacent to the adhesive and composite system. The pulp directly below the new bridge shows newly organized secondary odontoblastoid cells and reorganized blood vessels. The remaining dentin shows a small zone of new reparative dentin deposition. 40X magnification. Masson-trichrome stain.



4. This slide shows a human mandibular permanent molar tooth of an adolescent patient who presented with a chronic hyperemic tooth with no periapical radiolucency. Following rubber dam placement, gross caries was removed and caries detector placed to identify the remaining infected dentin. Further removal of soft dentin with a round bur created a cariously exposed pulp. The hemorrhage was controlled with 5% NaOCl on a cotton pellet and then rinsed with sterile water and gently air dispersed. The root canals are seen with hemorrhage control in preparation for direct capping.



5. A 7µm section through a non-inflamed monkey tooth (#21) following a severe mechanical exposure and direct capping with a new anti-microbial adhesive system after 27-days. The exposure damaged the opposing lingual wall. The clear area on the left is the composite-space following demineralization and removal for sectioning. A new pink-stained dentin bridge is present along the entire adhesive system interface. Coronal and apical areas of remaining dentin are seen above and below with a light pink-stained zone of remaining dentin. A hybridized dentin interface (purple-stained) is seen on all areas of the cavity interface. New odontoblastoid cells are seen along the dentin bridge pulp interface with viable pulp tissue beneath. No Ca(OH)₂ agent was present. 40X magnification. Hematoxylin and eosin stain.

does an infected pulp die? The intention of the following is to provide you with proper biological and clinical data to answer these questions and to enhance your clinical treatments.

Histological data provides biological insight into several issues that deal with direct pulp capping with adhesive systems. Studies by Cox et al. (1982, 1986) demonstrated that exposed and inflamed pulps respond with a high capacity to heal and bridge. However long-term data (Cox et al. 1985) reported increased failure after two-years direct pulp capping due to failure of the Dycal-Ca(OH)₂ base to provide a bacteriometric seal. This has been a reported clinical observation by Kidd (1976). A number of studies report that certain adhesive systems and their treatment systems are biologically compatible with the dental pulp with a high degree of dentin bridge formation when placed over an exposed pulp in the absence of any Ca(OH)₂ agent (Sudo et al. 1959, Katoh et al. 1978, Fusayama 1987, Hosoda et al. 1991, Harnirattisai and Hosoda 1991, Onoe 1994, Ebihara and Katoh, 1996). These publications focus on specific points. Acids themselves do not kill pulp tissue when placed and rinsed within the normal few seconds of clinical placement. Histological data show healing and bridging follows in a timely manner. Hemorrhage control is most important before placing an adhesive system onto the dentin pulp interface. Equally important is the removal of any contaminating biofilm from blood and

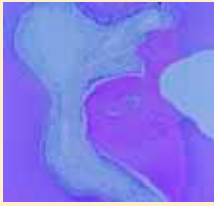
salivary components and bacterial organisms on the cavity walls as well as within the affected dentin. The interested reader is referred to recent publications (Cox et al. 1998, 2000, and Hafez et al. 2000, 2002), which have reviewed the issue of providing a properly cleansed cavity interface to receive an adhesive system. Histological data from these studies revalidate these data.

KNOWING THE VARIABLES HELPS YOUR ODDS; IF YOU GAMBLE

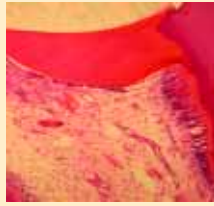
In order to develop an understanding of successful direct pulp capping it is imperative to consider the variables which lead to success or failure. These variables may allow us to understand and perhaps explain the discrepancies between several ISO usage studies. Kitasako et al. (1999a, 1999b) have suggested that if a tissue, or fluid exudate, protrudes onto the cavity floor and along the cavity wall before material placement, dentin hybridization will fail to occur, leading to microleakage and ultimately to a poor-to-none dentin bridge response. Stanley (1998) speculated that failure may occur from pulp tissue protruding into the cavity preparation, a sort of pulp polyp. It may be argued that failure to control the contaminating biofilm results in poor to incomplete hybridization, eventually permitting microleakage from loss of the "bacteriometric" seal. Do adhesives kill the pulp? A recent study by Cox et al. (2003) has reported in a six-month study,

that restoring an exposed pulp with an antimicrobial adhesive and composite resin presented several constant reproducible results. Dentin bridge formation was present directly adjacent to the restorative interface with no pulp inflammation (Figs. 6, 7) at long-term usage periods. These data suggest that the new antimicrobial adhesive systems will provide a dynamic means to provide a long-term clinical "bacteriometric" seal along the entire restoration interface.

Studies (Sudo 1959, Hirota 1959, Otsuki 1988, Katoh et al. 1978, Akimoto et al. 1998, Cox et al. 1998, Hafez et al. 2000, 2002) have demonstrated that various concentrations of NaOCl provide both cavity disinfection and hemorrhage control when placed onto an exposed pulp. More specifically, they demonstrate that NaOCl provides for removal of the coagulum, clot, fibrin, damaged cells, the organic biofilm and it provides antisepsis of the cavity interface, and provides for clearance of most operative debris in the subjacent tissues described as "chippitis" by Stanley (1989, 1998, 2002) who reported that the presence of dentin fragments are "definite stimulators of reparative dentin and can be an asset to encourage bridge formation in the right locations." However, when carious-infected dentin chips (operative debris) are forced into the pulp, the clinician should expect poor healing to regional pulp abscesses leading to necrosis when the issue or use of disinfection or lavage is avoided.



6. A 7µm section through a non-inflamed monkey tooth (#29) following a large (6-mm wide) mechanical bur exposure and direct capped with a new anti-microbial adhesive and composite resin system after 97-days. The clear area on the right is the composite-space following demineralization and composite removal for sectioning. A new pink-stained dentin bridge is present along the entire adhesive system interface. Areas of reparative dentin are seen above and below-merging with the dentin bridge. A hybridized dentin interface is seen along the cavity interface. New odontoblastoid cells are seen along the dentin bridge pulp interface with viable pulp tissue beneath. No Ca(OH)₂ agent was present. 40X magnification. Hematoxylin and eosin stain.



7. A 7µm section through a non-inflamed monkey tooth (#3) following a large (5-mm wide) mechanical bur exposure, lavaged with a 5% NaOCl, rinsed and direct capped with a new anti-microbial adhesive and composite resin system after 6-months. The clear area above is the composite-space following demineralization and removal of the composite for sectioning. A new pink-stained dentin bridge is present along the entire adhesive system interface, which is continuous with the reparative dentin seen on the right. New secondary odontoblastoid cells are seen along the pulp interface of the dentin bridge with normal pulp tissue beneath. A hybridized dentin interface is seen along the cavity interface above. No Ca(OH)₂ agent was present. 120X magnification. Hematoxylin and eosin stain.



8. A 7µm section through a non-inflamed human tooth (#1) following an occlusal cavity preparation and a large (6-mm wide) mechanical bur exposure and direct capped with a commercial Ca(OH)₂ base material (Life(tm)), restored to the cavosurface margin with an amalgam alloy for 192-days. No NaOCl was used for surgical lavage. The clear area on the right is the amalgam-space following demineralization and its removal for sectioning. A new green-stained dentin bridge is present along the Ca(OH)₂ interface. The dentin bridge is composed of operative debris with beginning fibrosis of the coronal tissue following its disintegration. 25X magnification. Masson trichrome stain.



9. A section through a non-inflamed monkey tooth (#29) that had received a class-V cavity preparation and restored with a Ca(OH)₂ base (Dycal(tm)) for 2-years. The cavity space is seen in the extreme left with the vital pulp along base interface. A rather long and thick deposition of reparative dentin is seen, which blends with the dentin bridge composed mainly of operative debris. In addition to the many operative debris chips, small tunnel defects are visible within the substance of the bridge complex. 50X magnification. Masson trichrome stain.



10. A section through a non-inflamed monkey tooth (#2) that had received a class-V cavity preparation and then restored with an acidic ZnPh cement to the cavosurface margin 21-days. The cavity space is seen in the extreme upper-right. An initial healing and repair process is evident-demonstrated by deposition of reparative dentin. A subjacent zone of localized 'compartmentalized' chronic inflammation is evident-due to bacterial microleakage along the demineralized restorative interface. Other than the upper-right compartment of chronic inflammation, which has proliferated into the dissolved cement space. The remaining pulp is normal. Normal primary odontoblasts are present along the entire lingual (left) and coronal pulp-dentin interface-revalidating the inherent capacity of the pulp to heal, until the "bacteriometric" seal is lost. 25X Hematoxylin and eosin stain.

Several important clinical conclusions may be drawn when based on these biological data. Various ISO usage studies on non-human primate pulps have demonstrated that use of 2% to 5% NaOCl, presents no in vivo toxicity to primary odontoblasts or to subjacent pulp cells or capillaries. In addition, there is no inhibition to pulp healing or to secondary odontoblastoid cell formation and eventual dentin bridge formation when capped with various adhesive systems. More importantly, there is a conspicuous absence of operative dentin debris (chips) at the exposure interface at all time periods. This debris has been shown to compromise the normal biological healing process (Figs. 8, 9). Perhaps a little known but histologically substantiated fact is the redeeming healing capacity of a dental pulp, which presents with an exposed carious lesion. It should be noted that Van Hassel (1971) described a localized pulp inflammatory response in terms of geographic "compartmentalization," (Fig. 10) instead of an immediate massive pulp death via congestive strangulation.

REFERENCES

Akimoto N, Momoi Y, Kohno A et al. (1998) Biocompatibility of Clearfil Liner Bond 2 and Clearfil AP-X system on non-exposed and exposed primate teeth. *Quint Int* 29:177-188.

Brännström M (1962) Observations on Exposed Dentine and the Corresponding Pulp Tissue. *Odont Revy* 13:235-245.

Brännström M, Nyberg H (1969) Points in the experimental study of pulpal response to restorative materials. *Odont Tidsk* 77:421-426.

Brännström M, Nyberg H (1971) The presence of bacteria in cavities filled with silicate cement and composite resin materials. *Swed Dent J* 64:149-158.

Brännström M, Vojinović O (1976) Response of the dental pulp to

invasion of bacteria around three filling materials. *J Dent Child* 43:15-21.

Brännström M, Nordenvall KJ (1978) Bacterial penetration, Pulpal reaction and the inner surface of Concise Enamel Bond. Composite fillings in etched and un-etched cavities. *J Dent Res* 57:3-10.

Brännström M, Nyberg H, Strömberg T (1979) Experiments with Pulp Capping. *Oral Surg* 48:347-352.

Brännström M (1981) in: *Dent and Pulp in Restorative Dentistry*. Nacka Sweden Dent Therapeutics AB.

Burchard HH (1900) Chapter XIII, Plastic Filling Materials-Their Properties, Uses, and Manipulation pgs. 306-344. In: *The American Textbook of Operative Dentistry*. Ed. By E.C. Kirk. Lea Brothers & Co.

Carvalho RM, Lanza L, Mondelli J et al. (2000) Side effects of resin-based materials. *Cirimido (Como) Italy G*, Eredue Press. 241-258. *Advanced Adhesive Dentistry, 3rd International Kuraray Symposium, Dec 3-4, 1999, Granada Spain*.

Cotton WR (1974) Bacterial contamination as a factor in healing of pulp exposures. *Oral Surg* 38:441-450.

Cox CF, Bergenholtz G, Fitzgerald M et al. (1982) Capping of the dental pulp mechanically exposed to the oral microflora-a five week observation of wound healing in the monkey. *J Oral Path* 11:327-339.

Cox CF, Bergenholtz G, Heys DR (1985) Pulp Capping of dental pulp mechanically exposed to oral microflora: a 1-2 year observation of wound healing in the monkey. *J Oral Path* 14:156-168.

Cox CF, Bergenholtz G (1986) Healing sequence in capped inflamed dental pulps of Rhesus monkeys (*Macaca mulatta*) *Int Endod J* 19:113-120.

Cox CF, Keall CL, Keall H et al. (1987) Biocompatibility of surface-sealed dental materials against exposed dental pulps. *J Prosthet Dent* 57:1-8.

Cox CF, White KC, Ramus DL et al. (1992) Reparative Dentin: Factors affecting its deposition. *Quint Int* 23:257-270.

Cox CF, Suzuki S (1994) Re-evaluating pulp protection: Calcium hydroxide liners vs cohesive hybridization. *J Am Dent Assoc* 125:823-831.

Cox CF, Hafez AA, Akimoto N et al. (1998) Biocompatibility of primer, adhesive and resin composite systems on non-exposed and exposed pulps of non-human primates. *Am J Dent* 10:55-63.

Cox CF, Hafez AA, Akimoto N et al. (1999) Biological basis for clinical success: Pulp protection and the tooth-restoration interface. *Pract Period Aesthet Dent* 11:819-826.

Cox CF (2000) Pulp Protection and direct capping with Ca(OH)₂ versus adhesive resin systems: a review of factors leading to failure or success. *Advanced Adhesive Dentistry, 3rd International Symposium, Dec 3-4, 1999, Granada Spain; Tagami, Toledano, Prati, editors, Cirimido (Como) Italy, pp. 149-176.*

Cox CF, Imazato S, Stevenson III RG, Ebisu S (2003) Pulp Healing & Dentin Bridge Formation Adjacent to an Antimicrobial Adhesive: A Long-

term Usage Study. *International Symposium on Adhesive Dentistry, Tokyo Japan April 2002* In press.

Dakin HD (1915) On the use of certain antiseptic substances in the treatment of infected wound. *Brit Med J* 2:318-320.

Ebihara T, Katoh Y (1996) Histopathological study on the development of adhesive resinous material containing calcium hydroxide as direct pulp capping agent *Jpn J Conserv Dent* 39:1288-1295.

Fusayama T (1987) Factors and prevention of pulp irritation by adhesive composite resin restorations. *Quint Int* 18: 633-641.

Hafez AA, Kopel HM, Cox CF (2000) Pulpotomy reconsidered: application of an adhesive system to pulp-tomized permanent primate pulps. *Quint Int*. 31(8):579-589.

Hafez AA, Tarim B, Akimoto N et al. (2002) An in vivo evaluation of hemorrhage control in exposed primate pulps using NaOCl, All Bond 2, and One Step adhesive systems. *Quint Int* 33:737-748.

Hamirattisai C, Hosoda H (1991) Pulpal responses to various dentin bonding systems to dentin cavities. *Dent Mater* 7:10:149-164.

Hamy (1882) Les mutilations dentaires aux Mexiques et Huastèques. *Bull d'Anthropolog de Paris* pp. 665-680.

Hermann (1930) Dentinobliteration der Wurzelkanäle nach Behandlung mit Ca. *Zahnartzl Rdsch* 21:888-899.

Hirotto K (1959) A study on partial pulp removal (pulpotomy) using four different tissue solvents. *J Jpn Stom Soc* 26:1588-1603.

Hirschfield H (1874) Therapy for an exposed Pulp. *Dent Cosmos* XVI:120-1xx.

Hopewell-Smith (1898) The healing capacity of an exposed pulp *Brit dent J* 19:654-6XX.

Hosoda H, Inokoshi S, Fujitani M (1991) Pulpal response to a new bonding agent and recently designed adhesive liners containing a salicylic acid. *Dent Mater* 7:10:149-164.

Hudson (1824) Chapter XVI, The Conservative Treatment of the Dental Pulp-Devitalization and Extirpation of the Pulp pgs. 409-441. In: *The American Textbook of Operative Dentistry*. Ed. By E.C. Kirk. Lea Brothers & Co.

Jack LC (1900) Chapter XVI, The Conservative Treatment of the Dental Pulp-Devitalization and Extirpation of the Pulp pgs. 409-441. In: *The American Textbook of Operative Dentistry*. Ed. By E.C. Kirk. Lea Brothers & Co.

Johnston (1894) Chapter XVI, The Conservative Treatment of the Dental Pulp-Devitalization and Extirpation of the Pulp pgs. 409-441. In: *The American Textbook of Operative Dentistry*. Ed. By E.C. Kirk. Lea Brothers & Co.

Kakahashi S, Stanley HS, Fitzgerald RJ (1965) The effects of surgical

(references continued on page 6)

Code for the Procedure, Not the Technique

Tom Limoli, Jr.

Third party payers contractually reimburse only for completed procedures. They do not reimburse for individual subcomponents or techniques required to complete the procedure. With all bonded restorations, the bonding is nothing more than the technique used to complete the procedure. As such, the technique sensitive procedures are simply coded as the completed procedure.

I do not recommend separate fees for bonded and non-bonded restorations. When taking into consideration your usual fee for the completed procedure, examine the number of bonded and non-bonded restorations that you routinely perform. Your single fee should equally address both restorative techniques. The additional cost of the bonding agent is reflected in your total fee charged for the restoration.

According to the American Dental Associations Current Dental Terminology:

“Local anesthesia is considered to be part of restorative procedures. A one-surface posterior restoration is one in which the restoration involves only one of the five surface classifications (mesial, distal, occlusal, lingual, or facial, including buccal.”

AMALGAM RESTORATIONS (INCLUDING POLISHING)

“Tooth preparation, all adhesives (including amalgam bonding agents), liners and bases are included as part of the restoration. If pins are used, they should be reported separately (see D2951).”

RESIN-BASED COMPOSITE RESTORATIONS - DIRECT

“Resin-based composite refers to a broad category of materials including but not limited to composites. May include bonded composite, light-cured composite, etc. Tooth preparation, acid etching, adhesives (including resin bonding agents), liners and bases and curing are included as part of the restoration. Glass ionomers, when used as restorations, should be reported with these codes. If pins are used, they should be reported separately (see D2951).”

Under most dental reimbursement contracts, a sedative filling that is placed to medicate the pulp is usually a benefit as long as no other

treatment is rendered to the same tooth on the same date of treatment. Sedative fillings are interim treatments and are not intended to be payable together with a completed restoration. If a sedative filling is reported in conjunction with a permanent restoration performed on the same date of service, it is most often classified as a component of the permanent restoration. The additional cost is neither reimbursable by the benefit plan nor payable by the patient.

According to the American Dental Associations Current Dental Terminology:

D2940 sedative filling

“Temporary restoration intended to relieve pain. Not to be used as a base or liner under a restoration.

Pulp cap procedures are frequently and easily confused with sedative fillings. According to current terminology and reimbursement criteria, sedative fillings (D2940) are an integral part of direct pulp caps (D3110), indirect pulp caps (D3120) and even therapeutic pulpotomy (D3220) procedures. Where the sedative filling is identified as a completed interim restoration, pulp caps are to be identified separately from the completed restoration. Sedative fillings are not to be identified separately when the completed procedure is either a direct or indirect pulp cap.

According to the American Dental Associations Current Dental Terminology:

D3110 pulp cap - direct (excluding final restoration)

“Procedure in which the exposed pulp is covered with a dressing or cement that protects the pulp and promotes healing and repair.

D3120 pulp cap - indirect (excluding final restoration)

“Procedure in which the nearly exposed pulp is covered with a protective dressing to protect the pulp from additional injury and to promote healing and repair via formation of secondary dentin.

It is most inappropriate to deceptively seek additional reimbursement from either the patient or their individual benefit plan by separately identifying adhesive techniques.

Atlanta Dental Consultants / Limoli and Associates is your source for insurance reimbursement information. From the Coding and Claim Submission Manual to the bimonthly newsletter, Dental Insurance Today, textbooks, fee reviews, consultations and seminars, they guide your practice through the ever-changing world of reimbursement systems. For additional information, contact them at 404-252-7808 or visit them at www.limoli.com

exposures of dental pulps in germ-free and conventional laboratory rats. *Oral Surg* 20:340-349.

Kanner L (1934) Folklore of the teeth. The Macmillan Co. 1-284.

Katoh M, Kidokoro S, Kurosu K (1978) A study on the amputation of pulp using sodium hypochlorite (NaOCl). *Jpn J Pediatr Dent* 16: 107-116.

Kidd E (1976) Microleakage: A review. *J Dent* 4:199-206.

Kitasako Y, Inokishi S, Tagami J (1999a) Effects of direct resin pulp capping techniques on short-term response of mechanically exposed pulps. *J Dent* 27:257-263.

Kitasako Y, Inokishi S, Fujitani M et al. (1999b) Short-term reaction of exposed monkey pulp beneath adhesive resins. *Oper Dent* 23:308-317.

Koecker L (1826) In: Principles of Dental Surgery pp. 434-435, T. and G. Underwood, London UK.

Kozlov M, Massler M (1966) Histologic effects of various drugs on amputated pulps of rat molars. *Oral Surg* 13:455-469.

Lufkin AW (1938) A History of Dentistry. Chapter XII-Germany Lea & Febiger, Philadelphia, PA. pp. 112-118.

Massler M (1967a) Pulpal reactions to dental caries. *Int Dent J* 17:441-460.

Massler M (1967b) Preventive endodontics: Vital pulp therapy. *Dent Clin N Amer* 11:663-673.

Onoe N (1994) Study on adhesive bonding systems as a direct pulp capping agent. *Jpn J Conserv Dent* 37:429-466.

Otsuki M, Tagami J, Kanca J III et al. (1997) Histologic evaluation of two Bisco adhesive systems on exposed pulps. *J Dent Res*; 76:78.

Pfaff P (1747) In: The Story of Dentistry, Bremner MDR (1939) Pfaff was the Dentist to the King of Prussia and reported to have been the first to successfully treat an exposed pulp.

Rowe AHR (1964) An Historical Review of Materials used for Pulp treatment up to the Year 1900: Part One. *Brit Dent J* 117:27-29.

Rowe AHR (1965a) A Thesis submitted in partial fulfillment for the M.D.S. degree. The University of London U.K.

Rowe AHR (1965b) An Historical Review of Materials used for Pulp treatment up to the Year 1900: Part Two. *Brit Dent J* 118:47-48.

Ruby JD (1999) Lectures to DMD Students in Caries Course, University of Alabama, School of Dentistry, Personal Communication.

Snuggs HM, Cox CF, Powell CS et al. (1993) Pulpal healing and dentinal bridge formation in an acidic environment. *Quint Int* 24:501-510.

Stanley HR (1998) Criteria for standardizing and increasing credibility of direct pulp capping. *Am J Dent* 1998; 11:17-34.

Stanley HR (2002) Calcium Hydroxide and Vital Pulp Therapy In: Seltzer and Bender's Dental Pulp, Ed. By Hargreaves KM and Goodis HE, Chapter 13:309-324.

Sudo C (1959) A study on partial pulp removal (pulpotomy) using NaOCl (sodium hypochlorite). *J Jpn Stom Soc* 1959; 26:1012-1024.

Van Hassel H. (1971) Physiology of the human dental pulp. *Oral Surg* 32:126-134.

White KC, Cox CF, Kanca J III et al. (1994) Pulp response to adhesive resin systems applied to acid-etched vital dentin: Damp Vs dry primer application. *Quint Int* 25:259-268.

Kuraray Newsletter - Spring, 2003

Q After placing many posterior direct composite restorations, Class I and II, some of my patients still experience a mild postoperative sensitivity. Also, some of the restored teeth have required endodontic treatment. The use of self-etching bonding products seems to be more accepted today as compared to a year ago and I am evaluating which product to begin using. However, in those cases where the postoperative sensitivity remains, should I replace the restoration and use a self-etching product or should I wait to see if the sensitivity subsides?

A As noted by Dr. Christensen in the February 2004 issue of Dental Economics, page 112, "Post-operative sensitivity can be caused by numerous factors. Among them are: Occlusion too high on the restoration, tooth preparation very close to the pulp, previously present pulpal degeneration, trauma caused by the tooth preparation, partially polymerized resin, improper priming of the dentin surface on the internal of the tooth preparation, a new or old crack in the tooth, or several other reasons."

Q Should I use a dual cure adhesive with my dual-cure core buildup material?

A According to Dr. Michael Miller in the "REALITY's answers" section of Dental Equipment & Materials, January/February 2004 issue, page 30, "For the most part, our (REALITY) results found dual-cure materials do not require—nor is its performance enhanced by using—dual-cure adhesives. As long as the core is no thicker than 5 mm, cure the adhesive prior to placing core material. After you light-activate the core material, a light-cure adhesive should work just fine. This is a significant finding, since it allows us to simplify the placement of cores."

Kuraray's Photo Core core-buildup product has regularly received the coveted REALITY 5-Star award, including again in 2003. Photo Core used with Clearfil SE Bond provide a core buildup solution that is very easy, fast and economically practical—they are perfect partners.

hybrid layer and if there is no decrease in other adhesive physical properties.

Recent studies at universities throughout the world have demonstrated that there is an antibacterial cavity cleansing effect with Clearfil Protect Bond, yet the physical properties remain as high as those of a similar adhesive product called Clearfil SE Bond.

How does the Antibacterial Cavity Cleansing Effect Work?

MDPB in the Protect Bond primer uses the quaternary ammonium compound in its chemical structure. It is this component that provides the antibacterial cavity cleansing effect. The antibacterial cavity cleansing component in Protect Bond works by destroying the bacteria cell membrane, thus killing the bacteria. Quaternary ammonium compounds kill bacteria by causing the bacterial cell membrane to "burst," much like a bursting soap bubble. This membrane bursting is called bacteriolysis and results when the electrostatic balance of the bacteria membrane is disrupted. The active operational point of the MDPB compound is the pyridinium group, which has a positive (+) charge. Bacteria cell membranes have a negative (-) charge. The positive charged pyridinium group is "attracted" to the negative charged bacterial cell membrane, and when contact is made, the electrostatic charge of the bacterial cell membrane loses its balance and "bursts," killing the bacteria by the phenomena called bacteriolysis.

The structure of this new MDPB monomer is very similar to the common bactericide "CPC" which is often employed in toothpastes and mouthwashes due to its strong antibacterial property. However, the MDPB monomer is very special and different since it has an added polymerization group that allows this monomer to be polymerized by light-curing.

Ensured biocompatibility and elimination of toxicity

After polymerization of the bond layer, the antibacterial activity stops with all active components being integrated into the polymerized bond layer. The purpose for adding a polymerization group to the bactericide is to prevent continuous dispersion of the

bactericide, perhaps dispersing even into the pulpal tissue and its' vascular supply. Continuous dispersion may have adverse systemic affects, such as toxicity and bacterial resistance. Many products, including those containing Chlorhexidine, are applied directly to the tooth structure followed by the application of an adhesive bonding system. The polymerization and bounding of the bactericide represents a significant difference between the direct, continuous acting bactericide compounds and the new Protect Bond product, where the antibacterial cavity cleansing component is bond by polymerization after exposure to the cavity. Therefore, after the Protect Bond is polymerized, the MDPB is bound and cannot continue dispersing into the dentin.

Antibacterial activity compared to other materials

It is well established that 40% phosphoric acid has an antibacterial effect also. However, in-house studies using agar plate diffusion test show that a 20 seconds application of the MDPB containing primer is significantly more effective for antibacterial cavity cleansing than the 40% phosphoric acid. And since Protect Bond is a self-etching system, problems associated with total etch (using phosphoric acid) systems such as "wetness" or "post operative sensitivity" can be avoided or eliminated. Moreover MDPB is effective even when it is diluted with water to only 2%. This means that antibacterial cavity cleansing effect is reliable in such cases where the cavity may be moist.

The Fluoride Release Function and How It Works

The bonding agent of Protect Bond contains a fluoride release property. While the exact, measurable benefits of fluoride containing properties has not yet been proven, there are strong indications that there may be remineralizing effects associated with fluoride release into the surrounding tooth structure. However, dental materials that have fluoride-releasing properties, such as bonding agents, adhesive cements, and glass ionomer products, are thought to have a reduction in physical properties after fluoride release. This physical property reduction is said to be due to the voids that are left in the material after fluoride ions are released.

Therefore, the sodium fluoride ion was coated with a proprietary "micro capsule" to maintain the physical property after fluoride release. This technology enables the fluoride ions to be released through the "micro capsule" as it reacts with water.

Since the capsule remains inside the bond material intact, voids do not exist and act as weak points in the adhesive bond layer. The chart below compares the affect of fluoride release on the physical properties of a few products and clearly shows that there is very little affect on the physical properties of Protect Bond, while the other products show a definite decrease in physical properties over time as fluoride is released.

Adding the antibacterial cavity cleansing effect and fluoride release have no adverse affect on the physical properties, including bond strength. The bond strength of Protect Bond is excellent, in fact it is almost equal to that of SE Bond. Both SE Bond and Protect Bond have the same adhesive monomer, MDP, and the general composition is practically the same. Thus, results of tensile bond strength tests show that Protect Bond has a much better bond strength compared to total etch products, 2 step self-etch or 1 step self-etch adhesives products.

In addition to having similar physical properties to Clearfil SE Bond, the basic application procedure and indications for use of Protect Bond are the same. Therefore, primer conditioning, priming, and antibacterial cavity cleansing are completed in just 20 seconds with Protect Bond. Then the Protect Bond bonding agent is applied and MDPB is light-cured safely within the bonding agent. As with SE Bond, Protect Bond is a two-step self-etching primer with a simple procedure, very low technique sensitivity, and very high bond strength. Now, however, the new adhesive system provides more than just adhesion between the tooth structure and the restorative material. Protect Bond, the epoch-making product, provides antibacterial cavity cleansing and fluoride release for your confidence and your patient's comfort.



Kuraray America, Inc.
101 E. 52nd Street, 26 Floor
New York, NY 10022

Presorted
Standard
U.S. Postage
Paid
Woodstock, GA
Permit No. 374

World's Leading Manufacturer of Dental Products

FUTURE ISSUES

- Practical cement applications.
- Practical criteria for tooth care when using adhesive procedures.
- Practical uses for sealants.
- Efficient post and core procedures.
- Earn **CECredit**

Published by Kuraray America, Inc.
101 E. 52nd Street, 26 floor
New York, NY 10022
(800) 897-1676
www.kuraraydental.com

Featured Products

Kuraray introduces another adhesive bonding milestone!

CLEARFIL PROTECT BOND is a new class of self-etching adhesive bonding that contains, in addition to the MDP adhesive monomer, a new functional monomer "MDPB," which exhibits an "Antibacterial Cavity Cleansing Effect" recently authorized by the FDA. For all your restorative treatment requiring a bonding agent, use Kuraray's newest adhesive bonding agent — it's the right thing to do for your patients!



THE TRULY UNIVERSAL COMPOSITE

CLEARFIL AP-X RESTORATIVE SYSTEM **CLEARFIL AP-X PLT**

Ten years of clinical experience and scientific research guarantee **Clearfil AP-X** offers superior aesthetic appearance and exceptional physical properties. And....the ideal direct restorative material to use with **SE Bond**, especially for posterior restorations. It's available in syringe or plt delivery systems. Enjoy the ease of use and the benefits of low wear and high fracture resistance, excellent polishability, low polymerization shrinkage, visible radiopacity, easy handling, ideal direct posterior restorative material, and very economical per application.



FEATURES & BENEFITS

- **Antibacterial Cavity Cleansing Effect**
- Low Post Operative Sensitivity
- Fast and Simple to Use
- High Bond Strength
- **Fluoride Releasing Properties**