The effect of citric acid concentration on the adaptability and bond strength of new resin root canal sealers (In vitro study)

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Pulpal and endodontic problem are primarily related to microorganisms or their by-product in the root canal system. Successful endodontic treatment depends on chemo-mechanical preparation of the root canal system as well as three dimensional obturation that provides complete sealing. The objectives of the canal space obturation are to prevent leakage from the oral cavity and the periradicular tissues into the root canal system and seal any microorganisms that could not entirely removed during cleaning and shaping procedures.

Gutta-percha as the main core of the root canal filling does not bond to root dentin and therefore must be used in association with sealer to fill the discrepancies of the root canal system as the gutta-percha has inability to be adapted to all irregularities of this complex system.

The ideal obturating material should be Stable in the oral environment, Radiopaque, Biocompatible, Antimicrobial, Non-shrinking during polymerization, Self-adhesive, form a monoblock, in which the root becomes a perfectly sealed, stable, solid mass with no gaps.

Good adhesion to root canal dentin is one of the ideal properties of sealer cements. Adhesion to dentinal walls is advantageous for two main purposes; in a static situation, it should eliminate space that may allow percolation of fluids between the filling and the canal wall. In a dynamic situation, it is needed to resist dislodgement of the filling during subsequent manipulation.

There are different types of root canal sealers are available, they can be grouped according to their basic components as, zinc oxide-eugenol, calcium hydroxide, resins, glass ionomer or silicon based. Ideally these materials should seal the canal laterally and apically and have good adaptation to root canal dentin.

More recently, the newly developed resin based sealers Metaseal sealer and Realseal SE sealers are comparable to self-adhesive resin luting cements in that both were designed with the intention of combining a self etching primer and a moderately filled flowable composite into a single product.

Adaptability and bond strength of this newly developed sealers are still unclear, so it worth to study them.

The incorporation of resin as an integral part of root canal obturating material has been early seen with the use of resin root canal sealers. Diaket a polyketone compound used as a root canal sealer, showed good sealing ability but it is very tacky material and showed high toxicity. AH26 was developed as a resin root canal sealer, it has a good flow, seals to the dentin wall, but it showed a very high toxicity when freshly mixed, this toxicity related to the release of very small amount of formaldehyde. AH plus was developed to overcome the problems of AH26.

The first generation of methacrylate resin-based sealers was introduced in the mid-1970s as Hydron. The use of poly [2-hydroxyethyl methacrylate] (poly [HEMA])as the major ingredient rendered the sealer very hydrophilic. Hydron was designed to be injected into a root canal and to be polymerized in situ. However, the sealer came to a disastrous end and became obsolete in the 1980s because discrepancies between the manufacturer's claims and laboratory /clinical findings on its physical /clinical properties and biocompatibility became apparent soon after its commercialization. The sealer caused severe inflammatory reaction, absorption of the material, severe leakage as well as water sorption and swelling [(1)]

The second generation of bondable sealer is non-etching and hydrophilic in nature (EndoREZ) and does not require the adjunctive use of a dentin adhesive. It is designed to flow into accessory canals and dentinal tubules to facilitate resin tag formation for retention and seal after smear layer removal with NaOCl and EDTA. EndoREZ is a dual cured radiopaque hydrophilic methacrylate sealer that might be used in the wet environment of the root canal system and is very effective in penetrating dentinal tubules and adapting closely to the canal walls. Although EndoREZ is recommended for use with either a conventional gutta-percha cone or with specific EndoREZ points (resin-coated gutta percha), low bond strength to the dentinal wall was reported with conventional uncoated guttapercha(1).

To simplify bonding procedures, new generations of self-etching (third generation) and self-adhesive (fourth generation) luting resin composites have been introduced to restorative dentistry during the last five years.

The third generation self- etching sealers (FiberFill root canal sealer, Resilon/Epiphany system, RealSeal , Resinate, and Smart systems) contain a self- etching primer and a dual-cured resin root canal sealer. The use of self-etching primers reintroduced the concept of incorporating smear layers created by hand/rotary instruments along the sealer-dentin interface. An acidic primer is applied to the dentin surface that penetrates through the smear layer and demineralizes the super-ficial dentin. The acidic primer is air-dried to remove the volatile carrier, and then a dual-cured, moderately filled flowable resin composite sealer is applied and polymerized [1]

The forth generation methacrylate resin-based sealers(e.g MetaSEAL, RealSeal SE) are functionally analogous to a similar class of recently introduced self-adhesive resin luting composites in that they have further eliminated the separate etching/ bonding step. Acidic resin monomers that are originally present in dentin adhesive primers are now incorporated into the resin-based sealer/ composite to render them self-adhesive to dentin substrates. The combination of an etchant, a primer, and a sealer into an all-in-one self-etching, self-adhesive sealer is advantageous in that it reduces the application time as well as errors that might occur during each bonding step. MetaSEAL is the first commercially available fourth generation self-adhesive dual cured sealer. The inclusion of an acidic resin monomer, 4 methacryloxy ethyl trimellitate anhydride (4-META), makes the sealer self etching, hydro-philic, and promotes monomer diffusion into the underlying intact dentin to produce a hybrid layer after polymerization. The sealer bonds to thermoplastic root filling materials as well as radicular dentin via the creation of hybrid layers in both substrates.

Irrigation and Bond strength of resin root canal filling materials:

Mannocci et al [(2)] Compared the apical seal of roots obturated with either of two kinds of dentin bonding agent, gutta-percha and epoxy-resin-based root canal sealer, by a die leakage test with that of an epoxy resin root canal sealer and gutta-percha without a bonding agent. Thirty-two roots were prepared and divided into three experimental groups. Group 1 was filled with gutta-percha, epoxy-resin sealer, and All-Bond 2 Adhesive. Group 2 was filled with gutta-percha, epoxy-resin sealer, and Scotchbond Multi-Purpose Plus adhesive. Group 3 was filled with gutta-percha and epoxy resin sealer. The teeth were immersed in 2% methylene blue solution. Groups 1 and 2 leaked significantly less than group 3. The materials most frequently observed at the apex were in group 1 dental adhesive and in group 2 gutta-percha. The interface between dentin and the adhesive materials in groups 1 and 2 was examined by scanning electron microscope and showed a hybrid-like layer.

Kataoka et al [(3)] Studied the effect of dentin conditioners and primers on dentin bonding by tensile bond strength testing and scanning electron microscopy. A Newly developed root canal resin sealers composed of vinylidene fluoride/ hexafluoropropylene copolymer and 30 wt% methyl, methyl methacrylate was mixed with zirconia powder and tributylborane and then used to examine its sealing ability. Apical and coronal leakages were evaluated at 1, 4, and 12-weeks intervals by a dye penetration test using a methylene blue solution. Pulp Canal Sealer EWT and Sealapex were used as controls. Significantly high bond strength was obtained by treating dentin with EDTA, followed by application of a glutaraldehyde / Bhydroxyethyl methacrylate primer. The experimental resin sealer produced a significantly superior coronal seal at 12 wk when compared with the two control sealers. Scanning electron microscopic examination revealed few gaps at the resin sealer-dentin interface.

Morris et al [(4)] Evaluated the effect of 5% NaOCl and RC-Prep treatment on the bond strength of a resin cement, C&B Metabond. Control roots (group 1) were biomechanically prepared using 0.9% NaOCl as an irrigant; group 2, roots with 5% NaOCI; group 3, roots with RC-Prep; group 4, roots with 0.9% NaOCl followed by 10% ascorbic acid; group 5, roots with 5% NaOCl followed by 10% ascorbic acid (pH4); group 6, roots with 5% NaOCl followed by 10% neutral sodium ascorbate; and group 7, roots with RC-Prep followed by 10% ascorbic acid. All roots were then filled with C&B Metabond, incubated in water for 24 h, and then cross-sectioned into six 1-mm thick slabs representing cervical and middle root dentin. The slabs were tested for tensile bond strength. The results demonstrated that both 5% NaOCl and RC-

Prep produced significantly large reductions in resin-dentin bond strengths, and the reductions could be completely reversed by the application of either 10% ascorbic acid or 10% sodium ascorbate.

Gaston et al [(5)] Measured the regional cervical, middle and apical thirds of the roots samples. Tensile bond strength of adhesive resin cements to dentin was measured. Twenty single rooted extracted human teeth were used. The crowns were removed post space was prepared in the canal using Gates Glidden no6. The roots were ground flat on one side to expose the canal and permit ideal placement of one of two resin cements (Panavia21 or C&B Meta bond).Composite buildups made to both external surfaces to create more bulk, the complex was cut into 1mm- thick slabs that were serially sectioned into sticks which were mounted on custom-made test device for tensile bond testing. Results indicated that both resin cements produced high bond strength, and bond strength at the apical third was significantly higher than the cervical or middle third with either cement.

Ngoh et al [(6)] Compared the regional bond strengths of C&B Metabond resin to root canal dentin, with or without treatment using eugenol containing endodontic sealer liquid. Eighteen extracted human canines were decoronated at the cemento-enamel junction. The apical third of the root was removed leaving the cervical and middle thirds. The cervical or middle third dentin was treated with Kerr Root Canal Sealer liquid, and then adhesive resin was luted directly to the prepared canal. The specimens were mounted to measure the micro-tensile bond strength. They found that the specimens treated with the eugenol liquid have significantly lower bond strength than those without eugenol.

Lee et al [7] Compared the differences in bond strength of endodontic sealers (ZOE sealer, Sealapex, AH26, Ketac-endo) Flat coronal dentin or gutta-percha surfaces were created. Aluminum cylinders were stabilized on the substrates with small amounts of wax and then filled with one of the sealers. The bond strengths and modes of failure were measured. The results indicated that sealant bond strengths of Ketac Endo and AH 26 were significant different from Kerr and Seal apex and from themselves. AH 26 gave significantly highest bonds to gutta-percha.

Tagger et al [8] Measured the bonding of endo-dontic sealers (Sealer26, AH26, Bioseal, Ketac-Endo, PulpCanal Sealer, Apexit, Calcibiotic Root canal sealer, then Roth cement and Sealapex to the dentin. Five mm long sections of polyethylene tubing, filled with freshly mixed sealer were placed perpendicular to the dentin surfaces for shear bond strength using the Instron testing machine. Results showed that the mean bond strength ranged from 0 to 4.9 MPa. They grouped the sealers according to their bond strength from highest to lowest as follows: Sealer 26, AH26, Bioseal, Ketac-Endo, Pulp Canal Sealer, Apexit, Calcibiotic Root canal sealer, then Roth cement and Sealapex. They found that this model provides a simple and reproducible mean for measuring the in vitro bond strength of endodontic sealers.

Sousa-Neto et al [(9)] Evaluated the effect of Er:YAG laser on the adhesion of Grossman, Endo-methasone, N-Rickert and sealer 26 resin sealer on human dentin. Forty human molars were divided into two groups: group1: no laser application and group 2 irradiation with Er:YAG laser. Five samples were tested for each sealer and each group. An Instron universal testing machine was used for the adhesion test. Results showed that application of Er:YAG laser did not alter the adhesion of Grossman, N-Rickert or Endomethasone sealers while laser application increased the adhesion of sealer 26.