MATERIAL TRENDS

Resin Modified Glass Ionomer Cement Update: A Marriage of Strength and Convenience

As clinicians work tirelessly to improve patient health, there are many occasions on the road to oral rehabilitation that the selection of materials used are required to be case-specific. Cementation is one of those clinical areas where the correct chemistry and substrates must be optimized, as failure to do so can result in a less than desireable clinical outcome!

Over the past few decades, we have witnessed the evolution of a myriad of luting materials, developed and presented to meet the ever-changing materials selected for use as definitive or permanent prosthetics. A very common choice for many of today's clinicians has been the chemical family of glass ionomer-based cements (GICs).

The composition and advantages of GICs

Conventional glass-ionomer cements (GIC) are a mix of calcium or strontium alumino-fluoro-silcate glass powder (base) combined with a water soluble polymer (acid). Today's GIC material use is predominantly cements. Traditional GIC luting materials are lacking in the areas of general strength and resiliency. Additional areas of concern are solubility and absorbtion, particularly when dealing with a prosthetic that offers an exposed margin(s). The industry standard for many years was the manual measuring and mixing of the GI cement's two components, powder and liquid. While this manual mixing allowed the user to control some variables such as viscosity and/or working/setting times, it unfortunately created issues with chemical consistency. More on that below.

Faced with these clinical shortcomings, dental manufacturers first started the evolution of the basic GICs by the inclusion of methacrylate resin(s) in an attempt to bolster the cements' physical values. Typically, the use of hydrophilic monomers such as hydroxyethyl methacrylate (HEMA)[1] have resulted in better "wetting" of dentinal surfaces. This wetting offers improved coverage of the substrate and more adhesion along with a general increase in overall resistance to abrasion and staining.

Resin Modified Glass Ionomer (RMGI) cements offer generally improved physical properties, such as flexural and compressive strength[3], as well as lower levels of absorption and solubility. Today, some RMGI materials do not need an adhesive placed first, while others will still suggest placing a modifier or conditioner on the tooth prior to the placement of the cement. This preconditioning step helps to ready the biological smear layer for its interaction with the RMGI cement's chemistry.

In many cases, when we prep a tooth for a crown, we strip the organic/inorganic structure down to a shadow of its former self. This is where a GIC's natural fluoride release becomes particularly useful[2]! Other features of the RMGI cement class include: a natural adhesive quality to tooth structure, a similar thermal dynamic coefficient of expansion and contraction (when compared to natural tooth structure), and a certain level of biocompatibility not found with bonded resin cements.

While these GIC benefits were appreciated, they were undermined by the required process and inaccuracies that came with first mixing powder and liquid by hand, and then later the required trituration steps associated with the application capsule. In response to these clinical inconveniences, manufacturers evolved the mixing process into the semi-automated, paste-to-paste dispensing system specific to RMGI cements. Allowing RMGI cements to be mixed and applied in a single dual-barrel syringe with greater accuracy, ease of application and thus ease-of-use. Unfortunately, while these systems offered the operator convenience and consistency in application, they negatively impacted the adhesive qualities of the RMGI cements, significantly reducing bonding strength.

Traditionally, RMGI paste-to-paste cements also may require a substrate modification of the prepped tooth prior to application. Yet even after this process, most still offer relatively low bond strengths to the modified smear layer/tooth. Two of the most common brands of paste-to-paste RMGI cements used today in North America, when tested, only offer bond strength in the region of 4 to 6 MPa to dentin (Fig. 1). In spite of these relatively low bond strengths, paste-to-paste RMGI cements in general continue to retain their prosthetics to date. Much of this success can be attributed to the other performance properties of the cement category such as the previously mentioned calcium complexing and a thermal dynamic coefficient of expansion and contraction (TEC) that is similar to tooth structure.

Meron Plus QM: An Evolution in Paste-to-Paste RMGI Cements?

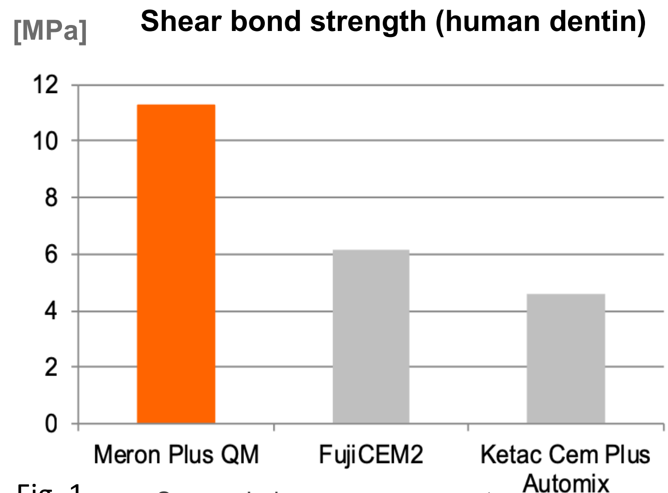


Fig. 1 Source: In-house measurement

Recently, VOCO launched a new iteration within the category of paste-to-paste RMGI cements in Meron Plus QM. This new paste-to-paste RMGI cement has rewritten expectations when converting the RMGI cement into a paste-to-paste format, allowing for increased bond strengths instead of sacrificing bond strengths in exchange for the increased ease-of-use. Meron Plus QM is delivered using a twin barreled QM (Quick Mix) syringe and mixing tip. Offering ease of application, consistency in mix ratio, minimal tip waste and easy clean-up, this new material allows the clinician to deliver predictable cementation results, case after case, while improving overall adhesion values to both tooth structure and the restorative substrate.

Two major differences factor into Meron Plus QM's improved formulation: 1) VOCO's investment in testing prodedures using human dentin rather than bovine dentin—the industry norm—which ultimately influenced formula decisions and 2) A carefully formulated use of long-chain Polyacrylic Acid.

The use of a long-chain Polyacrylic Acid (PAA) that is 3-4 times larger than currently available materials in the marketplace houses many more carbon atoms as well as more acidic groups within its makeup. However, the PAA needs to be balanced with the right "mix" of glass, and it is for this reason that VOCO has created its own "glass formula." While many current materials utilize three or four types of glass, VOCO has elected to balance their unique PAA with six different glass types. Balancing the types of glass with the right type of PAA can lead to dramatic improvements in the material's properties. The increased number of Carbon atoms within the PAA chain results in higher levels of ionic reactivity and thus improvements in the levels of adhesion of the cement. As well as the changes in chain size and glass formulation, the addition of the very hydrophylic monomer, HEMA, gives the cement an excellent viscosity and wetting behavior. It is this wetting quality that helps deliver the cement more easily, to a greater surface area – again, increasing the level of adhesion between the cement and the tooth substrate. A more simplistic way to think of the PAA would be to think of it as a more “pure” or effective version of a Polyacrylic acid that facilitates increased levels of chemical efficiency when in contact with the desired substrate. Additionally, this more efficient PAA eliminates the need for pre-conditioning of the tooth.

In the table above (Fig 1), shear bond strength to human dentin was recorded along with the two most common North American paste-to-paste RMGI cements, Fuji-Cem 2™ (GC America) and RelyX Luting Plus ™ (3M/Espe).

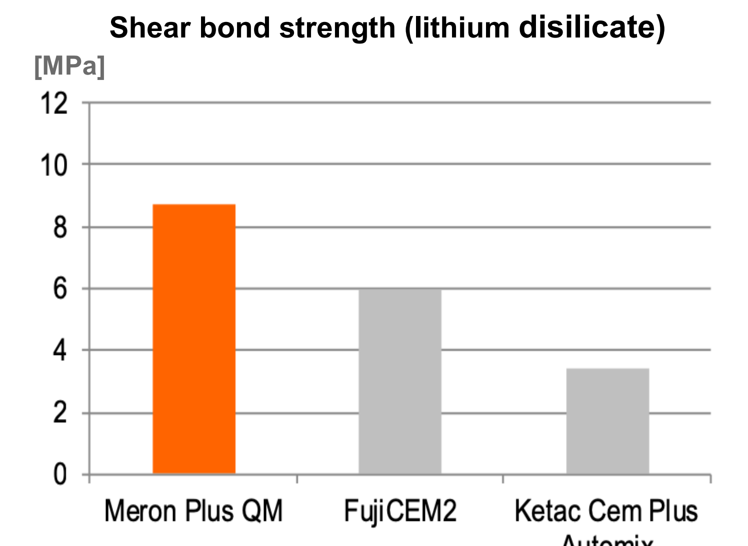


Fig. 2

Source: In-house

With the increase of prosthetics manufactured using Zirconium Dioxide (ZiO_2), the engineering of Meron Plus QM was also careful to include this substrate into its developmental process. The results of the new improved chemistry can be seen in Fig. 2. Again we see the two most common RMGI cements and their comparative values. While the levels of adhesion have been improved with this evolutionary formulation – which is a success all its own—solubility and absorbtion, more commonly referred to as ”ditching and staining,” were reduced wherever a margin is not completely protected. While the absorbtion is not esthetically pleasing, it is perhaps of less concern than the solubility/ditching. Erosion or undermining of the cement/adhesive interface can result in a premature debond and subsequent loss of retention and the prosthetic.

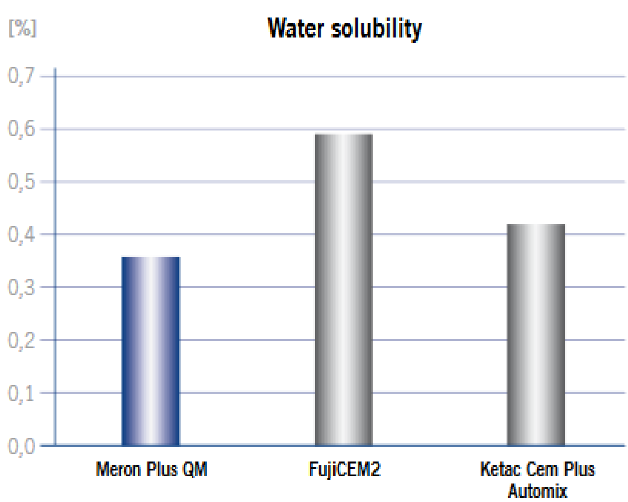
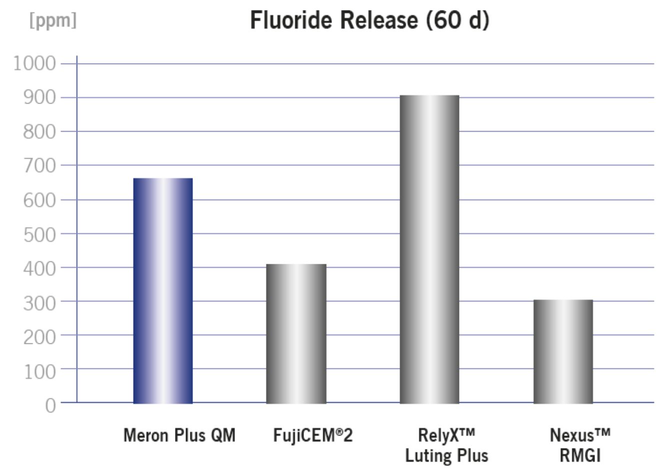


Fig. 3

In Fig. 3, we see the positive impact of this new formulation. The values are presented as a percentage (%) of the total mass/volume of the marginal cement lost over a controlled period of time. Exposure to a mild acidic liquid mix, at a variety of temperature values, was used to simulate a typical intra-oral environment.

Two other areas of consideration need also be evaluated when the decision to use a RMGI cement is made. As this class of cement is a “resin-modified” glass ionomer, it is expected that there will be an active ongoing exchange of fluoride ions between the cement and the tooth substrate. In Fig 4. below, we see the respective fluoride release values for a variety of commonly-used RMGI cements over a 60-day period. And again, this new formula delivers.

Toward the end of placing a restoration, the clinician has to consider clean-up. More specifically, how easy or difficult the excess cement can be to remove at the point of cementation. Cements can harden in two basic modes – the first is a "snap-set." The second is a delayed set, commonly referred to as an "extended gel" state. A snap set means the cement hardens almost immediately, leaving very little time for the clinician to clean off the excess before it is required to be picked off forcefully, usually with an instrument. The extended gel phase allows for a more gradual setting and offers the clinician an opportunity to easily clean off excess without force and the fear of possibly dislodging the prosthetic during cleanup.



Source: Internal measurement

Fig. 4

Meron Plus QM offers the clinician an opportunity to "tack-cure" the excess cement to facilitate immediate ease of removal. To offer this "controlled" cure, VOCO selectively limited the availablility of photo-initiatiors in such a manner as to only arrive at an immediate gel phase vs. a full cured, which can be easily peeled away from the margin of the prosthetic. Meron Plus QM's unique chemistry allows for this "limited" light cure capability to achieve the gel phase and alleviate further headaches during the cementation process. If, however, a light cure is not available for a tack-cure, one can clean the excess by simply waiting 2 minutes until the material reaches its "gel-phase" for easy removal.

Clinical concerns drive material evolution

This new chemistry is just the latest in the continual quest to improve and enhance the material tools available to clinicians. Cementation as a clinical procedure demands that the material perform immediately to retain the prosthetic and offer an ongoing continuous level of performance, post cure, to allow for successful and predictable clinical outcomes.

If you find youself still using the same cement that you were using five years ago or longer, perhaps now is the time to investigate what is available and embrace the change to improve dentistry in your practice.

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