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Opinion

Novel Upgrading of Conventional Glass Ionomer Cement Using Nanohydroxyapatite, Silica and Zirconia

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Abstract

Conventional glass ionomer cement is one of the commonly used dental restorative material due to its properties especially bond to tooth structure and anticariogenic. However, their uses are limited due to some weaknesses such as low in mechanical strength. Many modifications have been done to improve it but not fully successful. Recently a group of researchers has proved that addition of hydroxyapatite, silica and zirconia able to enhanced the mechano-physico and aesthetic properties.

Discussion

Glass ionomer cement (GIC) or term by the International Organization for Standardization, (ISO), is "glass polyalkenoate cement" [1]. was one of the mostly used material in dentistry since its invention in 1972 by Wilson and Kent. Conventional GIC was an acid-base cements produced from the reaction of weak polymeric acids with powdered glasses [2], composed of water soluble, polyacrylic acid and a fluoroaluminosilicate glass [3,4]. Later, the resin modified GIC (RMGIC) was produced by an incorporation of hydrophilic resin monomer into GIC and set by light curing [5]. Conventional GIC was well liked due to its easy to use [6], moisture less sensitive and the main attractions of GIC are the adhesive properties to enamel and dentin where it bond chemically to hard dental tissues by the formation of ionic bonds between carboxylate gropes and calcium [7], It is anti-cariogenic due to the ability to release fluoride and also act as fluoride reservoir if recharge [8], one of the magnificent inhibitor for caries process [9], inadequacy of exothermic polymerization and close thermal expansion to tooth [10,11]. It was highly used for treatment of deciduous teeth, as a liner or base, temporary restoration for permanent teeth and very suitable for atraumatic restorative treatment (ART) [12].

However, there are few weaknesses regarding to this material where its lack in strength and low resistance to abrasion and wears [13]. It has low hardness which cannot withstand occlusal stress for a long period of time [10]. Even it is tooth-coloured material but has poor aesthetic due to too opaque, not easily polished and has very poor resistance to acidic exposure in a situation of mouth with highly acidic environment [14]. Higher compressive strength of RM-GIC is may be due to the presence of resinous polymer that are absent in conventional GIC [15]. Compare to other material such as amalgam that highly controversial with its hazardous effect and metallic colour which is not aestrhetic especially for anterior restoration, GIC has better features. Also comparing to composite resins which become more popular. there are concerns that resin composites may be toxic based on the fact that they may release components which is harmful to pulp tissue if carelessly applied [16], GIC is more safe.

Due to its important usage many studies for improvement has been done by researchers since many years ago. The filler has been modified by incorporating elements such as silver-cermet, stainless steel powder [17], titanium dioxide, silver tin alloy, carbon and alumina-silicate fibres [3,7,10,18]. Hydroxyapatite, silica and recently zirconia have been used to modify the nano powder of the conventional GIC. HA participates in the setting reaction of GIC which increased the flexural strength [19]. The resemblance between chemical formula of HA ($Ca_{10}(PO_4)_6(OH)_2$) and natural bone and teeth due to the continuous formation of aluminum salt bridges, improved the final strength of the cements [3,20,21,22]. In other circumstances, the incorporation of HA alone into GIC did not improve the mechanical properties of GIC as HA did not involve in the cross-linking matrix and also disrupts the stetting reaction of GIC [23].

On the other hand, limited literatures can be found on the incorporation of silica into GIC. Rahman, et al. [2014] described on one pot synthesis of nanosilica-hydroxyapatite (nanoSiO_2-HA) via sol-gel method has successfully produced elongated nanoHA with size of~103nm and spherical nanoSiO_2 with size of~30nm. This incorporation of nanoSiO_2-HA resulted in the hardness enhancement of~73 % when compared to conventional GIC [22]. Studies have found that the incorporation of a HA-SiO_2 phase in a conventional GIC enhanced its mechanical properties with favorable cytotoxic response [24,25]. A comprehensive review of the available literature has revealed that not all modifications in glass powder have resulted in the desirable strengthening of GICs.

Lately, zirconia has been used to modify the powder of GIC. Zirconia was popularized into dentistry in the early 1990s, as an endodontic posts and hard framework cores for crowns and fixed partial dentures [26]. Earlier, Gu and colleague reported on the improvements on mechanical strength with the addition of hydroxyapatite/zirconia (HA/ZrO_2) into the GIC. but the presence of voids on the fractured surface and cracks at the interface showed the failure of HA/ZrO_2 in improving the brittle manner of GIC [23]. Study using HA/yittra-stabilized ZrO_2 nanocomposite has successfully improved the characteristic of GIC owing to the high strength, fracture toughness and biocompatibility of ZrO_2 [11]. Recently, a new prototype named GiZiDent which is a GIC-nanozirconia-silica-HA hubrid has been produced by Wan Bakar, et al. 2017 [27]. They have found a specific tec technique of synhesizing and specific ratio of addition the new nano powder to the conventional GIC to produce new hybrid material with many mprovedvements following ISO standard [28].

This new noivel material has improved tmechano-physico-chemico and biological properties of the conventional GIC [28,29]. The incorporation of nanoceramics (HA, SiO_2, ZrO_2) has resulted in improved mechanical properties of GICs due to their ability to release F-, high surface area, and better particle size distribution [3,24,30]. GIC nano ZrO_2-SiO_2-HA demonstrated, a statistically significant difference in cell viability at both 100 and 200mg/ml concentrations for the 24h and 72h. incubation periods [31]. Study result showed an overall higher F- ion elusion from the GIC-nano-ZrO_2-SiO_2-HA when compared to conventional GIC throughout the duration of the study (p≤0.05) [32]. Nanozirconia which is translucent may also improve the aesthetic property of GIC as shown in a study by Rahman, et al. [30].

Conclusion

The new novel nano GIC-ZrO_2-SiO_2-HA can be a promising dental restorative material in future for a wider scope of used including high stress bearing area.

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Conflict of Interest

The authors declare no conflict of interest.

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