Fluoride-Releasing Restorative Materials

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Fluoride-Releasing Restorative Materials

- **The anticariogenic potential of silicate cement confirms the ability of F^- to inhibit demineralization and lead to the development of several fluoride-containing restorative materials and cements: conventional glass ionomers, resin-modified glass ionomers, polyacidmodified composites (compomers).**

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Glass-Ionomer Cement

Glass polyalkenoate cement is the proper designation for specialized glass powders that react with polyacrylic acid. However, **glass ionomer, glass-ionomer cement, and GIC** are recognized as acceptable names within the dental profession.

Two powder–liquid type II restorative glass-ionomer cements. A, Two-bottle system for hand mixing. B, Capsule for trituration (GC Fuji Triage capsule).

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Glass-Ionomer Cement

GICs **are versatile material that is adherent, translucent, and fluoride releasing. GICs have been used for:**

(1) the esthetic restoration of anterior teeth (e.g., class III and V sites),
(2) adhesive cements for fixed prostheses and orthodontic appliances,
(3) intermediate restorations,
(4) pit and fissure sealants,
(5) cavity liners and bases, and
(6) corebuildup materials.

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Glass-Ionomer Cement

Type I: Luting crowns, bridges, and orthodontic brackets
Type II a: Esthetic restorative cements
Type II b: Reinforced restorative cements
Type III: Lining cements and bases

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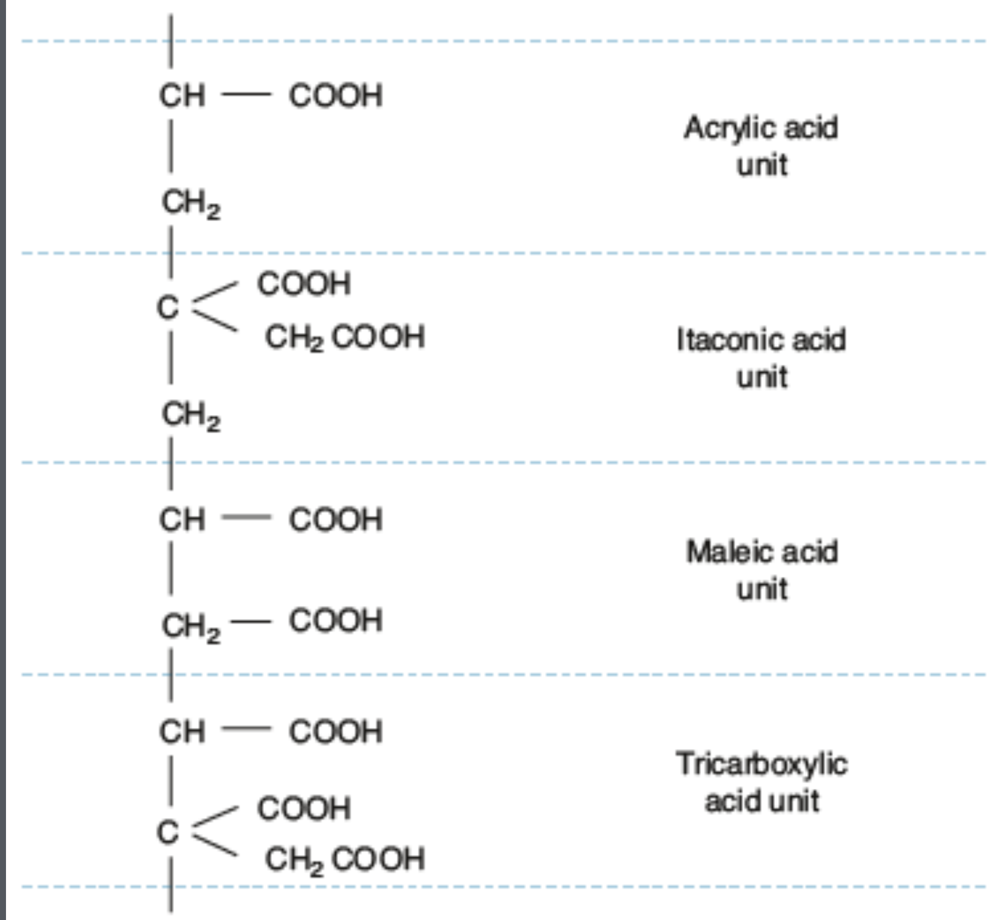
Glass-Ionomer Cement-Chemistry and Setting

TABLE 7-5 **Nominal Compositions of Glass-Ionomer Cement Powders (wt%)**

Compound	A	B	C	D	E	F
SiO_2	36	20–30	41.9	35.2	34	32
Al_2O_3	36	10–20	28.6	20.1	45	32
AlF_3			1.6	2.4		
CaF_2			15.7	20.1		
NaF			9.3	3.6		
$AlPO_4$			3.8	12.0		
F	9	10–15			9	8
Na_2O	7	1–5				7
La_2O_5						3
BaO		10–20				
CaO	14	10–20				13
SrO					11	
P_2O_5	5	1–5			1	5



• **Figure 7-9** Structure of various types of alkanoic acids that make up polyacids of glass-ionomer cements.

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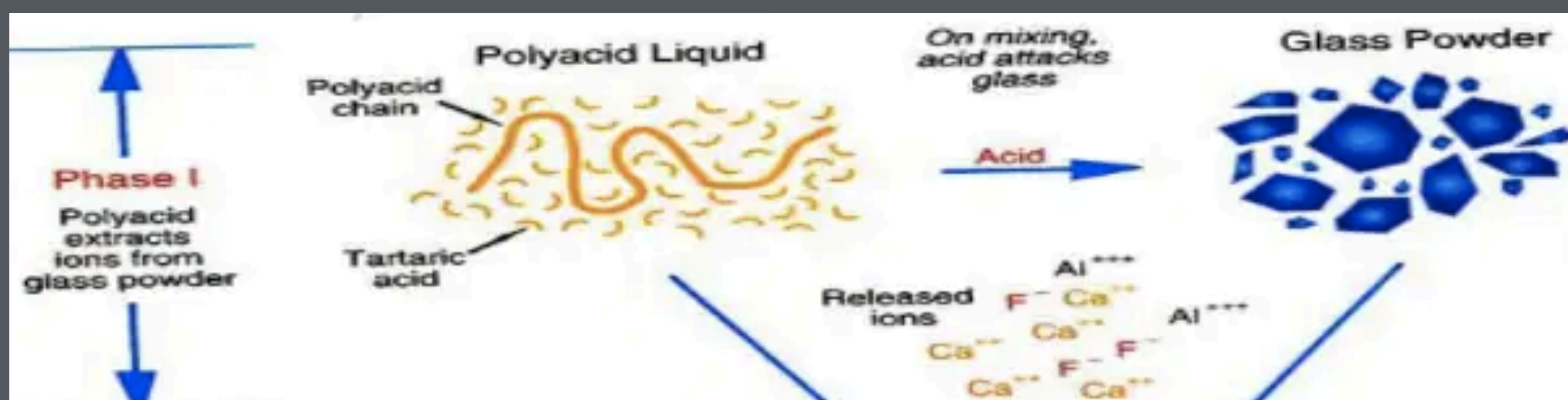
Glass-Ionomer Cement-Chemistry and Setting

- **When the GIC powder and liquid are mixed, the acid starts to dissolve the glass, releasing calcium, aluminum, sodium, and fluorine ions into the liquid.**



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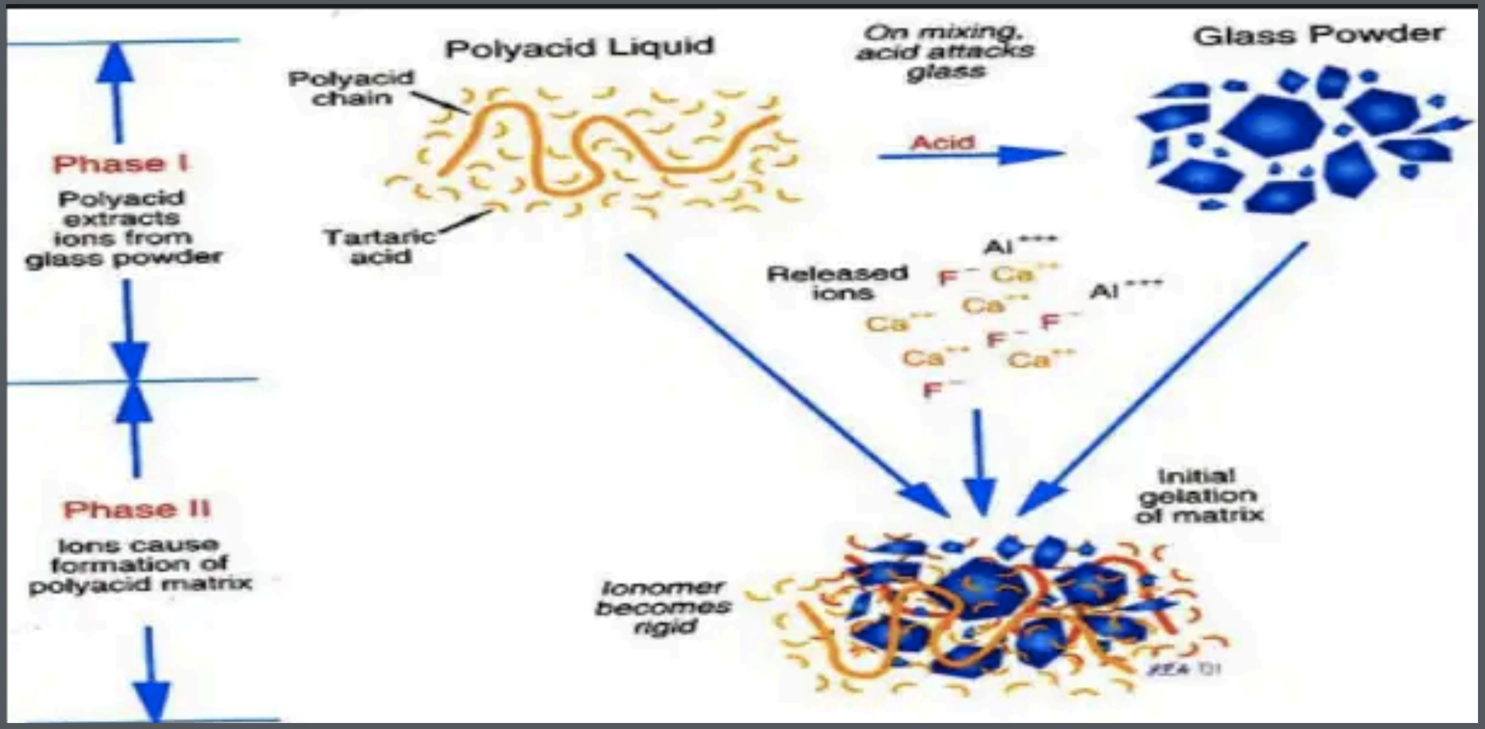
Glass-Ionomer Cement-Chemistry and Setting

The high aluminum content is the key to the glass reactivity with polyacrylic acid. The undissolved portion of the glass particles is sheathed by a silica-rich gel formed on the surface of the glass particles when the ions are leached.



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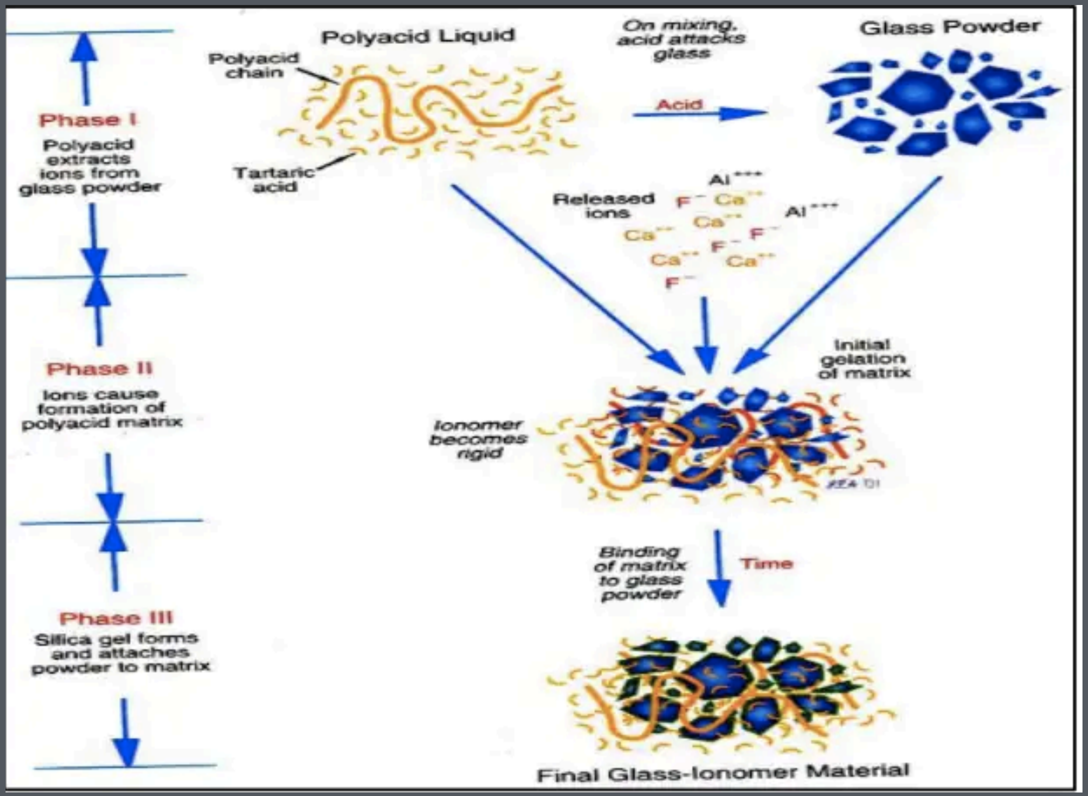
Glass-Ionomer Cement-Chemistry and Setting

The polyacrylic acid chains crosslink with the calcium ions and aluminum ions. Sodium and fluorine ions of the glass do not participate in the crosslinking of the cement. The set GIC consists of undissolved glass particles with a silica gel coating, embedded in anamorphous matrix of hydrated calcium and aluminum polysalts containing fluoride ions.



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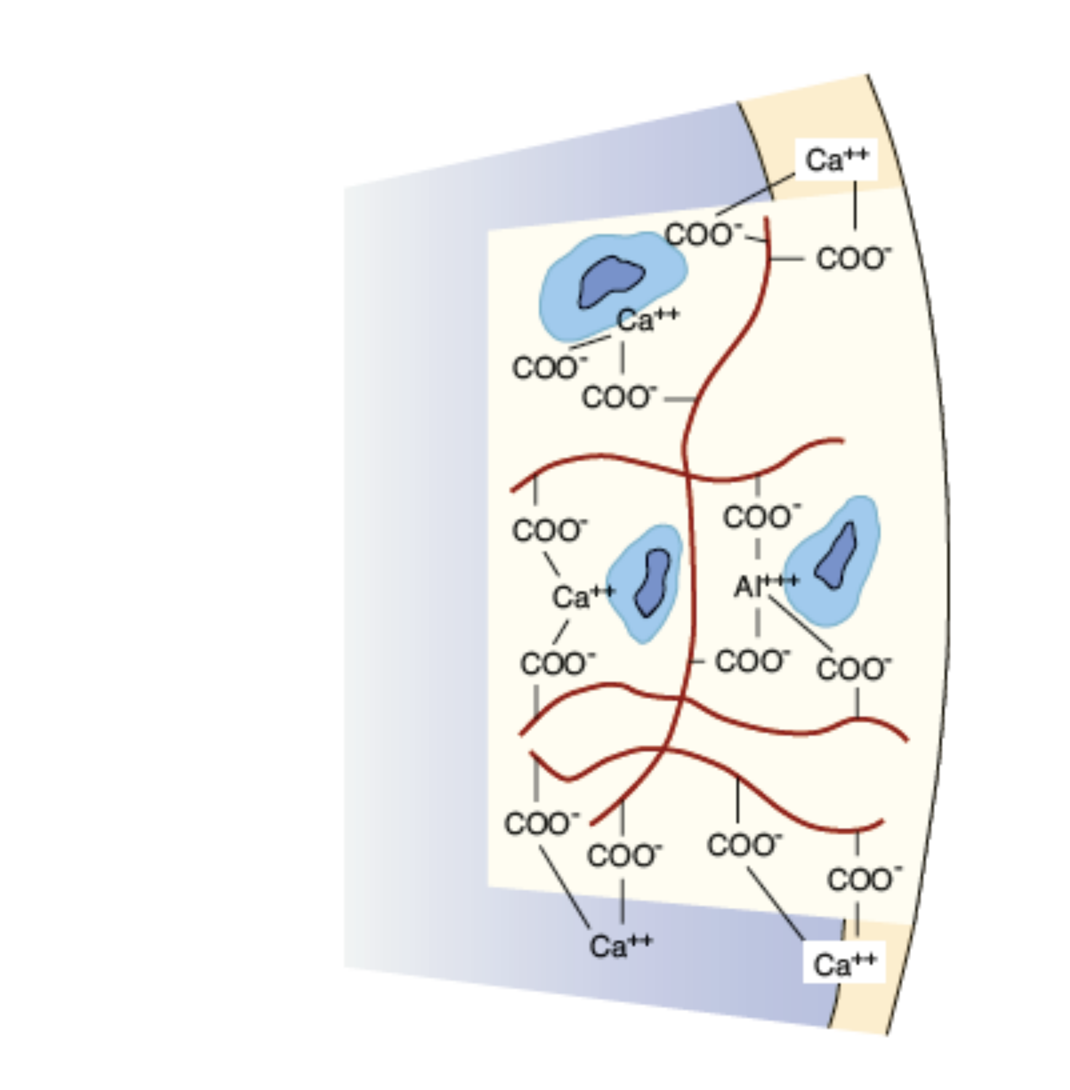
Glass-Ionomer Cement

Glass ionomers bond to tooth structure by chelation of the carboxyl groups of the polyacrylic acids with the calcium in the apatite of the enamel and dentin.



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Metal-Reinforced Glass-Ionomer Cement

- Metal powders have been incorporated into glass-ionomer cements with the objective of faster setting and perhaps replacing amalgam.
- The metallic fillers can be silver alloy powder, such as the alloys used in amalgams, termed alloy admix, or particles of silver sintered to glass, known as cermet.

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Metal-Reinforced Glass-Ionomer Cement

- **Metal Metal fillers make the GIC grayish but more radiopaque.**

- **More fluoride is released from the admix type because the alloy particles are not bonded to the glass. Less fluoride is released from GI cermet because a portion of the glass particle is coated with metal.**

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High-Viscosity Glass-Ionomer Cement

- Atraumatic restorative treatment (ART) is a preventive and restorative caries-management concept developed for dentistry in regions of the world that do not have infrastructure such as electricity or piped water systems.

- Glass-ionomer cements are a natural choice for ART because of their adhesion and fluoride release. High-viscosity GICs have been developed for this purpose with smaller particle sizes and using a higher P/L ratio, which increases the compressive strength

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Fluoride Release from Glass-Ionomer Cement

TABLE 7-7 Cumulative Fluoride Release From Various Glass-Ionomer Products

	FLUORIDE RELEASED (µg)	
Cement Type	14 Days	30 Days
Cermet	200	300
Type II glass ionomer	440	650
Type I glass ionomer	470	700
Glass-ionomer liner (conventional)	1000	1300
Glass-ionomer liner (light-cured)	1200	1600
Alloy admix glass ionomer (silver alloy admix)	3350	4040

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Properties of Glass-Ionomer Cement

TABLE 7-8 Properties of Restorative Glass-Ionomer Cements

	Compressive Strength (MPa)	Diametral Tensile Strength (MPa)	Hardness (KHN)
Glass ionomer (Type II)	196–251	18–26	87–177
Cermet	176–212	19–22	30–45
High-viscosity glass ionomer	301	24	108
Hybrid ionomer	202–306	20–48	64–85

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Properties of Glass-Ionomer Cement

TABLE 7-9 Fracture Toughness of Glass-Ionomer Materials and Selected Restorative Materials

Type of Material	Fracture Toughness ($MPa\cdot m^{1/2}$)
Conventional GIC (luting)[3]	0.27–0.37
Metal-modified GIC (admixed)[5]	0.30
Metal-modified GIC (cermet)[5]	0.51
High-viscosity GIC[6]	0.45–0.72
Conventional GIC (restoration)[4]	0.72
Resin-modified GIC (luting)[3]	0.79–1.08
Compomer (restoration)[2]	0.97–1.23
Resin cement[3]	1.30
Resin-modified GIC (restoration)[5]	1.37
Amalgam[1]	0.97–1.60
Hybrid composite[2]	1.75–1.92

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Resin-Modified Glass-Ionomer Cement

- RMGIs are also referred to as hybrid ionomers

- These cements contain water-soluble polymerizable monomers in a liquid, usually a water solution of polyacrylic acid, 2-hydroxyethyl methacrylate (HEMA), and polyacrylic acid–modified methacrylate. Catalysts, such as diphenyliodonium chloride (DPICI), are included. This type of cement has a longer working time and is less sensitive to water contamination than conventional glass-ionomer cement.

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Resin-Modified Glass-Ionomer Cement

- The monomers in hybrid glass-ionomer cements make the cements more translucent than glass ionomer and therefore more suitable for restorative indications.
- The fluoride release and the higher diametral tensile strengths over glass-ionomer cements make the hybrid GICs more desirable for restoratives.
- The hybrid ionomers have a higher tensile strength that is attributed to their lower elastic modulus imparted by the resin component.

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Resin-Modified Glass-Ionomer Cement

- **As a powder–liquid system, the liquid component comprises lower water and carboxylic acid contents than that of GIC**
- **The powder contains fluoroaluminosilicate glass particles and initiators for light curing and/or chemical curing monomers in the liquid**

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Resin-Modified Glass-Ionomer Cement

- The incorporation of polymerization of the methacrylate groups makes RMGI a dual-cured cement

- The acid–base reaction begins upon mixing but continues after the monomer polymerizes.

- A tri-cured cement has both chemical and light activation that are included with the hybrid cement.

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Resin-Modified Glass-Ionomer Cement

- **The carboxylate groups in hybrid ionomer cements bond to tooth structure as in other GICs, and the monomers form an amorphous layer at the cement–dentin interface, with some resin infiltration into the etched dentin for added adhesion.**

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Resin-Modified Glass-Ionomer Cement

- **Higher bond strengths have been measured for hybrid ionomer cements than for conventional glass ionomers.**
- **The higher bonding to teeth may occur because of better micromechanical interlocking to a roughened tooth surface**
- **The adhesion of the GIC component of hybrid ionomers to dentin reduces the probability of gap formation at gingival margins. This feature helps compensate for the polymerization shrinkage of an overlying resin composite restoration placed on a hybrid ionomer cavity base.**

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Resin-Modified Glass-Ionomer Cement

- **Some hybrid ionomer cements are marketed based on the unique filler properties and their ability to flow or to not flow, the latter allowing "stacking." Marketing terms such as "S-PRG" and "Giomer" are unique terms from manufacturers that indicate a glass-ionomer filler.**

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Resin-Modified Glass-Ionomer Cement

- **Some hybrid ionomer cements also contain nonreactive filler particles, which lengthen the working time, improve the early strength, and reduce sensitivity to moisture during setting.**

- **The use of nonreactive filler particles along with less carboxylic acid available for bonding to tooth structure; therefore a dentin bonding system is needed.**

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Resin-Compomer (polyacid modified composite resin)

- Compomer is a light-cured material that integrates the fluoridereleasing capability of glass ionomers with the durability of composite resins in a one-paste restorative resin.

- As a restoration, compomer restorations perform better than resin-modified glass ionomers but are inferior to hybrid composites.

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Resin-Compomer (polyacid modified composite resin)

- They contain nonreactive inorganic filler particles, reactive silicate glass particles, sodium fluoride, a polyacid-modified monomer (e.g., di-ester of 2-hydroxyl methacrylate with butane carboxylic acid [TCB]), and photo activators.
- Compomers are usually one-paste materials for restorative applications

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Resin-Compomer (polyacid modified composite resin)

- **Single-component compomer cements are water-free and are packaged in moisture-resistant blister packs**

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Resin-Compomer (polyacid modified composite resin)

- **Compomers set by a polymerization reaction, and then absorb water from the saliva to initiate the slow acid-base reaction between the acidic functional groups and silicate glass particles.**

- **The product of the acid–base reaction becomes the source of fluoride release. However, restorative compomers release less fluoride than GICs and hybrid ionomers.**

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Resin-Compomer (polyacid modified composite resin)

- Compomer pastes require a dentin-bonding agent prior to their placement as a restorative because they do not contain water to be self-adhesive like GICs or hybrid ionomers. The tooth structure should be etched and followed by the dentin-bonding agent before placing the compomer.

- The bond strength of paste compomers to tooth structure using a dentin-bonding agent is like that of hybrid ionomers.

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