Dentin substitute materials in the restorative dentistry - A comprehensive update

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Abstract
The dentin substitutes are the dentin like materials which have a similar properties as that of the normal dentin structure. The ideal dentin substitutive material should be bio-compatible, impermeable to the oral fluids, antibacterial, should induce hard tissue formation, dimensionally stable and economical. The different materials were used as the dentin substitutive material in the past such as the calcium hydroxide and glass ionomer materials. However, with the advancements in the dental material sciences various other materials such as the mineral trioxide aggregate, biodentin, smart dentin replacement, bioactive glass were introduced into the restorative dentistry. The present review summarizes the chemical and mechanical properties and various clinical applications of dentin substitutive materials.

Keywords: Mineral trioxide aggregate, Biodentin, Smart dentin replacement.

Introduction
Dental caries is one of the very common oral disease affecting the enamel and underlying dentinal tissues.[1] The rehabilitation of the carious teeth with an appropriate dental material with properties similar tooth structure is very important for efficient masticatory functions. The advancements in the dental material sciences have led to the development of materials with a similar properties as that of dentin and enamel.[2] In such a context, dentin substitute materials were developed which have properties similar to that of dentin structure. The ideal dentin substitutive material should be bio-compatible, impermeable to the oral fluids, antibacterial, should induce hard tissue formation, dimensionally stable and economical.[3]

The history of dentin substitute materials start from the calcium hydroxide, where it has the ability to form the reparative dentin which makes this material as the gold standard for dentin replacement.[4] Later, Glass ionomer cements (GIC) were introduces, which has changed the era of restorative dentistry. The chemical adhesion with the tooth structure and the fluoride release properties makes this cement as ideal material for dentin replacement.[5] Later, the GIC materials were modified in different ways to improve the physical and mechanical properties and to withstand the occlusal forces in the posterior teeth.[6]

Recently, different newer dentin substitutive materials were introduced with improved mechanical and functional properties. The Biodentin, Smart dentin replacement materials (SDR) and Bio-active glass were few among them.[7-9] The present literature review discusses various dentin substitutive materials, their mechanical and physical properties, advantages and disadvantages in the restorative dentistry.

Calcium Hydroxide
Calcium hydroxide is probably one of the oldest dentine substitutes that one can account. Herman first demonstrated the formation of dentinal bridge in a exposed pulpal surface in response to calcium hydroxide material.[4] Calcium hydroxide is a strong base with high pH of 12.5 and a solubility of 1.2 gram per litre at a temperature of 25 degree centigrade.[4] Calcium hydroxide increases the local pH at the site of its placement which results in irritation of pulpal tissues, thus initiating the dentinal repair. The dentinal repair is enhanced by the bioactive molecules as Transforming growth factor and Bone morphogenic protein.[10] Thus this induction of mineralization is due to highly alkaline pH of CH.[10]

Calcium hydroxide has very good antibacterial properties and it can be used as a direct pulp capping agent. It was reported that, there was a hundred percent reduction in microorganisms associated with pulpal infections after calcium hydroxide application. It has the ability to stimulate reparative dentin formation and to effect pulpal repair are its other well-known advantages.[11] CH has few disadvantages such as inadequate strength, lack of long-term solubility, lack of chemical and mechanical adhesion to the surrounding tissues, poor seal, accelerated degradation after being acid etched during bonding procedures, and tunnel formation in the dentinal bridge formed.[12]

Glass Ionomer Cement
Glass Ionomer cements (GIC) were derived from binary compound like polyacrylic acid and glass element such as fluoroaluminosilicates. The chemical reaction of glass ionomer cements is accelerated with the release of metallic ions. The slow release of aluminum ions is responsible for increased strength after few days of final set in conventional GICs.[13] Earlier, different varieties of GICs with high molecular weight and fast setting properties were available which were used as long term restorative materials in high stress bearing areas. The fast setting properties are due to the presence of finer glass particles and high molecular weight polyacrylic acids and different powder liquid mixing ratios.[5]

In 1992, resin modified glass ionomer cements (RMGIC) were introduced as hybrid ionomers. The setting of RMGIC is aided by both acid base reaction and amine peroxide chemical reaction. The polymerizable methacrylates with a photo-initiator aids in the light induced setting reaction of RMGICs.[14] One of the biggest advantage of GICs is the fluoride release from the set material.[6] The calcium ions from the tooth reacts with the acids in the GIC and form the final set material.[14] The electrical equilibrium was maintained by the displacement of calcium ions by the phosphate ions which result in the formation of ion enriched layer over the tooth. The acid base reaction resolves the tooth surface allowing the penetration of the glass ionomer cement gel. After the final set, interpenetrated poly-alkenoic particles linked with the tooth surface and then followed by creating a hybrid layer of GIC with mineral apatite of the dentin.[5]

The tooth bonding GICs explained in the theory seals the cavity protects the pulp, removes secondary caries and prevents leakage ant the margin. When compared to the other materials, the shear bond strength of the conventional RMGICs is relatively low in conditioned enamel and dentin.[15] As there is no polymerization in the setting reaction of GICs, they are more dimensionally stable when compared to the conventional resin restorations.[16] GICs can be used as restorative materials, luting cements, sealant materials and as a base or liner materials. GICs can be used as a liner materials beneath the composite materials where the GICs act as a dentine substitute material beneath the composites.[17]

Mineral Trioxide Aggregate (MTA)

MTA is a bioactive salt cement material which is widely used as a pulp capping material in restorative procedures.[18] MTA has very tiny particle size, waterproofing ability, alkaline pH after setting and also shows slow release of the calcium ions. It was reported that MTA induces proliferation of the pulpal cells, release of the cytokines and induce hard tissue formation which resembles the composition of normal hydroxyapatite structures.[19] MTA is non-absorbable material, sets with the moisture, it has high compressive strength and a high alkaline pH. The high alkalinity of MTA, calcium release and sustained pH of 12.5 most likely prevents microbial growth that were left after caries excavation. The high pH after setting of MTA, extracts growth factors from adjacent dentin structure which is responsible for promoting dentin bridge formation.[19] In addition, when MTA comes in contact with tissue fluids, it generates a reactionary interfacial layer of hydroxyapatite crystals by the release of calcium ions on its surface, and their presence also may contribute to reparative dentin formation.[20] Throughout the dentin formation, these cells characterized by synthesis associate degreed secretion of numerous non-collagenous proteins in an extra-cellullar scleroprotein matrix that finally mineralizes in the absence of bacterial microleakage.[21]

Biodentin

Biodentin is used as a dentin substitute materials in direct and indirect pulp capping procedures in restorative dentistry. The reparative dentin formation, antibacterial and mechanical properties of Biodentin made it a rapidly improving dentin substitute material in the recent times.[9] Biodentine consist of tricalcium silicate and zirconium oxide as main components. Biodentin aids in the formation of homogeneous dentinal bridge at the pulpal exposure in direct pulp capping procedures.

The pulp vitality after direct pulp capping with Biodentin can be maintained because of reparative dentin formation and anti-bacterial properties.[8] The anti-bacterial properties were developed from the alkaline environment and the release of growth factors aid in the reparative dentin formation.[22] The mechanical properties of Biodentin are similar to the dentin when compared to other materials which aids in the use as a base material beneath the composite resins or as a core buildup materials in vital teeth.[23]

Smart Dentin Replacement (SDR)

SDR is the first posterior composites, which can be used as a dentin substitute material in restorative dentistry. SDR can be restored in the cavities as a four millimeter thickness and can be light cured at once. It can also be used as a base material in the class I or Class II cavities beneath the traditional enamel or dentin adhesives. The main advantages of SDR is the aesthetic rehabilitation of posterior teeth in an economic way.[24] The SDR also has the ideal mechanical and physical properties to use as a bulk fill flowable base as well.[25] The SDR aid in time saving restorations when compared to the conventional composites. It also aids in optimal adaptation to the cavity walls. It is also compatible with the methacrylate adhesives which are very widely used in the restorative dentistry.[25]

Bioactive Glass

Bioactive glass is formed from compounds like silicon oxide, phosphorus oxide and appears like small grained glass powder. Bioactive glass is enormously laborious and stiff, and it replace a number of inert glass fillers that square measure presently mixed with polymers to form a novel composite tooth fillings.[7] Bioactive glass can aid in prolonging the durability of restorations, because the penetration depth of microorganisms into the tooth restoration interface is considerably smaller than for the conventional composites. Restorations with bioactive glass tend to slow down the secondary dental caries, and further release some minerals that facilitate the re-mineralization of the lost dentinal structures.[26]

Conclusion

Dentin substitutes have dentin like mechanical and physical properties which can be used for the rehabilitation of dentin structure. The dentin substitutes should be bio-compatible, impermeable, anti-bacterial, regenerative, non-absorbable and easy manipulative. The recently introduced materials such as the bio-dentin and smart dentin replacement materials nearly considered as the ideal dentin substitutive materials in restorative dentistry.

Conflict of Interest: None.

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How to cite this article: Chugh VK Chugh A, Patnana AK, Choudhari A. Dentin substitute materials in the restorative dentistry - A comprehensive update. *Indian J Anat Surg Head Neck Brain* 2019;5(2):37-9.