Effects of Temperature on Mechanical Properties of Dental Restoration - A Review

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Abstract

The aim of the review was to determine the effect of temperature on mechanical properties of dental restoration in the oral environment . Dental restorative materials are exposed to temperature ranging from ten degree to five degree celsius, since the properties of dental material are sensitive to temperature of this magnitude it is important to define the effect of services temperature on the mechanical properties of dental composites. Increase in the mechanical properties of compressive strength, diametral tensile strength, compressive elastic modulus and hardness for all investigated composites with increase of temperature. The mechanical properties of nanohybrid composites were less sensitive to temperature change. Ultimate strength decreases linearly increasing temperature strength is higher for the lower volume fraction material and is decreased by the presence of a small percentage of very large particles. Elastic modulus and yield strength decrease sigmoidally with increasing temperature and depends only on particle volume fraction. In the clinically significant temperature range ultimately decreases to 14%,the decrease in elastic modulus is either 6 or 11% and yield strength decreases to 45%. Dental restoration like gold, silver amalgam are often unaffected even after prolonged exposure to fire. Dental tissues and restoration can undergo a series of changes which correlate with temperature to which they are exposed. The temperature condition of the oral environment can significantly affect the mechanical properties of dental restorative materials.

Keywords: *Dental restoration;; effective temperature; gold amalgam; mechanical property; resin composites.*

Introduction

A dental restoration or dental filling is a treatment to restore the function integrity,and morphology of missing tooth structure resulting from caries or external trauma as well as to the replacement of such structure supported by dental implants . The variation in the oral environment can affect the mechanical properties of dental restorative materials. Eating hot or cold foods and drinking beverages are the causes of the most extreme temperature variation in the oral cavity. In addition to the temperature variations in oral condition,water or other liquids such as saliva,beverages or components may influence their mechanical properties. [1 2 3].The mechanical instrumentation may not be sufficient to remove bacteria from root canals owing to complex anatomy. The mechanical properties such as modulus of elasticity, stress, strength, toughness, brittleness, fatigue. The mechanical properties of the dental composites temperature from 5 to 50 degree celsius. dental restorative materials undergo a series of changes which are corrected well with a varying temperature to which they were exposed.[4 5]. Heat induced alteration to dental and restorative materials can be of great interest to forensic dentistry. Knowing the specific optical behaviour of dental materials can be of high importance

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as recognition of changes induced by high temperature can lead to the determination of material which was used in dental restoration. Dental avulsion is a type of traumatic tooth injury because it causes damage to several structures and results in the complete displacement of the tooth from its socket in the alveolar bone.[6 7] The aim of the study was to determine the effect of temperature on mechanical properties of dental restoration.

Materials and Methods

The literature review was carried out from Scopus and pubmed databases from 2000 till date. Five step process involved in selection of articles. They are identification of relevant articles, section of articles, data extraction and charting and final analysis and report. Recent similar, relevant publications are taken into account for the collection of knowledge and to get clear about it. Articles collected through Medline-embrace, cochrane library. Number.of. Articles-39.

MECHANICAL PROPERTIES

Mechanical properties of importance to dentistry include brittleness compressive strength, ,ductility , elastic modulus, fatigue limit , flexural modulus, flexural strength, fracture toughness, hardness, impact strength, malleability, percent elongation,poisonous ratio , proportional limit , shear modulus, shear strength, tensile strength, torsional strength,yield strength and young's modulus. Dental caries is the most common cause for the loss of enamel in a clinical situation and it is easily detectable. [8 9]. Mechanical properties are defined by law of mechanics that is the physical science dealing with forces that act on bodies and the resultant motion, deformation or stress that those bodies experience when force acts on the body tending to produce deformation. Their resistance developed within the body to the external force.the internal resistance the body to the external force is called stress. Mechanical properties and parameters that are measures of the elastic strain or plastic strain behaviour of dental material include elastic modulus also called young's modulus. Pulp canal obliteration is characterized by deposition of hard tissue within root canal space and yellow discoloration due to change mechanical properties.[10 11]. Strain is expressed as change in length per unit length of the body. When a stress is applied ductility is the ability of material to withstand permanent deformation under a tensile load without rupture.young's modulus is the ratio of stress to strain proportional limit Is greatest stress that may be produce in a material such that stress is directly proportional to strain. [12 13]

MECHANICAL PROPERTIES OF GOLD

The available restorative material, direct filling gold is the gold filling material that is still used in restorative dentistry while most of the metals can be welded and alloyed at a temperature above the temperature [14 15] .The pure gold can be cold welded. Malleability exceeds all other metals it may be reduced by beating to sheets of 1/250,000 of an inch in thickness.ductility Is most ductile of all metals.the importance of minimum requirement for the mechanical properties of dental gold alloy arises from the large stress. Advantages are strength, maintaining high polish,perfect adaptation to cavity walls because of ductility insoluble in oral fluids. Disadvantages are inharmonious color can lead to sensitivity to hot and cold. It is not indicated on the subject of stress of mastication.[16 17 18]

MECHANICAL PROPERTIES OF AMALGAM

Amalgam is strongest in compression and weaker in tension and shear. The compressive strength of a satisfactory amalgam restoration should be at least 310 MPa. Creep is a slow change in shape caused by compression due to dynamic intraoral stress. The rate at which amalgam develops strength is an important characteristic. Amalgam is much weaker in tension. Tensile strengths of amalgam are only a fraction of their compressive strength cavity design that should be constructed to reduce tensile stress resulting from biting forces. High early tensile strength is important to resist fracture by biting forces.[19 20]. The effects of porosity facilitate stress concentration. Propagation of crack corrosion and fatigue failure of amalgam restoration. Modulus of elasticity in high copper alloys tends to be stiffer than low copper alloys, when rate of loading increases, values of approximately 62 GPa have been obtained. 380 MPa for low copper amalgam, 414 MPa for high copper amalgam. Dentin has a relatively low elastic modulus and as much tooth structure as possible should be preserved to prevent the dentin from bending which allows amalgam to bend and for tensile stresses to develop. Amalgam cannot withstand high tensile strength. There is danger that will be flexed with tension.

The effect of the mercury content upon the compressive strength of amalgam. Dental amalgam is an alloy made by mixing mercury with a silver tin alloy. Silver tin alloy to which varying amounts of copper and zinc has been added.[21 22 23] Advantages are easy to manipulate,wear resistant,well condensed and amalgam has good comprehensive strength. Disadvantages are unnatural appearance ,tarnish and corrosion, lack of mechanical adhesion to the tooth structure [24].

MECHANICAL PROPERTIES OF RESIN COMPOSITE

Resin composites are the material of first choice for anterior and posterior dental restoration due to their excellent optical properties associated with adequate mechanical properties. Strongly depends on some factors, such as filter content, integrity of the organic to filters, adhesion. Porosity percentage of the cured material and on the oral environment. Strength of composite depends on the ability of the coupling agent to transfer stresses. The crack propagates to a bonded filter, the crack must pass around the particle since it is stronger than the matrix and the interfacial bond. [25 26]. The final stiffness or rigidity of a resin composite may play a compensating role in coping with polymerization stress. Thick resin layer stacking of this layer provides sufficient elasticity to relieve stress of resin composite. There is no correlation between fracture toughness and filter content by volume of flowable composite but hardness and fracture toughness tend to be linearly proportional to filter of fracture toughness values.Advantages are mechanical properties than traditional and microfilled composites, wear resistance, high compressive strength, high modulus of elasticity. Disadvantages are heavy metal glass filters are softer and prone to hydrolysis so long term durability of these resins lowered.[27 28]

MECHANICAL PROPERTIES OF GLASS IONOMER CEMENT

Strength has both tensile and compressive strength is greater than conventional glass ionomer cement. Compressive strength is fairly high up to 200 MPa. Flexural strength is fairly low 5 to 40 MPa and shear strength is fairly low, 3 to 5 MPa. Coefficient of thermal expansion similar to tooth structure. Dimensional changes shrink on setting, expand with water absorption. Abrasion resistance is greater than conventional glass ionomer cement due to silver particles incorporation. Modulus of elasticity tends to be relatively lower than conventional glass ionomer cement.[29 30]. Advantages are inherent adhesion to the tooth surface, coefficient of thermal expansion similar to tooth structure and low thermal conductivity. Disadvantages are opacity in glass ionomers cement is higher than resin and less polishability than resin. It also has poor wear resistance and poor tensile strength.[31]

EFFECTS OF TEMPERATURE

Dental restoration the amalgama at 200 degree Celsius and 400 degree Celsius. Lost its shine due to mercury operation and showed an opaque black colour from 600 degree celsius[32 33].At higher temperature silver metallic shine on the roots probably due to mercury decomposition, the pink pigments root and crown between 1000 degree celsius and 1100 degree Celsius. [34] The composite Restoration turned to a bright brown colour with white veins at 400 degree Celsius and increased its shine. [35 36]. Resin composite is used for class 2 fracture. At 600 degree Celsius resin change to grayish black colour. At 200 degree Celsius the amalgam and composite filling should be a marginal contraction probably due to the evaporation of the mercury loss of the organic matrix.[37 38 39]

Conclusion

In the oral environment, dental restorative materials are usually exposed to temperatures ranging from 10” to 50°C. High temperatures reduce the stiffness. Low temperature increases the stiffness. Higher annealing temperatures cause mechanical properties of amalgam to deteriorate. With the help of the review, we are able to conclude that temperature can significantly affect the mechanical properties of dental restoration.

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Ethical Clearance: As it is a review article so it is not required.

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