Lec. 1 # *Dental Materials* **Dr. Aula Kamal**

Dental Materials: It is the science which deals with the materials used in dentistry, their physical, mechanical & chemical properties and with their manipulation as such properties are related to proper selection and use by the dentist.

Dentistry started since the Christian era, gold bands and wires were used by the Phoenician for the construction of partial dentures. It is evident that many of the restorative and accessory materials of today have been in use for quite some time ago.

In the middle of the nineteenth century, research studies on AMALGAM were done by G.V Black. Later on the American dental association determined the physical and chemical properties of dental materials and the development of new dental materials, instruments & test methods, the primary of it is to formulate standards or specification for dental materials and to specify the products which meet those requirements.

The objective for this course is to learn the physical, chemical and mechanical properties of some dental materials and their manipulation in order to understand the behavior of these materials and how to use them to their best advantages.

General Properties of Dental Materials

All materials have physical properties like color, weight, solubility, thermal conductivity & others, also mechanical properties like hardness or softness, strength or weakness. There is no material till now which has ideal physical & mechanical properties. Most materials have some good & bad properties & sometime a property that is bad in one material may be good or acceptable in another.

Physical Properties

1. Linear Coefficient of Thermal Expansion & Contraction:

As the temperature rises, a solid material will expand & on cooling it will contract, this is measured by the linear coefficient of thermal expansion and contraction which is the change in length per unit length for 1C temperature change.

α: coefficient of thermal expansion or contraction

$$\alpha = \frac{\text{final length} - \text{original length (cm)}}{\text{Original length} * \text{temp. change (cm.c)}}$$

Clinical importance in Dentistry:

Close matching of the coefficient of thermal expansion (α) is important between:

1-The *tooth* and the *restorative materials* to prevent *marginal leakage*:

Filling materials should have the same coefficient as the tooth, if it dose not, it will press too hard against the cavity wall on expansion & may cause pressure on the pulp, or pull away from the wall when chilled by cold water. The later effect will cause the filling to leak temporarily, which may in turn, lead to further caries. Opening and closing of gap results in → breakage of marginal seal between the filling and the cavity wall, this breakage of seal leads to:

i. Marginal leakage ii. Discoloration
iii. Recurrent caries iv. Hypersensitivity.

2-*Porcelain* and *metal* in ceramic - metal restorations (crowns and bridges) to provide metal ceramic bonding.

3-*Artificial tooth* and *denture base* to avoid crazing.

** Gold alloy is used to cast crown or bridge. After cooling of the gold from the melting temperature, it will contract & so the crown will be smaller. To compensate for this contraction, we use certain type of investment, which will expand the same amount.

Hard tooth structure has the smallest coefficient, metals are intermediate, and polymers have the largest.

Tooth = $11*10^{-6}$ cm/cm C^0

Gold = $14*10^{-6}$ cm/cm C^0

Impression compound = $250*10^{-6}$ cm/cm C^0

2. Thermal Conductivity (k):

It is the amount of heat in calories or joules passing per second through a body 1cm thick, $1cm^2$ cross sectional area when the temperature difference is 1°C.

Clinical importance in Dentistry:

1- Metallic filling materials. 2- Metallic denture base materials.

Generally, metals are better heat conductors than non-metals. Melting filling material like AMALGAM, sometimes cause pulp pain by transmitting heat or cold more than natural tooth especially in deep cavities thus they require heat insulting layer between the filling & the pulp. Here it is undesirable property on the other hand the thermal conductivity of metallic denture base material is an advantage as it gives feeling closer to the normal condition& the patient will feel normal also it will protect him from drinking very hot drinks which may burn his mouth.

3. Electrical Activity:

It is the ability of metals to ionize by losing electrons. If there is a high difference in the electrode potentials of two metals in contact with the same solution like gold and aluminum, an electrolytic cell may develop & the patient may feel discomfort.

***GALVANISM IN DENTISTRY*:** Phenomenon of electric cell and flow of electrons in oral cavity which is perceived by patient as pain or discomfort and metallic taste**.** Requires presence of two metals of different electric potential and an electrolyte (saliva).

4. Density:

Is the mass per unit volume. Lightness is nearly always an advantage in restorative materials, but sometimes TIN or LEAD is used inside full lower denture to make it heavy to control its mobility.

Gold= 14 gm/ cm3 Acrylic= 1.2 gm/cm3

Chromium/ cobalt= 8.3 gm/cm3 Water= 1 gm/cm3

5. Dimensional stability

Dental material should not change its dimensions during and after setting. Amalgam is filling material for posterior teeth; it may sometimes change shape permanently as a result of heavy biting force. This is bad property; on the other hand, the investment material that forms the mold for dental casting should expand for certain amount to compensate for the contraction of the molten metal after it is cooled from the molten stage.

Dimensional change occurs due to:

A- Water absorption: Dental material should not have high water absorption; because it will lead to dimensional changes and if water absorbed too great, it will lead to unhygienic condition. Some materials have absorption which extends to certain period of time, like acrylic which has absorption of 1.4%. But it continues for 24 hour only so water absorption should not continue for long time.

B- Solubility : Dental material should not be soluble in water and in oral fluids (*if it dissolved* in the mouth ,it should not release toxic substances) ,so it will not fill the cavity as a good felling material (e.g. composite anterior filling material has a solubility of 0.01%, while silicate has a solubility of 0.7 - 1.6%).

6. Cohesion:

Is the force which makes the molecules of the substance to hold together.

7. Adhesion:

Is the force which makes molecules of two or more different substances to hold together**.**

Optical Properties

Dental materials have to look like natural teeth and gum and should not stain or change color by time.

Translucency

Is a property of the material that allows the passage of light short away inside the material before being reflected back again.

Transparency

Is a property of the material that allows the passage of light in such a manner that little distortion takes place so that objects can be clearly seen through them.

Opacity

Is a property of the material that prevents the passage of light. Opaque material absorbs all of the light. Objects cannot be seen through them.

Complete Transmission	Transparent
Incomplete Transmission	Translucent
No Transmission (absorption)	Opaque

COLOR

It is the visible aspect of an object other than form and size.

A- Hue: It is the dominant wave length. It represents the color of the material, i.e yellow, green, red and blue.

B- Chroma: It represents the strength of the color or degree of saturation of the color (color intensity).

A beaker of water containing one drop of colorant is lower in chroma than a beaker of water containing ten drops of the same colorant.

C- Value.

Color sensitivity: Eye responds differently among individuals.

Color Vision: Normal is trichromatic vision. Some individuals may have color blindness and inability to distinguish certain colors.

Color Fatique(hue adaptation): Constant stimulus of one color decreases the response to that color.

Shade guide: Is used for color matching. So, it is important to match colors under appropriate conditions.

Metamerism: Two objects that are matched in color under one light source but are not matched under other light sources form metameric pair.

Surrounding: Colors of wall, lips or clothes of the patient modify the type of light reaching the object. Avoid colored and inclined walls, Cover patient's clothes if so bright. Remove lip sticks and heavy make up.

Biological Properties

Dental materials should be biocompatible,

–nontoxic for patient, dentist and staff.

–non irritating to oral cavity and tooth tissues.

–non allergenic.

–non mutagenic or carcinogenic.

Mechanical Properties

One of the most important properties of dental material is the ability to withstand the various mechanical forces placed on them during their use as restoration, impression, models, appliances & tools.

Strength: is the measure of the resistance of the material to the externally applied forces.

Types of strength:

1. Transverse Strength:

It is the strength of the middle of a beam which is supported only at its ends, it is important in dental bridges.

2. Fatigue Strength:

Occurs when the material constantly subjected to change in shape due to frequent application of force like clasp arm of partial denture.

3. Impact Strength:

It is the ability of the material to break on sudden impact. Low impact strength means brittle material, like dropping of the denture.

Stress: is the force per unit area induced in a body in response to some externally applied force. It is **force / area** measured in **Kg/ cm²** or **Pound/ inch²** or **Pascal**.

Strain: is the change in dimension per unit dimension caused by externally applied forces. It is a unit less quantity.

Strain= final length - original length / original length

**** Percentage of elongation= strain x 100%**

Types of Stress: Every stress is accompanied by a strain of the same type. There are different types of stresses according to the direction of the applied force.

A- Tensile stress: it is the force per unit area produced in the material in response to externally applied force which tends to stretch or elongate the material. Tensile stress is usually accompanied by tensile strain.

B- Compressive stress: it is the force per unit area induced in the material in response to externally applied force which tends to compress or shorten the material; it is usually accompanied by compressive strain. Investment materials, restorative materials & models should have high compressive strength.

C- Shear stress: it is the force per unit area induced in the material in response to externally applied force, one part of the force is in one direction while the other is in the opposite direction. *Shear force* is the force which cause tearing a paper or card. If one part of the crown is in occlusion while the rest is not, shear stress will develop. It is accompanied by shear strain.

Usually three types of stress occur at the same time, if a piece of metal is being bend it will exhibit tensile stress on the outer surface, compressive on the inner & shear in the middle.

Stress- Strain Curve:

Proportional limit: When a stress is applied to a material, the material will tend to deform (change in shape & dimension) in an amount proportional to the magnitude of applied stress. The greatest stress which may be produced in the material such that the stress is directly proportional to the strain. Its unit is the same of the stress.

Elastic deformation (elastic limit): The greatest stress to which the material can be subjected such that it will return to its original shape & dimension when the stress is removed.
If the stress is increase beyond the elastic limit or the proportional limit the material will deform & if we remove the stress the material will not return to its dimension, this is called **plastic deformation**.
If the stress is increased more& more the material will break.

Ultimate strength (point): It is the greatest stress which breaks the material (fracture).

Modulus of Elasticity: It is the constant of proportionality; it is when any stress value equal or less than the proportional limit is divided by its corresponding strain value. The unit is the same of that of stress
Y (Modulus of elasticity) = stress/ strain

Flexibility: The higher strain which occurs when the material is stressed to its proportional limit.

Stiffness: Is just the opposite to property of flexibility.

Ductility: It is the ability of the material to withstand permanent deformation under tensile stress without fracture; it depends on plasticity & tensile strength, it's the ability of the material to be drawn into a fine wire.

Brittleness: It is the opposite of ductility, it requires lack of plasticity.

Malleability: It is the ability of the material to withstand permanent deformation under compressive stress without fracture. It's the ability of the material to be drawn into sheet.

Toughness: It is the total work or energy required to break the material. It's the total area under the stress - strain curve. It requires strength & elasticity.

Resilience: The amount of energy absorbed by a structure when it is stressed within the proportional limit.

Hardness: It is the resistance of the material to deformation caused by penetrating or scratching the surface, it is done either by using steal ball (Brinell or Rocwell test) or using diamond ball (Vicker & Knoop test). The higher the number the harder the material.