History of Dental Materials

700 – 500 BC

Two teeth ligated with wire

Ancient Greeks
Etruscan Dentistry (Ancient Romans)

Etruscan appliance for supporting three artificial teeth, two of which were made of one ox tooth. (Civic Museum of Corneto.)
1st century AD  Celsus - Italian

- Use of lint, lead, & variety of other substances for filling carious teeth.

1480 Arculanus – Italian: 1st authentic record of gold fillings.

deVigo – Italian: Description of the removal of carious matter prior to gold placement.

1730 Fauchard – French: lead, tin, & gold for restorations. WHY use these metals?

1735 – removable prosthetic appliances.

1756 – use of plaster models (to enable better fit of prosthetics).
1775 – Artificial ivory teeth fixed into base with gold pins

Geo Washington’s dentures

1788 – Introduction of fused porcelain – very significant development WHY?

1805 – Gold points used to fill root canals – Endo!! - beginning to preserve not extract teeth.

1826 – developed “silver paste” - mix of silver & Hg. What is this mat’l called today??

1848 – Gutta percha used as a restorative material…. 35 years later……

1883 – Utilized as a root canal filler material – currently today!!!
Greene Vardiman Black, DDS

Numerous contributions to dentistry. Began the process of “standardization” - products being developed with specific properties & designed for a definite purpose.

Simple formula:

Specific materials properties + specific procedure of use = clinical success
Standards describe the properties of a product so that a user may select the proper material for a particular use.

If a product is used according to manufacturer’s directions – clinical success should be met.

In addition, advertising for products that have been awarded the ADA Seal is reviewed for truthfulness.
The Dental Specialties

- Endodontics
- Oral & Max Surgery
- Oral Path
- Dental Public Health
- Orthodontics
- Pediatric dentistry
- Prosthodontics
- Periodontics
- Oral & Max Radiology
What would be the characteristics of the IDEAL dental material???????

Is there an IDEAL dental material??????
Characteristics of Materials

Classes of Materials:
Metals, Ceramics, Polymers, Composites
- See handout
Dental Materials

Physical, Mechanical & Biological Properties
Physical Properties are based on the laws of physics that describe mass, energy, force, light, heat, electricity, and other physical phenomena. Examples are color, density, and thermal conductivity.
A. Electrical and Thermal Properties

1. Electrical Conduction – metals conduct electricity, generate electrical currents to pulp, causes pain.

Clinical situation:

a. Contact of dissimilar metals ex: gold & amalgam
b. Amalgam restoration within 1-2 mm of the pulp.

Prevention: Use of an insulating base (dental cement)

*Composite & ceramic restorations do not conduct elect. & do not need insulators
2. **Thermal Conduction** – metals conduct heat, stimulus to pulp, causes pain.

Clinical situation:
- large, deep amalgam restorations
- Metal crowns, bridgework

Prevention: Use of an insulating base (dental cement)
*Composite & ceramic restorations are not thermal conductors.*
3. **Coefficient of Thermal Expansion** – measurement of change in size in relation to change in temperature.

Situation: Consumption of food/beverage with temperature change greater or less than body/tooth temperature.  

- **Cold** – contracts  
- **Hot** – expands

Process is known as **percolation** which compromises the seal between tooth and restoration.

**Result:** tooth sensitivity & 2° decay; breakdown of adhesive bonds
B. Solubility and Sorption

1. Solubility
   a. All dental mat’ls are soluble to some extent (dissolve in water).
      - most soluble: polymers
      - least soluble: porcelain, ceramic
   b. Consequence: loss of molecule/ions may result in irritation to oral tissues.
   c. Benefit: release of fluoride ion from glass ionomer restor. producing a therapeutic effect.

2. Sorption
   a. Uptake of fluid by a mat’l.
   b. Consequence: discoloration of composite restorations.
   c. Benefit: swelling of polymeric mat’l to cause slow expansion & facilitate marginal adaption; improvement of the “seal” btw the tooth & restoration.
C. Adhesion and Cohesion

1. Adhesion: attraction between the molecules on two different surfaces. Achieved by chemical or mechanical means.

   Ex: cementing ortho bracket on tooth surface

2. Cohesion: attraction of molecules within a material.

   Ex: dental cement components:

   cement in tact & outline of bracket is visible
D. Viscosity and Wetting

1. Viscosity – flowage of a liquid material.
   - high viscosity has a high resistance to flow & less likely to spread out (wet) on a surface.
   - low viscosity – possible loss of control of mat’l placement.

2. Wetting – ability to spread out over a surface. (ex: paint vs. putty)
   - increases the contact area between two surfaces.

Ex: a.) Sealant mat’l – less viscous (thinner) to flow over (wet) & into the tooth’s pits & fissures.

b.) Composite restorations – more viscous (thicker) to be adapted within the prepared tooth and shaped anatomically.
E. Color and Esthetics – desirable to have esthetically acceptable restorations

1. Munsell – visual color measuring system

   3 indices:  
   a. Hue – dominate color of object: red, yellow, blue  
      Natural dentition = yellow range
   b. Value – lightness of color. Scale of 1 – 10 (1 = black + 10 = white)  
      Natural dentition = 6-8 range
   c. Chroma – intensity of color. Scale of 1 – 10 (1 = pale + 10 = saturated)  
      Natural dentition = 1-3 range

2. Translucency – light entering a tooth:

   a. Transmitted completely through
   b. Reflected – no penetration at all
   c. Scattered – absorbed

   Transparent – clear (glass)
   Opaque – totally absorbing light
F. Corrosion

1. Definition: surface & structural deterioration (irreversible)
2. Tarnish – surface discoloration only (reversible)
3. Dental metals corrode in warm, salty, acidic environments – oral cavity!!
   - exception – noble metals: gold.

1. Amalgam (silver filling) beginning to tarnish and corrode.

2. Cast gold restoration with smooth polished margins.
G. Density – amount of a mat’l in a given volume dependent on the type of atoms present, packing together of atoms + voids present within the material. As the atomic # increases, so does the density.

Ex: Mercury (80) vs. Sodium (11)

I. Hardness

1. Definition – ability of a mat’l to resist forces of indentation.

2. Hardness tests: Brinell (BHN) & Knoop (KHN) hardness numbers – assign hardness values to mat’ls. Ex: enamel = 350 KHN, porcelain = 500 KHN
J. Abrasion Resistance

Definition – wear resistance of opposing materials.

Ex: a.) Natural dentition opposing porcelain denture teeth or porcelain crown.
    b.) Polishing agents used on dentition.

Significance of Harness & Resistance clinically?
Antagonistic wear of opposing dentition
Mechanical Properties

Mechanical properties are a subgroup of physical properties. Mechanical properties describe a material's ability to resist forces. Mechanical properties are dependent on the amount of material and on the size and shape of the object. Examples are strength and stiffness.
A. Stress and Strain

1. Stress – force per area; materials response to a force to counter it.

   Types of force:
   
a. Tensile – pulling
   b. Compressive – crushing
   
c. Shear – sliding of top over bottom

d. Torsion – twisting

e. Bending – combination of tensile, compressive & shear forces

2. Strain – deformation or dimensional change due to applied force.
B. Resilience & Toughness

1. Resilience – amount of energy absorbable by a material & not deform.
   
   Ex: mouthguard while protecting dentition

2. Toughness – amount of force an object/mat’l can absorb up to the fracture point. The object/mat’l may or may not break/distort.
   
   Ex: crash helmet – head is protected – helmet may or may not distort/break.
C. Elastic modulus – ability to resist change in shape. Deformation occurs under stress, then resumes original configuration once stress is removed.

Ex: rubber band

D. Plastic deformation – permanently stretched out.

What happens to the rubber band with extended use?
E. **Ductility** – ability to withstand permanent deformation under tensile stress

Which type of action is this force??

F. **Malleability** – ability to withstand permanent deformation under compressive stress.

Which type of action is this force??

G. **Fracture toughness** – resistance to cracking

H. **Fatigue** – repeated application of stress that causes tiny cracks within a structure. Does not cause failure initially; however, the cracks spread & eventually the structure breaks. Important for predicting longevity.
I. Creep – gradual but permanent change in dimension under a constant load. Occurs with amalgam & plastic dental materials.

**Fig. 10-6** Schematic view of marginal ditching in an amalgam restoration, produced by creep and expansion elevating the margins of the amalgam, and functional stresses producing marginal fracture.
Biological Properties

Biologic properties of materials are the effects the materials have on living tissue. Dental materials must not cause local or systemic injury to oral or other tissues. For example, a crown should not irritate the gingiva, tongue, or buccal mucosa.
A. Microleakage – greatest deficiency of dental materials.

1. Interface – where the tooth & materials join; microleakage occurs between the restoration & tooth. Lacking a seal between the restoration & prepared tooth.

2. Outcome – fluids, microorganisms, & debris from the mouth penetrate the outer margins of the restoration (interface) & progress down the walls of the cavity preparation.

3. End result – recurrent caries, stain, pulpal sensitivity, or pulpal necrosis (death).
B. Temperature effects

1. Fluctuations (percolation) may crack restorative materials or produce dimensional change.

2. End result – possible pulpal sensitivity or $2^\circ$ decay.

3. Provisions must be made for pulpal protection by placing a layer of insulating cement under the restoration.
C. Galvanism

1. Caused by an electrical current that is created by two different metals contacting in the oral cavity.

2. End result – possible sensitivity, corrosion, discoloration of amalgam & gold, metallic taste.

3. Sited as possible cause of various diseases (oral cancer, ulcers, kidney dysfunction); remains controversial – little evidence supports this theory.
D. Toxic effect of materials

1. Acidity -
   a. dental cements – use of phosphoric acid liquid can result in pulpal irritation.

   b. sealants and bonding procedures utilize this acid as an etchant mat’l – can result in irritation to the oral tissues.

2. Setting of restorative materials can produce chemical reactions that can facilitate undesirable effects to the pulpal issue.

3. Non-irritating to the soft tissue – should not produce an allergic or sensitizing effect on any tissue. Ex: denture materials in contact with soft tissues.

Figure 1. Denture sore mouth.
Final thoughts -

Sec – 01 = Follow the directions provided in today’s class for lecture #2 & #3. Be prepared to work with that content in lecture #4. See you in class on 9-28-15 \textit{and} Remember to bring 3 different colored highlighters & a glue stick to class.

**Don’t forget to do your homework & hand it in the blue box in the Ms. Dunnigan’s office no later then 4:00PM on Tuesday, 9.8.15!**

Sec – 02 = See you next week. Don’t forget to do your homework. \textit{Remember to bring 3 different colored highlighters & a glue stick to next week’s class.}