LAB Manual

SKILLS LAB

WOMEN MEDICAL COLLEGE
A b b o t t a b a d

ABBOTTABAD

Created by:
Dept. Medical Education & Research (DME&R)

DENTAL MATERIALS

PREFACE

This book is a useful source of knowledge and information in the field of dental material science. It provides up- to-date information on materials that are used in the dental office and laboratory every day, emphasizing practical, clinical use, as well as the physical, chemical, and biological properties of materials. Clinical photographs illustrate the topics, and color plates are integrated close to related concepts as they are discussed in each chapter. Numerous boxes and tables throughout, summarize and illustrate fundamental concepts and compare characteristics and properties of various dental materials.

Content has been thoroughly updated to include information on the most current dental materials available. Revised artwork gives a fresh look, with high-quality illustrations and clinical photos to aid in the visualization of materials and procedures described. I have tried to cover all topics under the subject of dental materials and hence the complete syllabus is covered. The language of the text is clear, concise and easy to understand. This would be a beneficial book for all undergraduate students of dental sciences and a valuable addition to the library of any dentist.

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CONTENTS

Description:

The skills lab of Women Medical College was constructed in 2019; the purpose of the skills laboratory was to support the acquisition of clinical skills through hands-on training within a non-threatening environment.
Learners commonly practice the procedural skills' psychomotor component under the trainers' instruction, who have previously demonstrated the relevant skill. Subsequently, the skills are then performed by the learners themselves under supervision.

Aims and Objectives:

The core aim of the skills lab is to

1. Help undergraduate students and health professionals learn the correct steps and sequence for performing a skill.
2. It also helps to measure students' progress in learning as they gain confidence in the skill.
3. Ensure patient safety.
4. Using high-fidelity simulation devices such as partial-task trainers or full-body mannequins to practice and acquire psychomotor skills.

The mission of the laboratory is to promote clinical competence, ensure patient safety and enhance the skills of medical students (both undergraduate and postgraduate) during their training.

Faculty Responsible for Course Conduction:

Sr. No	Department	Designation
1.	Prof. Dr. Bilal zaman babar	HOD
2.	Dr. Ghazal	Senior Lecturer
3.	Dr. Zainab	Lecturer

Introduction to Sciences of Dental Material

Chapter 1

DENTAL BIOMATERIALS

A science that deals with the study of materials used in dentistry, which includes chemical properties, physical properties, manipulation and their applications in dental practice (Fig. 1.1).

Fig. 1.1: Lab analysis.

TYPES OF MATERIALS

Preventive Materials

Sealants, liners, bases

Restorative Materials

Silicate, GIC, composites, metallic inlays

Auxillary Materials

Impression materials, casts, waxes

OBJECTIVES OF THE DENTAL BIOMATERIAL SCIENCES ARE TO

- Know the proper usage of dental materials
- Know the physical and chemical properties of dental materials
- Understand proper manipulation of materials in dental profession
- Stimulate further research so we can further improve the quality of the material
- Introduce the students to the materials used in dentistry
- Bridge the gap between knowledge from chemistry, physics, etc. with dental materials
- Provide certain criteria on selection of facts and propaganda

GOAL OF DENTISTRY

Maintain or improve the quality of life of dental patients by preventing disease, relieving pain, improving mastication efficiency, enhancing speech and improving the general appearance of patients.

BRANCHES OF DENTISTRY ASSOCIATED WITH THE SUBJECT

Restorative Dentistry

- Branch of dentistry that deals with the prevention and treatment.
- Deals with the restoration of original function and color of natural teeth.

Prosthodontics

- Branch of dentistry that deals with the replacement of function and aesthetics.
- Three types of appliances are:
    - **Fixed Partial Denture**

      Replacement of a single tooth or a segment of teeth.

Characterization of Biomaterials in Relation to Dentistry

Chapter 2

INTRODUCTION

- Dental biomaterials are subjected to a very hostile environment, in which pH, salivary flow and mechanical loading fluctuate constantly and often rapidly. These challenges require substantial research and development to provide products for the clinician. Much of this is possible through the application of fundamental concepts of material sciences.
- Understanding properties of polymer ceramics and metal is crucial their selection and design in dental restorations. It is important to know the comparative values properties in different restorative material; it is also essential to know quality of the sup- porting and investing hard and soft tissue.
- The material properties are illustrated in (Fig. 2.1).

ATOMIC BUILDING BLOCKS

- All materials are built up from atoms and molecules, so it is not surprising that there is a close relationship between the atomic basis of a material and its properties.
- Important in this context are nature of the atoms and the ways in which they are arranged.
- When two atoms are brought together they link to form a molecule, and the bond that in formed between them is called primary bonding.

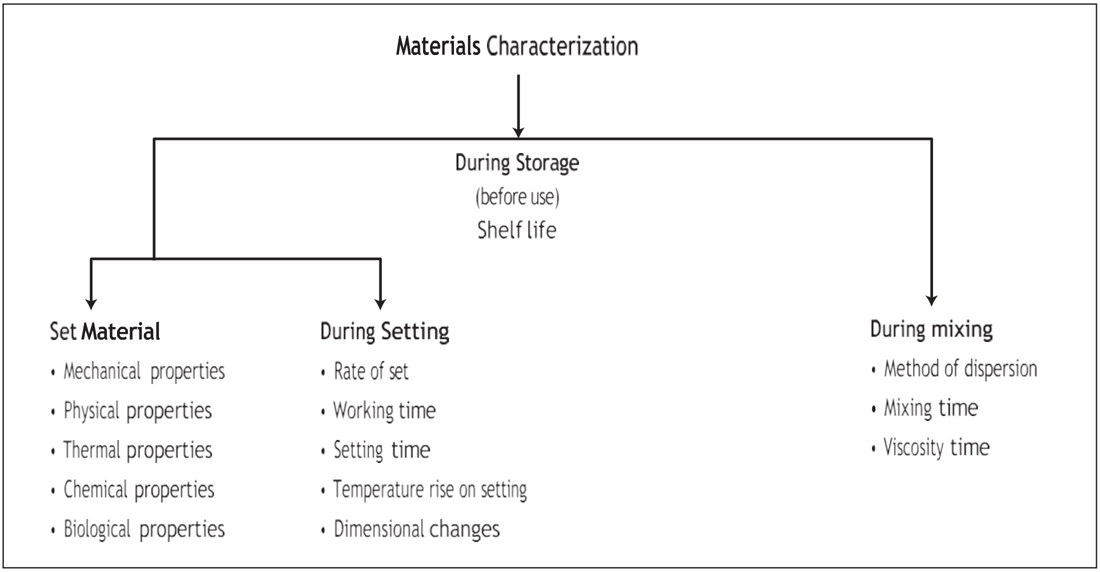


Fig. 2.1: Description of mechanical properties.

Chapter 3

Gypsum Products in Dentistry

INTRODUCTION

Gypsum is a mineral mined in various parts of the world and is also produced as a byproduct of fuel gas desulfurization in some of the coal-fired electric power plants. It is white powdery mineral with the chemical name calcium sulphate dihydrate ($CaSO_4.2H_2O$). Its product used in dentistry are based on calcium sulphate hemihydrates ($CaSO_4$. H_2O). Various crystalline forms of gypsum such as selenite and alabaster exist in nature (Fig. 3.1).

Fig. 3.1: Showing crystal form of gypsum.

Dental plaster, dental stone, high-strength dental stone and casting investment constitute gypsum products. They are *supplied as* hemihydrates powder that is produced by heating ground gypsum particles. When mixed with water the mixture reverts back to gypsum.

A mixture of plaster (gypsum product), lime and water is used in joining the stone blocks of ancient Egypt's pyramids. Gypsum and gypsum products are used today for many applications including building construction, soil conditioning, food additives, pharmaceutical uses, medical devices and dental applications. Main uses in dentistry include casts on models, dies and investments.

DENTAL CAST

It is dimensionally accurate positive replica of the teeth and the surrounding oral structures made by producing impression [negative replica] with a durable hard material (Fig. 3.2).

Fig. 3.2: Dental cast.

REQUIREMENTS OF DENTAL CAST MATERIAL

a. Should have good dimensional accuracy.
b. Should have adequate mechanical properties.
c. Should have good dimensional stability after setting.
d. Should be fluid at the time of pouring so that it gives fine details.

Dental Waxes

Chapter
4

INTRODUCTION

Dental waxes primarily consist of two or more components which may either be natural or synthetic waxes, resins, oils, fats and pigments. Appropriate blending of components is done to achieve desirable properties of the material for a specific application.

Waxes are thermoplastic materials which allow them to be moldable above a specific temperature and to be transformed into a solid state, when cooled. In other words, waxes remain solid at room temperature, but melt when temperature is increased without decomposition, to form mobile liquids. This thermoplastic proper- ty makes them handy for a range of applications in dentistry. Dental waxes have poor mechanical properties, but due to their thermoplastic nature they are commonly used to form wax patterns for dental appliances (e.g. dentures) before casting (shown in Fig. 4.1). Waxes are used in pattern formation of inlays, crowns, pontics, partial and complete dentures.

In dentistry, waxes usually serve the purpose of wax pattern construction. They may however aid in other procedures as well e.g., at the bite registration stage of complete denture fabrication and to record impression of edentulous areas.

CLASSIFICATION

Waxes can be classified in two ways:

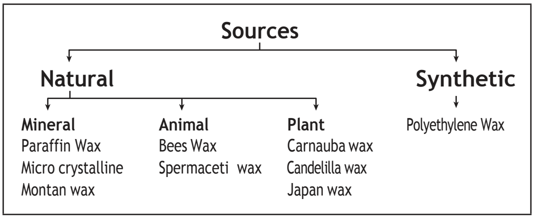
1. ACCORDING TO DENTAL USE

Pattern Waxes
Inlay wax
Casting wax
Modelling wax

Processing Waxes
Sticky wax
Carding Wax
Boxing wax

Bite Registration Waxes
Bite registration wax
Connective wax

2. ACCORDING TO SOURCES



WAX PATTERN

Wax patterns are formed on a stone model, die or on a prepared cavity in the mouth during fabrication of dental appliances. These patterns determine the final shape and size of the appliance or restoration being casted through a technique known as the *lost-wax technique*. In lost-wax technique, the wax is burned out or 'lost', leaving behind a space (mold) which is then replaced by polymer or alloy depending on the appliance under production, e.g. complete denture or a metal crown.

To carry out the lost-wax technique, waxes must exhibit few desirable characteristics as listed below:

1. Conforming to the exact contour of appliance that is being constructed.

Investment and Refractory Dies

Chapter

5

INTRODUCTION

- After the production of wax pattern (either direct or indirect methods), the wax pattern is embedded in an investment material.
- When the investment sets hard, the wax and sprue are removed either by softening or burning it with an alloy by using or ceramic casting technique.

TYPES OF WAX PATTERN

For acrylic dentures

- Wax pattern, in which the teeth have been setup, is embedded in a two-part mold, made up of either plaster of Paris or dental stones, or metal container which is known as 'Flask'.

  The wax is removed by boiling H_2O leaving the teeth embedded in the set gypsum.
- The space of wax is subsequently filled with the polymeric denture base material e.g. Acrylic Resin Material (Fig. 5.1).

For casting metals and alloys

- Wax pattern of an inlay or other casts restoration is embedded in a Heat-Resistant investment material, which is capable of setting to a hard mass as shown in Fig. 5.2 (a, b).
- The wax is removed from such mold usually by burning out or Lost Wax-Technique, then the space of wax is replaced by Molten Alloy.

DENTAL INVESTMENT MATERIAL

It is a ceramic based material which is suitable for forming a mold into which a metal or alloy is appropriately cast. Reason for reinforcing ceramic is to produce material which withstands high temperature associated with the casting procedure and not to chemically react with cast metal. The procedure for forming the mold is described as "investing".

Fig. 5.1: Showing packing of acrylic.

Fig. 5.2 (a): Showing investment procedure.

Application of Metals and Alloys in Dentistry

Chapter
6

CRYSTAL STRUCTURE OF METALS AND ALLOYS

INTRODUCTION

Metals are defined as "An opaque lustrous chemical substance which is a good conductor of heat and electricity and when polished is a good reflector of light". They are used not only as restorative materials but also as tools and in orthopedic surgeries.

They can be base metals or noble/inert metals. In dentistry most frequently used metals are:

1. NOBLE METALS

This group of metals consists of mainly anticorrosive metals. They are highly inert since they cannot form oxide layer. In case of gold the layer of oxide which forms is highly unstable.

Gold	Au	IB
Silver/Argentums	Ag	IB
Platinum Group metals	Pt	VIIIB

2. BASE METALS

Base metals are usually used with combination of other metals. These metals are prone to oxide layer formation which does not make them suitable for dental applications. Once oxide layer is formed these metals lose their integrity and become dangerous for dental applications. To increase their anticorrosion behavior they are used in combinations. e.g. Iron(Fe), Copper(Cu) etc.

CLASSIFICATION OF METALS

In existing elements found in periodic table; 70% are metals. They are classified in various types i.e. Alkali, alkaline earth metals, transition and rare earth metals.

1. ACCORDING TO THEIR COMPOSITION

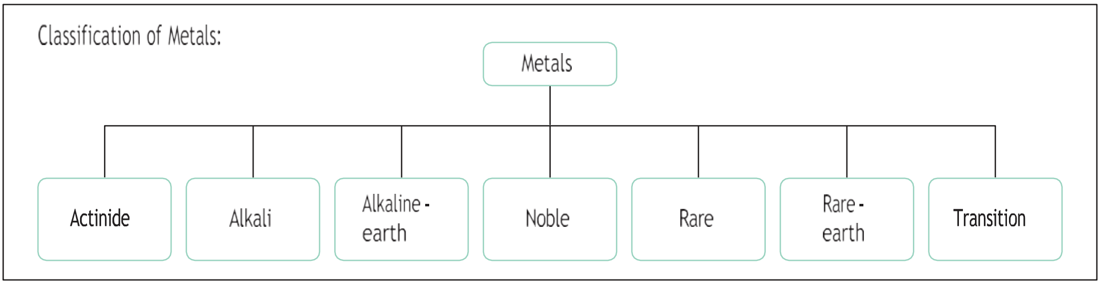
***Pure metals*:** Metals composed of only one metallic element. For example: gold, silver, iron, copper etc.

***Metal alloys*:** An alloy is a homogeneous combination of two or more metals. For example: bronze, brass, steel, etc.

2. ACCORDING TO THEIR IRON CONTENT

Ferrous: These are iron (the pure metal) or alloys that contain iron (steel and cast iron).

Non ferrous: These are pure metals which aren't iron (e.g. copper) or metal alloys that don't contain iron e.g. bronze, copper, aluminum, lead, zinc, tin, brass, titanium, chrome, silver, gold.



Casting Procedure for Dental Alloys

Chapter

7

CASTING

Casting is the process by which a wax pattern of a restoration is converted to a replicate in a dental alloy (Fig. 7.1). The casting process is used to make dental restorations such as inlays, onlays, crowns, bridges and removable partial dentures (Fig. 7.2).

In dentistry, all casting is done using same form or adaptation of the lost wax technique. The lost wax technique has been used for centuries but its use in dentistry was not common until 1907 when W.H. Taggart introduced his technique with the casting machine.

The process consists of surrounding the wax pattern with a mold made of heat resistant investment material, eliminating the wax by heating and then introducing molten metal into the mold through a channel called sprue. In dentistry the resulting casting must be an accurate reproduction of the wax pattern in both surface details and overall dimension. Small variation in investing or casting can significantly affect the quality of the final restoration. Successful castings depend on attention to detail and consistency of technique. An understanding of the exact influence of each variable in the technique is important so rational decisions can be made to modify the technique as needed for a given procedure.

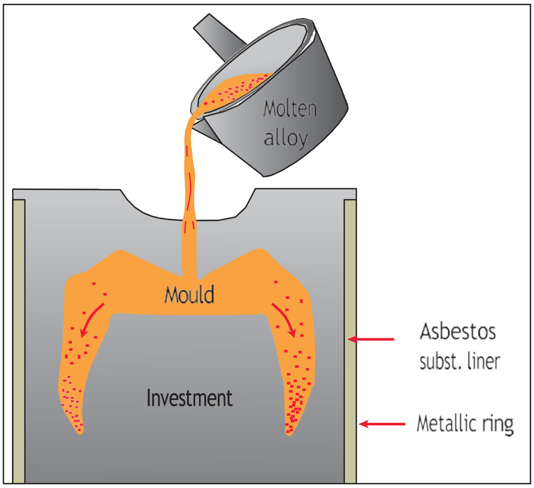


Fig. 7.1: Illustration showing the procedure of casting.

Fig. 7.2: Porcelain fused to metal crown.

STEPS IN MAKING A CAST RESTORATION

Following are the Steps of Making Metal Crown

- Tooth/teeth preparation
- Impression
- Model pouring
- Wax pattern fabrication
- Attachment of sprue former
- Ring liner placement
- Investing
- Burn out or wax elimination
- Casting
- Recovery
- Pickling
- Polishing

Dental Implants and Surface Modifications

Chapter 8

INTRODUCTION

A dental implant is a metallic prosthesis that functions as a root for supporting artificial teeth to replace missing or lost dentition (Fig. 8.1). Over one million dental implants are placed every year. An implant is in direct contact with the alveolar bone. The idea of placing 'prostheses' such as shells into the jaw bone dates back to the ancient Mayan civilization; archeological excavation sites have led to the discovery of human jaw bone with tooth-shaped shells embedded in it. The concept of modern implantology was dis- covered rather accidentally by P. I. Brånemark. While conducting research on bone regenera- tion around titanium chambers inserted in rabit femurs, he noticed that after several months he was unable to remove them. He later developed an implant system which could be used to support dental prostheses. The requirements of dental implants are: biocompatibility, stability, acceptable function and ease of manufacture. Prior to the introduction of the Brånemark implant system, sub-periosteal implants were used. Sub-periosteal consisted of a cobalt-chromium framework resting over the bone under the oral mucosa. This design is now outdated and has been replaced by osseo-integrated dental implants. Another older type of implant is the blade-vent implant. In these implants, one end of the implant (the blade) is inserted into the bone whilst the other end projects through the mucosa into the oral cavity. These implants carry a very high risk of infection and ultimately, im- plant failure.

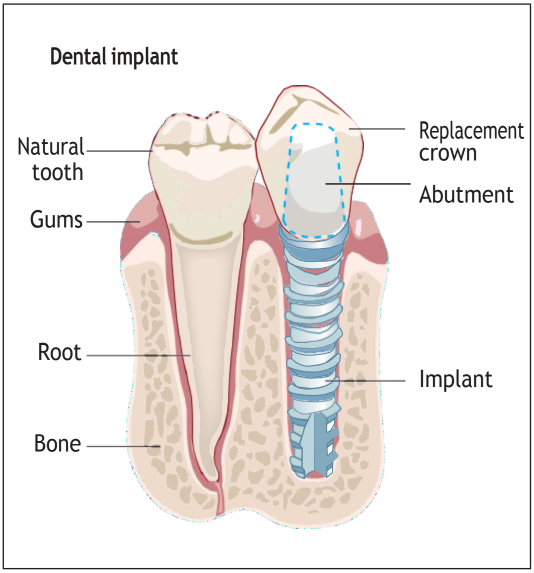


Fig. 8.1: Comparison between a dental implant (right) and a natural tooth (left).

OSSEOINTEGRATION

When any biomaterial is inserted into the living tissue, almost immediately, it is covered by cell adhesion proteins. Surface characteristics such as wettability and charges affect the quality of absorption of these proteins onto the implant. Cells then interact with these proteins to adhere to the implant surface. Similarly, in bone tissue, osteoblasts, the bone forming cells, are laid down onto the implant surface and consequently, there is a direct bone-implant interface formed. This interface is known as osseo-integration. If there is a loose connective tissue formed instead of a bone-implant interface, the implant fails. Osseo-integration is the main factor that dictates the success of dental implants. According to Brånemark, osseo-integration depends on the quality of the bone, surface morphology of the implant, the implant material, surgical technique employed to place the implant and the design of

Application of Polymer Technology in Dentistry

Chapter 9

INTRODUCTION

Polymer science or macromolecular science is a subfield of materials science concerned with polymers, primarily synthetic polymers. The field of polymer science comprises three main sub-disciplines.

Polymer chemistry or macromolecular chemistry which deals with the chemical synthesis and chemical properties of polymers or macromolecules.

1. Polymer physics is concerned with the bulk properties of polymer materials and engineering applications.
2. Polymer characterization is concerned with the analysis of chemical structure and morphology and the determination of physical properties in relation to compositional and structural parameters.
3. Polymers (poly = many, mer = unit) are made by linking small molecules (mers) through *primary covalent* bonding in the main molecular chain backbone with C, N, O, Si, etc (Fig. 9.1). Polymers have a major role in most areas of dentistry.

Nowadays, synthetic polymers have been widely used in both restorative and prosthetic dentistry for over five decades, and used in medical disposable supplies, dental materials, implants, dressings, bleaching tray, extracorporeal devices, encapsulants, polymeric drug delivery systems, tissue engineering scaffold, and brackets in orthodontic treatment.

Applications for acrylic polymers based on functional methacrylate, include dentures, (Fig. 9.2 and 9.3) restorative materials, relining and repair material, soft liners, bonding agents, temporary crown and bridges. Elastomeric materials such as silicones, polysulphides and alginates are used for recording impressions of the hard and soft oral tissues, which are then utilized for constructing appliances outside the mouth. Water- soluble polymers are used in adhesive dental cements. Polymer composites an important part of restorative dentistry, at present is the material with the widest range of indications and is vital to modern dentistry.

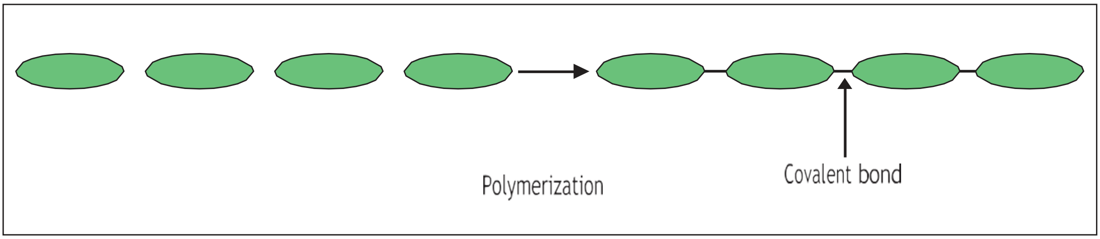


Fig. 9.1: Illustration representing the process of polymerization.

Chapter 10

Dental Impression Materials

INTRODUCTION

Those materials that are used to take impression of teeth and surrounding structures of oral cavity for making accurate prosthesis of the patient.

How do we use impression material?

A. Examine the Patient

With the help of impression tray select the size of the tray, and check the patient whether it is edentulous/dentulous.

B. Load of Material in Tray

Select the material which type of it would be used to take such impression (Fig. 10.1).

C. Take Impression

The material should be fluid enough when it is inserted in the oral cavity in order to adapt the oral tissues (Fig. 10.2).

D. Pour Model

The model is poured with dental stone plaster. For examination of oral tissues or for making prosthesis e.g. Partial denture, crown and bridge.

Fig. 10.1: Metallic stock trays.

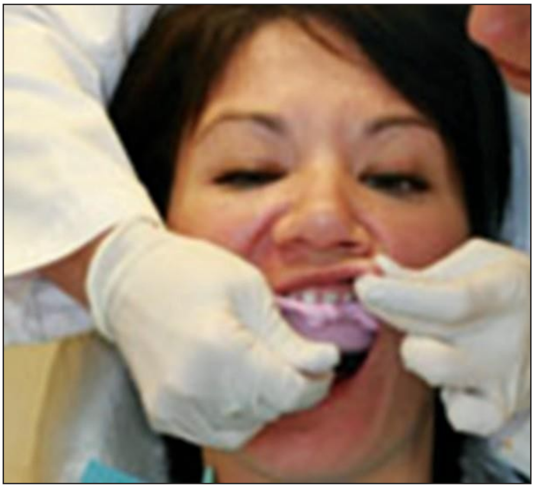


Fig. 10.2: Checking impression tray size in Patients mouth.

Ceramic Products in Dentistry

Chapter

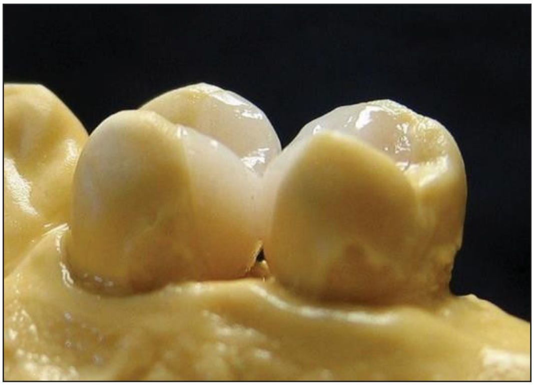
11

INTRODUCTION

Ceramics is driven from Greek wovd "KERAMOS" meaning burnt stuff but it is related to material produced by firing or burning. The first ceramics fabricated by man were earthenware pots used for domestic purpose. This material is opaque, relatively weak and porous and would be unsuitable for dental applications. Silica and feldspar was added to improve translucency and strength required for dental application and was given the name of Porcelain also known as Conventional or feldsphatic porcelain. Dentistry has turned to porcelain for the production of artificial teeth, crowns, bridges and veneers (Fig. 11.1).

(a)

(b)



(c)

Fig. 11.1: A few applications of ceramic in dentistry.
(a) Veneers, (b) All-ceramic Crown, (c) Indirect Inlays.

CLASSIFICATION OF DENTAL PORCELAIN

Dental porcelain can be classified as follow:

1. ACCORDING TO FIRING TEMPERATURE

- High fusing-1300 °C
- Medium fusing-1100-1300 °C
- Low fusing–850 °C
- Ultra low fusing–less than 850 °C

2. ACCORDING TO TYPES

- Feldsphatic porcelain
- Aluminous porcelain
- Cast glass ceramic
- Lucite reinforced
- Glass infiltrate

Dental Amalgam

Chapter

12

INTRODUCTION

Some dental materials are used to restore diseased (caries, secondary caries), traumatized (incl. wear) or lost teeth, or neighboring tooth structures (and tissues), and rehabilitate biting functions.

Dental materials can be classified as restorative materials, preventive materials and auxiliary materials. On the other hand, any material that is used for the above described purpose may be regarded as a biomaterial.

IDEALLY RESTORATIVE DENTAL MATERIALS SHOULD BE

- Inert
- Biocompatible
- Non-irritant
- Non-cytotoxic
- Not carcinogenic or mutagenic
- Not appreciably soluble in oral fluids
- Dimensionally stable
- Possessing adequate biomechanical properties
- Acceptable to patients
- Cleansable
- Indistinguishable from natural tissue
- Long lasting when a permanent restoration done
- Induce fast healing process (if relevant)
- Possessing adhesion to tooth tissues (if relevant)
- Osteoconductive and capable of osseointegration (if relevant)

Examples

Restorative dental materials can be classified as (a) direct and (b) indirect materials.

Direct restorative materials, such as resin-based composites (resin composites, filled resins), dental silver amalgam and glass ionomer cements (GIC), are used directly inside the oral cavity in a plastic form which will then set to restore the function of teeth.

Provisional (temporary) dental materials are used for a limited planned period of time, usually a few days or a few weeks. It may be necessary for the dentist to decide the definitive treatment, such as in the case of very deep cavities. In such a case the application of zinc oxide (ZnO) eugenol cement (ZOE) as a temporary filling material may be used. Also, a prepared tooth may need to be covered with an acrylic temporary crown before the definitive crown is prepared by the dental laboratory.

DENTAL SILVER AMALGAM

An amalgam is an alloy that contains mercury (Hg) as one of its constituents. Mercury is a liquid metal at room temperature.

Dental silver amalgam has been the most commonly used direct restorative filling material having served for more than 160 years. It is a permanent restorative material mainly used to restore cavities of decayed permanent posterior teeth. It has been a very effective and economical restorative material over a long time. Its challenges may be related to its appearance and while some have expressed doubts about its safety, there are no substantiated problems. One of the cur- rent aspects in the discussion is whether resin

Dental Resin-Based Composite Chemistry and Its Uses

Chapter 13

INTRODUCTION

With the advancement in polymer science, new resin reinforced by means of fillers has been developed. In general, the properties of these composite resins are superior to those of conventional unfilled resins like acrylic resin. Historically, silicate cements were developed first as esthetic material followed by acrylic resins, and then by composite resins.

ACRYLIC RESINS

INTRODUCTION

That type of unfilled direct resins has been largely replaced by the composite resins. Discussion on it is necessary to understand the chemistry and properties of the newer resin systems.

MODE OF SUPPLY

They are supplied as powder and liquid.

COMPOSITION

Powder
Polymethyl methacrylate, Benzoyl peroxide (initiator), Color pigments.
Liquid
Methlymethacrylate monomer N, N-dimeltyl-P-toluidine (activator)

ADVANTAGES

a. Less prone to erode.
b. It has low solubility.
c. It is less acidic.
d. It is less brittle.
e. It has good thermal insulator.
f. It has good appearance.

DISADVANTAGES

a. Level of residual methyl methacrylate monomer, which is irritant.
b. Material undergoes setting contraction (6% by volume) and it can produce marginal gap.
c. It has low value of modulus of elasticity and it indicates that acrylic resin is a far more flexible than either enamel or dentine.
d. It has low compressive strength and hardness value and this value reflects that it has poor durability.

Current Status

This material is still in use for temporary crown and bridge construction.

COMPOSITE

In materials sciences it is defined as a product, which consists of at least two distinct phases normally formed by blending together components having different structures and properties. Composite is made by combining two or more dissimilar materials in such a way that the result- ant material has a property superior to any of its parental ones.

Typical engineered composite materials include:

a. Composite building materials such as cement, concrete
b. Reinforced plastics such as fiber-reinforced polymer
c. Metal composites
d. Ceramic composites (composite ceramic and metal matrices).

Glass Ionomer Cements and Their Modifications

Chapter 14

INTRODUCTION

Glass ionomer restorative materials are hybrids of silicate and polycarboxylate cements. It consists of interpenetrating network of inorganic and organic components forming a matrix in which particles of unreacted glass are embedded (Fig. 14.1).

Polycarboxylate were developed several years earlier and were the first dental cements for which an inherent adhesion to tooth substance could be demonstrated. In late 1960s Glass-ionomer became available as a result of the pioneering studies of Alan Wilson and Brian Kent at the Laboratory of the Government Chemist, London. Commercial dental cements of this type were launched in 1975, though these had very inferior properties compared with the materials available today.

When zinc oxide of the polycarboxylate material was replaced by a reactive ion leachable glass similar to that used previously in silicate cements a storage, less soluble and more translucent cement could be produced.

Fig. 14.1: GIC restorative material.

CLASSIFICATION

Types and their uses:

Type I: For luting cast restorations and orthodontic bands

Type II(A): Aesthetics restorative cements, used for class III and class V cavities

Type II(B): Reinforced restorative material, mainly used for core build up

1. Miracle mix–GIC powder + Ag amalgam alloy powder
2. Class cermet–GIC powder + pure Au/Ag (mostly Ag), also known as ketac silver

Type III: Lining cement, base

Type IV: Visible light activated liners/bases

Type V: Glass1 ionomer for stabilization and protection

TypeVI:AtraumaticRestorativeTechnique(ART) in anterior teeth

Type VII: High viscous/condensable glass ionomers, ART for posterior teeth

SUPPLIED AS

- Powder and liquid
- Powder mixed with water
- Encapsulated form

Dental Adhesive Systems

Chapter

15

INTRODUCTION

Dental adhesive systems form an intermediate layer between the tooth and restoration, effectively bonding a resin-based restorative material or cement and hard dental tissues, enamel and dentine. Dental adhesives are based on a blend of resin monomers, mostly methacrylates and di- methacrylates. Adhesion to enamel and dentine is primarily based on "micro-mechanical inter- locking" through superficial demineralization of enamel and dentine followed by adhesive infiltration into the demineralized tissue [1] though certain monomers are able to chemically bond to hydroxyapatite [2]. This inter-phase formed by adhesive resin and tooth tissue is called the "hybrid layer" [3]. On the other side, the adhesive forms covalent bonds with monomers in resin-based composite or cement. Similarly, to resin-based composites, adhesives too harden through the process of polymerization which may be light-or chemically-initiated. Most con- temporary adhesives belong to the light-cured rather than chemically-cured materials. Some adhesives contain both photo-initiators and chemically curing initiators and are referred to as dual-cured adhesives.

Dental adhesives are often referred to as "dentine bonding agents" or "dentine adhesives". This terminology most likely originates from the scientific focus being on dentine bonding which remains to be a challenge as oppose to enamel bonding which proves to be reliable and durable following phosphoric acid etching and adhesive application. Since the adhesives are applied to enamel as well as to dentine, the term "dental adhesive system" or "dental adhesive" is more appropriate.

COMPOSITION

Dental adhesives consist of resin monomers, solvents, initiators, stabilizers and may contain fillers. There are three categories of resin monomers: functional, cross-linking and intermediary monomers. Functional monomers contain at least one acidic group, -COOH or $-H_2PO_3$. Their primary role is interaction with Ca ions from hydroxyapatite that leads to demineralization. Functional monomers are also responsible for enhanced wetting and promoting adhesion into the substrate. Polymerizable methacrylate groups (C=C) allow functional monomers to become part of polymer chains. The so-called spacer groups between the methacrylate and acidic groups affect properties such as acidity, hydrophilicity, hydrolytical stability. Among the most common functional monomers are HEMA, 4-META, 10-MDP, Phenyl-P1.

Cross-linking monomers are mostly dimeth-acrylates, such as BisGMA, UDMA, TEGDMA and BisEMA2, which contain two polymerizable methacrylate groups (C=C). During polym-erization, these monomers form cross-linked polymers which are responsible for mechanical properties of the adhesive [4]. Cross-linking monomers are well solvated in organic solvents, ethanol and acetone, and only limitedly in water due to their hydrophobic nature. Cross-linking monomers are often used in conjunction to

- HEMA-2-hydroxyethyl methacrylate; 4-META-4-methacryloyloxyethyl trimellitate anhydride; 10-MDP-10-methacryloyloxydecyl dihydrogenphosphate; Phenyl-P-2-(methacryloyloxyethyl)phenyl hydrogenphosphate
- **BisGMA**-bisphenol A diglycidyl methacrylate; **UDMA**-urethane dimethacrylate; **TEGDMA**-triethyleneglycol dimethacrylate; **BisEMA**-ethoxylated bisphenol A glycol dimethacrylate

Dental Cements

Chapter

16

INTRODUCTION

Cements are defined as a material that produces a mechanical interlocking effect on hardening. In dentistry, cements are defined as a Substance that hardens to act as a base, liner filling materials and luting or adhesive to build prostheses to tooth structure or to each other.

Dental cements are used for a variety of dental applications e.g. use as luting agents, pulp-protecting agents and cavity-lining material. Dental cements are hard, brittle materials formed by mixing powder and liquid together. They are either resin cements or acid-base cements.

As these materials are used in a very sensitive environment so they must fulfill basic requirement which are as follows, discussed under particular category.

LINING MATERIALS

Certain filling materials are not suitable for placing directly into a freshly prepared cavity. In such circumstances, a layer of cavity lining material is placed in the **occlusal floor** of the cavity, and on the **pulpal axial** dentine wall for class II cavities, prior to placement of the filling.

REQUIREMENTS

Depends on the

a. Depth of the cavity
b. Thickness of residual dentine
c. Type of filling material

PURPOSE OF LINING OR BASE

a. To acts as a barrier between the filling material and the dentine which, by virtue of the dentinal tubules, has direct access to the sensitive pulp
b. To provide sufficient mechanical strength to resist disruption during the placement of filling.
c. To provide a firm, rigid base this will adequately support the filling above it.
d. To provide a thermal, chemical and electrical barrier (Fig. 16.1).

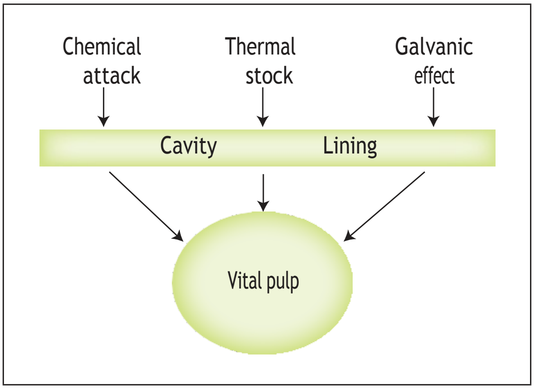


Fig. 16.1: Diagram illustrating the way in which a cavity lining protects the dental pulp.

A. Thermal Barrier

The cavity lining or base is often expected to form a thermally insulating barrier in order to protect the pulp from sudden intolerable changes in temperature. A thermally insulating cavity lining is particularly required when a metallic filling, such as amalgam is used because the thermal diffusivity value for amalgam is about 40 times greater than that for dentine.

1. In deep cavities

- Having only a thin residual layer of dentine, and there is a danger of “thermal shock” to the pulp when the patient takes hot or cold.

Hybridization VS. Bio-mineralization: An Evolution for Dental Restorations

Chapter 17

ABSTRACT

In the early 1980's the dentin hybridization model was proposed. It was described as a bioengineered tissue integration of resin into the living dentin of the tooth. Over the following years there have been generations of dentin hybridization adhesives created to attempt to overcome the shortcomings of the previous generations or to attempt to make the process easier for clinical application. However, it has been determined that the average life span of typical resin bonded composite restorations is 5.7 years at a cost of approximately five billion dollars annually in the United States alone. Various agents have been proposed and subsequently used in an attempt to create more long lasting hybrid bonds. However, it has been stated that the use of these agents applied either separately or mixed with the primer/adhesive agents appear to only retard rather then prevent bond degradation. It is obvious that a different pathway needs to be traveled and it is proposed the use of bioactive/bio-mineralization integrating materials could be the direction to success.

1. INTRODUCTION

The restoration of dental tooth structure after it has been damaged by dental caries or trauma has been the goal of the profession of well over one hundred years. Over this time the procedures performed have evolved from extraction of the tooth, to the placement of cast gold restorations, direct gold foil restorations, amalgam restorations, porcelain jacket crowns, porcelain fused to metal crowns and finally to the use of glass ionomer restorations, bonded adhesive restorations and pressed and milled ceramics and zirconia. The ultimate goal being the creation of a long term beneficial method to bring the dentition back to function and health.

In this chapter we will focus on the benefits and challenges presented to us each day with the utilization of resin bonding adhesive restorations and look at the evolution currently going on that is looking at a way to with the use of bioactive materials create bio-mineralization and enable our materials to work with nature not have the natural protective mechanisms of the tooth essentially "reject" our attempts to help the tooth.

2. THE HISTORY OF ADHESION

While at Eastman Dental Dispensary in Rochester, NY (now the Eastman Institute for Oral Health), Dr. Michael Buonocore [1] had a paper published in the Journal of Dental Research entitled "A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces". At that time there was a need get the acrylic fillings of that time to adhere to the tooth surface. He proposed the use of an acid etch technique to enable this to occur. He stated:

"A filling material capable of forming strong bonds to tooth structures would offer many advantages over present ones. With such a material, there would be no need for retention and resistance form in cavity preparation, and effective sealing of pits, fissures, and beginning various lesions could be realized."

This was the first step in attempting to create a better adherence to the tooth structure: a way of working so that a non-mechanical intimate interface could be created. Dr. Ray Bowen [2], in 1963, noted that there was a need to improve the materials being used (silicate cements and self cure methyl methacrylates), so that those materials would have less solubility, sensitivity to

Regenerative Dentistry

Chapter 18

INTRODUCTION

To date most of the procedures performed in dentistry are restricted to replacement of damaged tissues for biocompatible synthetic materials that may not present chemical, biological or physical characteristics and behavior similar to the host tissue. These discrepancies altogether with the hostile environment of oral cavity results in relatively short lived successful clinical outcomes and quite frequent needs of re-treatment [1]. Tissue engineering and regenerative medicine (TERM) is a multidisciplinary field that has evolved over the past few decades to recreate functional, healthy tissues and organs in order to replace and restore diseased dying or dead tissues [2]. It employs the understanding of life sciences for growth and development of new tissues. Next it draws on advances in materials science and engineering to amalgamate current engineering design principles in the formulation of strategies to engineering truly functional tissues. The field then incorporates the therapeutic principles of medical and dental clinicians in order to bring the scientific side to practical application.

BIOLOGICAL TOOTH REPLACEMENT AND REPAIR

Although there are an increasing number of alternative treatments in dentistry most are non-biological and are based on procedures that have been practiced for decades. The aim of stem cell based tissue engineering is to reproduce an embryonic tooth primordium from cultured epithelium and mesenchymal cells. New bone formation is a critical component of bio tooth formation. As bio tooth has to be able to anchor itself to the jaw bone with roots and periodontal ligaments [3]. Some of the prominent strategies reported under this technique are the natural tissue regeneration, signaling based strategies and cell and gene based strategies. Progress in the identification, isolation and understanding of the differentiation of the adult and embryonic stem cells altogether with a continuing understanding of the control of tooth development will aid the production and refinement of approaches for bio tooth formation. Although, there are certain pitfalls and drawbacks, biological tooth replacement is now a realistic possibility (Fig. 18.1) [4].

SCAFFOLDS

Scaffolds work as a temporary construct or template that provides a three-dimensional microarchitecture whereby cells are triggered to attach, proliferate and differentiate to produce desired tissue. Scaffolds should ideally mimic extracellular matrix (ECM) of the natural tissues, it should not only allow delivery of bioactive molecules such as drugs or growth factors to be able to allow oxygen influx to maintain high metabolic demands of cells engaged in TE [6].

A number of techniques have been used for the fabrication of non-porous and porous cell-supporting scaffolds/constructs or templates such as particulate leaching, phase inversion and freeze drying, solvent casting, electrospinning [7]. More recently additive manufacturing (3D printing) have been considered as a potential technique to fabricate biomimetic templates of dental TERM [8,9]. However; drawbacks include difficulty in controlling the pore size, low interconnectivity, and residual salt and skin formation.

Degradation and Durability of Resin-Dentine Hybrid Layers

Chapter 19

INTRODUCTION

Dr. Buonocore first introduced (1955) the adhesion of resin-based materials to dental enamel. He proposed the use of phosphoric acid to chemically condition the enamel, thereby forming micro porosities in which the resin can infiltrate, creating tag-like projections [1]. Enamel is composed of approximately 96% hydroxyapatite, which is a solid crystalline structure [2]. It is generally agreed that enamel bonding is predict- able and successful when etched with phosphoric acid [1]. Dentine, in terms of overall volume, has a 50% inorganic component, 30% organic component of which 90% is collagen, and the remaining 20% is water [3,4]. The intrinsic wet- ness and organic material in dentine decreases the surface energy and, thus makes successful bonding difficult; this in part explains the reduction in durability of resin-dentine bonds com- pared to resin-enamel bonds [5]. Nakabayashi *et al.* [6] in 1982 demonstrated the presence of a hybrid layer. A resin-dentine hybrid layer is made of a demineralized collagen fibrillar matrix that is infiltrated by hydrophilic and hydrophobic resin monomers to form a micromechanical bond [5].

Two different classes of dental adhesives can form a hybrid layer; etch and rinse (ER) and self-etch adhesives (SE) [2,7]. Etch and rinse adhesives completely remove the smear layer and demineralize the dentine superficially using a phosphoric acid etchant, which is then rinsed, followed by the application of a primer and bond system or by a single-step one-bottle self-priming system [7]. Conversely, self-etch adhesives partially remove the smear layer, using an acidic primer and may be followed by the application of a bonding resin depending upon the system employed by the clinician (e.g. two-step or all-in-one adhesive systems) [7]. Unfortunately, the incomplete infiltration of adhesive systems into demineralized dentine, particularly when an ER approach is used, represents a clear problem defying the clinical success of resin-based dental restorations [8]. Most adhesive systems produce very good immediate bond strengths but the long-term strengths are a cause for concern [3].

Complete infiltration of resin into dentine would be the ideal situation because acid etching with phosphoric acid also uncovers and activates endogenous proteins of the dentinal matrix, such as matrix metalloproteinases (MMPs) and cysteine cathepsins [9]. However, the complete infiltration and replacement of all water by resin is often practically rarely achieved in practice, thus creating gaps within the hybrid layer and leaving collagen fibers unprotected, which decreases the durability of the resin-dentine bond [1].Degradation of the hybrid layer, the decreased durability of resin-dentine bonds and the continued destruction of tooth structure, are all very important and prevalent phenomena in clinical dentistry and for this the author intended to gather information and present a comprehensive and comprehendible chapter to help clinicians understand and prevent such occurrences in the future.

HYBRID LAYER DEGRADATION

Two main mechanisms have been identified to constitute towards resin-dentine hybrid layer degradation: intrinsic or proteolytic degradation of the organic matrix and extrinsic or hydrolytic degradation of the resin matrix [7]. Both mechanisms are interlinked, and decrease the durability of resin-dentine bonds.

Introduction to Partial Denture

Chapter

20

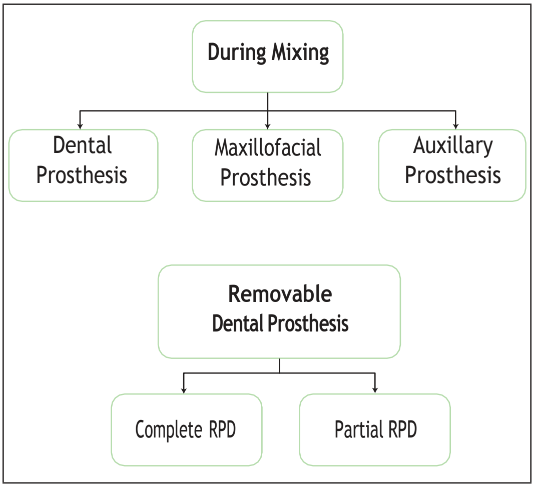
PROSTHODONTICS

Prosthodontics is the dental specialty pertaining to the diagnosis, treatment planning, rehabilitation and maintenance of the oral function, comfort, appearance and health of patients with clinical conditions associated with missing or deficient teeth and/or maxillofacial tissues using biocompatible substitutes.

PROSTHESIS

An artificial replacement of an absent part of the human body.

REMOVABLE PROSTHODONTICS



1. TREATMENT OBJECTIVES

a. Preserve remaining teeth
b. Restore esthetics and phonetics
c. Restore and/improve mastication
d. Restore health and quality of life

2. INDICATIONS FOR RPDs

a. Lengthy edentulous span
b. No posterior abutment for a fixed prosthesis
c. Excessive alveolar bone loss
d. Reduced periodontal support for a fixed prosthesis
e. Cross-arch stabilization of teeth
f. Need for immediate replacement of missing/ extracted teeth
g. Cost/patient desire

3. ALTERNATIVE TO RPDs

a. Fixed partial denture
b. Implant supported prosthesis
c. Complete denture
d. No treatment. (Shortened Dental Arch)

4. DEMERITS OF PARTIAL DENTURES

a. Stomatitis
b. Poor access for oral hygiene
c. Caries
d. Periodontal and endodontic lesions
e. Tooth mobility
f. Poor speech and mastication
g. Bone resorption

COMMONLY USED TERMS

1. SADDLE

The part of a denture that rests on the oral mucosa and to which the teeth are attached.