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MAXILLOFACIAL PROSTHETIC MATERIALS- PAST, PRESENT AND FUTURE TRENDS

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ABSTRACT

Patients can acquire maxillofacial defects due to congenital defects, trauma or cancer. Such defects often require high quality prosthetic treatment because of the associated esthetic and psychological problems. A maxillofacial prosthesis restores normal anatomy and appearance, protects the tissues of a defect, and provides great psychological benefits to the patient. Success in the field of maxillofacial prosthodontics depends a lot on the appropriate knowledge about dental material sciences related to it. A skilful prosthodontist would exploit this knowledge to fabricate prosthesis with best possible aesthetics, functions and durability.

INTRODUCTION

Angina bullosa hemorrhagica is a benign condition affecting mucosa of oropharynx, characterized by sudden appearance of blood filled submucosal blisters of unknown etiology. It was first described in 1933 as 'traumatic oral hemophlyctenosis' then the term 'angina bullosa hemorrhaegica (ABH)' was coined by Badham for the same condition in 1967 and later it was renamed as 'recurrent oral hemophlyctenosis'. It is also less often named as localized oral purpura or stomatopompholyx haemorrhagica [1]. These blisters present a color ranging from dark red to purple and may cause some discomfort. It may occur either as solitary or multiple lesions. These lesions, however, are frequently asymptomatic and they are only observed when their content is spilled over the oral cavity. The most common site affected being the soft palate, but these lesions can also occur in the anterior pillar of the fauces, epiglottis, arytenoids, pharyngeal wall and esophagus.

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Body abnormalities or defects that compromise appearance, function, and render an individual, incapable of leading a relatively normal life have usually prompted responses that seek to bring the person to a state of being acceptable normally. In response to congenital or acquired defects man has continually sought to cope with his debilities by using his genius and the material resources available for restoration.

Patients can acquire maxillofacial defects due to congenital defects, trauma or cancer. Such defects often require high quality prosthetic treatment because of the associated esthetic and psychological problems. A maxillofacial prosthesis restores normal anatomy and appearance, protects the tissues of a defect,and provides great psychological benefits to the patient [2].

Maxillofacial prosthetics is defined as that branch of prosthodontics concerned with restoration and replacement of both of stomatognathic and associated facial structures by artificial substitutes that may or may not be removed" (GPT).

Success in the field of maxillofacial prosthodontics depends a lot on the appropriate knowledge about dental material sciences related to it.

A skilful prosthodontist would exploit this knowledge to fabricate prosthesis with best possible aesthetics, functions and durability [3].

History:

Auricular, nasal, and even ocular prosthesis fabricated with various materials, have been found in Egyptian Mummies. Chinese are known to fabricate nasal and auricular prosthesis using natural waxes, resins and metals usually gold or silver have been used. Alphonse Louis fabricated a silver mask for a French soldier. He was wounded by shell fragments which removed nearly all of the left side of the mandible and maxillae [4,5].

According to Beder the first obturator was described in 1541 by Ambrose pare. It consisted of a simple disc attached to sponge.

Tycho Brache (1546-1601), who used an artificial nose made from gold to replace his own nose.

1600 to 1800:- Pierre Fauchard (1678) made monumental contributions to prosthetic facial reconstruction.

1800 to 1990:- William Morton was credited with fabrication of a nasal prosthesis using enameled porcelain to match the complexion of a patient.

In 1880:- Kingsley described a combination of a nasal palatal prosthesis in which the obturator portion was an integral part of the nasal prosthesis.

In 1900 to 1940:- In the nineteenth century, vulcanite rubber was widely used by the dental profession and was adapted for use in facial prosthesis. Upham described the fabrication of nasal and auricular prosthesis made from vulcanite.

In 1905, Ottofy, Baird and Baker all reported using black vulcanized rubber.

In 1913 – Gelatin-glycerin compounds were introduced for use in facial prosthesis in order to mimic the softness and flexibility. Kazanjian described the use of celluloid prints for coloring vulcanized rubber facial prosthesis.

From 1940 to 1960:- Acrylic resin was introduced in the dental profession.

From 1960 to 1970:- The introduction of various kinds of elastomers resulted in major changes. Barnhart was the first to use silicone rubber for construction and coloring of facial prosthesis. Tashma used dry earth pigments dispersed in colorless acrylic resin polymer powder for intrinsic coloring of a silicon facial prosthesis.

In 1970 to 1990:- Gonzalez described the use of polyurethene elastomer. Lewis and Castelberry described the potential use of siphenylene for a facial prosthesis.

Ideal Properties of Maxillofacial Prosthetic Materials [4,7]:

1.**Esthetic Properties**: Color Texture Form Translucency 2. **Physical Properties**: Sufficient flexibility Dimensionally stable Light weight Good edge strength Low thermal conductivity 3. **Biological and Chemical Properties**: Stability when exposed to insults like UV rays, oxygen and adhesive. Non toxic, non allergic, non carcinogenic. Biocompatible. Resistance to stains. Durable 4. **Processing Properties**: Easily processed material. Polymerisation should occur at low temperature to permit reusability of molds. Sufficient working time Materials should be adaptable to intrinsic as well as extrinsic coloration.

MATERIALS AVAILABLE [4,6,8,12]

Acrylic and Acrylic Co-Polymers Acrylic Resin is used particularly in those cases in which little movement of the tissue bed takes place during function. **Composition**: Acrylic powder: Polymethyl methacrylate Liquid: Methyl methacrylate Colors used: Extrinsic and Intrinsic colorants Heat polymerized acrylic resin is preferred when compared to auto-polymerized because of no residual monomer, more color stability and free of tertiary amine activator. Acrylic Co-polymers are soft and elastic but have not received wide acceptance because they possess poor edge strength, poor durability and subject to degradation when exposed to sunlight.

Polyvinyl Chloride Co-Polymers: It consists of combination of polyvinyl chloride and plasticizer (a hard clear resin that is tasteless and odorless). It is a flexible material and adaptable to both intrinsic and extrinsic coloration. Prostheses fabricated with this material have an acceptable initial appearance. However, plasticizer migration and loss results discoloration of the prostheses. This material has low tear edge strength. This can be stained easily but degrade when exposed to UV Light. Fabrication requires metal molds for curing at high temperature.

Chlorinated Polyethylene (CPE): CPE is similar to polyvinyl chloride (PVC) in both chemical composition and physical properties. This system included additives including low density polyethylene, calcium stearate, soyabean oil and low molecular weight CPE. Because of the high tear strength, thin cross sections of the CPE materials can be prepared. Prostheses are fabricated from pigmented sheets of the thermoplastic polymer alloy by processing it at high temperatures in metal molds. Chlorinated polyethylene may have advantages over conventional silicone rubber materials in its ability to be repaired, relined, or reconditioned, extending the life of the prosthesis. In addition, it can be used with any adhesive type. It has greater edge strength, does not support fungus growth, and is much lower in cost compared with silicone materials.

Terpolymer Latexes The components of this system are two latexes based on acrylate monomers with formaldehyde as a crosslinking agent. The latexes are compounded together at a solids level of about 50% and

pre-crosslinked with the formaldehyde. Prostheses are usually fabricated by dip casting over male models. Its mechanical properties are generally in the desired range for a suitable extraoral maxillofacial material. The fabrication procedure is unusual when compared to that of other materials and may retard its wide acceptance.

Polyurethanes These elastomers are synthetic preparations of long chain linear polyesters or polyethers reacted with diisocynates. These can be thermoplastic or thermosetting. These elastomers, when properly processed, are chemically inert, resistant to solvents and ozone, odourless, abrasion resistant, have high tear and tensile strength. They do not require use of plasticizers and have a wide range of flexibility and softness. The bridge of the nose is hard and rigid, whereas the tip and alae are soft and flexible. It is possible to fabricate a prosthesis with tissue-like softness and flexibility with this material. This material does not harden with wear and is dimensionally stable, can be colored easily. However, they require great precision and care in processing.

Epithane-368 It has a three component kit – a polyol, a diisocyanate and an organotin catalyst. Serious problems encountered with this polyurethane include variability in quality of material, deterioration of the prosthesis, and occasional skin irritation to clinicians working with the diisocyanate component

Isophorone Polyurethane The material is being formulated as a three component kit comprising an isocyanate –terminated pre-polymer, a triol as the crosslinking agent and an organotin catalyst. The pre-polymer is prepared by the controlled combination of isophorone diisocyanate, butane diol and a polyether polyol. The elastomers have unusually high strength which results from the cycloaliphatic isophorone moiety in the vulcanised network.

Silicone Elastomers The silicones were introduced in 1946, but have been used in the fabrication of maxillo-facial prosthesis only for the past few years. Silicones are a combination of organic and inorganic compounds. The first step in their production is the reduction of silica to elemental silicon. Then, by various reactions, the silicon is combined with methyl chloride to form dimethyl dichlorosiloxane, which forms a polymer when reacted with water. The name ‘silicones’ is based on their similarity with ketones, because in most cases, there is an average of one silicone atom, one oxygen, and two methyl groups. These polymers are translucent, watery and white fluids whose viscosity is determined by the length of the polymer chain. Silicones are classified into 4 groups according to their applications: Class I: - Implant grade, which requires the material to undergo extensive testing and must meet FDA requirements. Class II: - Medical grade, which is approved for external use. This material is used for fabrication of maxillofacial prosthesis. Class III: - Clean grade Class IV: - Industrial grade commonly used for industrial applications.

HTV Silicones:
- Silastic 370, 372, 373, 4-4514, 4-4515.
- HTV silicone is usually a white, opaque material viscous and putty like in consistency.
- 1-component or 2-component putty.
- Catalyst / vulcanizing agent of HTV is Dichlorobenzyl peroxide/ platinum salt.
- Various amounts of fillers are added depending on the degree of hardness, strength and elongation.
- Silica – Filler Size 30
- Copolymerization of silica with small amount of methyl, vinyl, or methylphenyl siloxane radical.
- Polydimethyl siloxane may be added to reduce the stiffness and hardness of the prosthesis.

Various types of HTV Silicones:
- Silastic S-6508, 382 and 399 (Michigan).
- Silastic S-6508 in raw stage is similar to sticky modeling clay. It must be vulcanized at 2600F and formed in pressure molds.
- Silastic 382 is an opaque white fluid with a viscosity like that of a thick honey.
- Silastic 399 resembles white Vaseline in its raw state. Easily spatulated, but non-flowing.
- Silastic 382 is tougher, non-flowing, but easier to handle.

Advantages:-
- Excellent thermal stability.
- Color stable.
- Biologically inert.

Disadvantages:-
- Not adequately elastic in function.
- Low edge strength.
- Opaque, life less appearance.

RTV Silicone (Silastic 382, 399) It includes a filler – Diatomaceous earth particles.
A catalyst - stannous octate.
A cross linking agent - Ortho alkyl silicate.
Polymerization – condensation silicone
- They are available as clear solutions that enable the fabrication of translucent prosthesis.
- RTV silicone is blended with suitable earth pigments; to produce the patients' basic skin color.

Procedure:
Material in fluid state;
Molds – cure for 30 min;
Chloroform (cleaning);
Uncured + xylene = Desired consistency;
Surface is tinted with artistic brushes, allowed to stand overnight, catalyst is gently applied with a brush (Stippling and other skin characterizations are done). Glossy surface

is dulled with pumice using mild finger pressure. Prosthesis is fitted using medical grade adhesive. Cosmetic effect may be achieved by the patient with commercially available make up creams. Quellete has recently described a new technique of spray-coloring a silicone elastomer.

Advantages:-

- They are color stable.
- Biologically inert.
- Easier to process.
- Retain physical and chemical properties at wide ranges of temperature.
- Stone molds can be used.

Disadvantages:-

- Poor edge strength.
- Costly.
- Cosmetic appearance of the material is inferior to that of polyurethenes, acrylic resins & polyvinyl chloride.

Recent Advances Silicone Block Copolymers [9,10,11]: It has been introduced to improve some of the weaknesses of silicone elastomers, such as decreased tear strength, low percent elongation and its susceptibility to bacterial growth. **Polyphosphazenes**: Fluroelastomer has been developed for use as a resilient denture liner, and has the potential to be used as a maxillofacial prosthetic material. **Cosmesil**: It is a RTV silicone showing a high degree of tear resistance. **Foaming Silicones**: Silastic 386 is a form of RTV silicone. The basic silicone has an additive so that a gas is released when the catalyst, stannous octoate is introduced. The gas forms bubbles within the vulcanizing silicone. After the silicon is processed, the gas is eventually released; leaving a spongy material. Advantage: Formation of bubbles within the mass can cause the volume to increase by as much as seven fold. Purpose of the foam silicon is to reduce the weight of the prosthesis. **Silphenylene** – It is an arylene silicone polymer, polytetramethyl-silphenylenesiloxane -dimethylsiloxane. It is synthesised and formulated as a pourable, viscous, room temperature vulcanizing liquid. It is available in a three component kit – a base resin, tetrapropoxysilane (crosslinking agent) and an organotin catalyst. Though this material is classified as a silicone chemically, it differs from polydimethylsiloxanes (PDMS) in several aspects. These have an unusual combination of high tensile strength and low modulus. PDMS feels slick to touch while these have a skin like feel. These are transparent even when reinforced with silica fillers. Improvements in edge strength and reduction in cost will be necessary to make silphenylenes clinically acceptable. Studies suggest that addition of modified fillers may substantially improve the tear strength.

Longevity Degradation and discoloration will require a remake of the prosthesis after few years of use. Discoloured prostheses can cause esthetic problems and have a negative impact on quality of life. Factors associated with the longevity of maxillofacial prostheses include the use of skin adhesives, ultraviolet radiation, discoloration, loosening of the acrylic resin clip carrier from the silicone, aging by environmental influences such as pollution and degradation by microorganisms. On an average, maxillofacial prostheses need to be remade every 1.5 to 2.5 years, which can be a considerable burden to the patient.

CONCLUSION

Each of the materials available has its strengths and weaknesses as well as its own physical and mechanical properties. However, they all have two common clinical problems: Discoloration of prosthesis over time Degradation of static and dynamic mechanical properties of the polymeric materials. There is a need for periodic replacement of any prosthesis because of deterioration of maxillofacial materials that are currently available. Accurate records and a reproducible fabrication technique are essential so that replacement prosthesis can be made without the continual presence of the patient Future research should concentrate on: Improvement of physical and mechanical properties of existing materials available or Development of new materials so that replacement materials will behave more like human tissue and increase the service life of prosthesis.

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CONFLICT OF INTEREST:

The authors declare that they have no conflict of interest.

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