

Maxillofacial Prosthetic Materials: A Literature Review

Harsh Mahajan, Kshitij Gupta

ABSTRACT

Rehabilitation of patients with disabilities of head and neck region, due to either congenital or acquired defects is a challenging task. These defects range from minor cosmetic discrepancies to major functional limitation. The prosthodontics management of these patients should aim at not only restoring the functional and esthetic handicap, but also ensure psychological well being. For facial rehabilitation assessment of materials used in maxillofacial prosthesis is necessary. Till date we have come a cross various materials which exhibit some excellent properties but also have many deficiencies. This article will review various materials used in maxillofacial prosthesis.

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INTRODUCTION

Like any other specialty in dentistry the success in the field of maxillofacial prosthodontics also depend a lot on the appropriate knowledge about dental material sciences related to it. A skillful dentist would exploit this knowledge to fabricate prosthesis with best possible esthetics, functions and durability. Materials used in the construction of facial and body prosthesis are varied.

Materials for maxillofacial prosthetic reconstruction span the full range of chemical structures, with physical properties ranging from hard, stiff alloys, ceramics and polymers to soft, flexible polymers and their formulation as latex and plastisols. The scope of this article is in providing some background about the evolution and current trends in using these materials.

DESIRED PROPERTIES¹

Esthetic Properties

Color, texture, form and translucence must duplicate that of missing structure and adjacent skin.

Physical Properties

1. Material should have sufficient flexibility so, that it is comfortable in movable tissue.
2. Dimensionally stable.
3. Light in weight.

4. Good edge strength.
5. Low thermal conductivity.

Biologic and Chemical Properties

1. Material should be stable when exposed to insults like ultraviolet rays, oxygen, sicilians and adhering.
2. Nontoxic, Nonallergic, Noncarcinogenic.
3. Biocompatible.
4. Resistance to stains.
5. It should be durable for at least 6 months without compromising esthetic and physical properties.

Fabrication Properties

1. Material should be easily processed.
2. Polymerization should occur at low temperature to permit reusability of molds.
3. Working time should be sufficient.
4. Materials should be adaptable to intrinsic as well as extrinsic coloration.

HISTORICAL BACKGROUND

Before 1600

The origin of prosthetic reconstruction of facial defects has not been well documented. Archeologists have found artificial eyes, noses, and ears constructed from waxes, clay and wood in ancient Chinese culture.

Ambroise Pare (1510-1590)¹, a famous French surgeon, made nasal prostheses using gold, silver, paper and liner cloth glued together.

1600 to 1800

Pierre Fauchard (1678-1761)¹ made a silver mask painted with oil paints to replace the lost portion of mandible of a French soldier.

1800 to 1900

William Morton (1819-1868)¹ fabricated a nasal prosthesis using enameled porcelain to match the patient's complexion. Claude Martin (1889) fabricated a nasal prosthesis using ceramic material.

1900 to 1940

Upham¹ fabricated a nasal and auricular prosthesis made from vulcanite rubber. In 1913 gelatin glycerin compounds

were introduced for use in facial prostheses. But their lifespan was too short for practical clinical application.

1940 to 1960

Acrylic resin was introduced to the dental profession in 1937 and it replaced vulcanite rubber. Its translucency, colorability and ease of processing were attractive in spite of its rigidity.

To overcome the rigidity problem of acrylic resin Tylman¹ introduced the use of a resilient vinyl copolymer acrylic resin for facial prostheses.

1960 to 1970

Fine described the use of colored nylon flockings as a major colorant for both internal and external coloring of facial prostheses.

1970 to 1990

Udagama and Drane^{2,3} introduced the use of silastic medical adhesive silicone type A for fabrication of facial prosthesis. Gonzalez described the use of polyurethane elastomer.

Lewis and Castelberry described the potential use of sphenylene for facial prosthesis.

MATERIALS AVAILABLE

Acrylic resin: Polymethyl methacrylate was once commonly used for maxillofacial prostheses and is still used occasionally to make artificial facial parts. It can be successfully employed for specific types of facial defects, particularly those in which little movement occurs in the tissue bed during function (e.g. fabrication of orbital prostheses).

Acrylic resin is easily available, easy to stain and color, has good strength to be fabricated with feather margin and a good life of about 2 years. Its rigidity and high thermal conductivity is a drawback.

Acrylic copolymer: Acrylic copolymers are soft and elastic but have poor edge strength, poor durability and being subject to degradation when exposed to sunlight. In addition complete restoration is often tacky predisposing to direct collection and staining.

Polyvinyl chloride and copolymer: Polyvinylchloride has been used widely for maxillofacial application, but it has been replaced by newer material with superior properties. It was the most widely used plastics for maxillofacial prostheses. Polyvinyl chloride is a rigid plastic that is clear, tasteless, and odorless, with a glass transition temperature higher than room temperature. For maxillofacial application plasticizers are added to produce an elastomer at room temperature. These additives however, extended processing

time and predisposed to undesirable shrinkage. It is processed at 150°C and metal mold are generally used.

Recently, a copolymer of 5 to 20% vinyl acetate with the remaining % being vinyl chloride has been introduced this copolymer is more flexible but apparently less chemically resistant than polyvinyl chloride itself. The vinyl acetate makes it more stable to heat and light.

Polyurethane elastomer: Polyurethane elastomers contain a urethane linkage. The reactants are a polymer terminating with hydroxyl group and others terminating with isocyanate in the presence of a catalyst. They can be synthesized with a wide range of physical properties by varying the reactants and their amounts. They have excellent properties like elasticity and ease of coloration but have certain deficiencies like isocyanate, and are moisture sensitive leading to gas bubbles when water contaminated. According to Gonzalez they also causes local irritations.⁴

Silicones

The silicones are probably the most widely used materials for facial restorations but they exhibit objectionable properties that prevent them from being accepted by all clinicians. Silicones are a combination of organic and inorganic compounds.

Silicone Elastomers

They are of two basic types.

1. Room temperature vulcanizing (RTV)
2. Heat vulcanizing (HTV)

Room Temperature Vulcanizing Silicone Elastomers (RTV)

They are viscous silicone polymer including filler, a stannous octate catalyst and an orthoalkyl silicate cross linking agent. Fillers are usually diatomaceous earth which improves strength.

- **Silastic 382, 399:** They are viscous silicone polymers which are color stable and biologically inert.
- **MDX4-4210:** In a survey by Andres,¹ 41% of clinicians used this material for maxilla prosthesis fabrication. Moore⁵ reported that it exhibits improved qualities relative to coloration and edge strength. The material is not heavily filled, hence it is translucent. It exhibits adequate tensile strength, is nontoxic, color stable and biologically compatible.
- **Silastic 891:** Udagama and Drane² first reported its use, also known as silastic medical adhesive silicone type A and it is compatible with wide range of colorants.
- **Cosmesil:** It is a RTV silicone which can be processed to varying degree of hardness as described by Woofaardt.⁶

Heat-temperature Vulcanizing Silicone Elastomers (HTV)

Designed for higher tear resistance in engineering applications, this type of polymer requires more intense mechanical milling of the solid HTV stock elastomers compared with the soft putty RTV silicone, especially for incorporating the required catalyst for cross link.

- *Silastic 370, 372, 373, 4-4514, 4-4515*: They are usually white, opaque material with a highly viscous, putty-like consistency. The catalytic agent is dichlorobenzoyl peroxide. They exhibit excellent thermal stability and biologically inert but do not possess sufficient elasticity to function in movable tissue beds.
- *PDM siloxane*: This HTV silicone was developed by Veterans' administration and reported by Lontz and Schweiger. Independent evaluations of physical and mechanical properties were reported by Abdelnabi.⁷
- *Q7-4635, Q7-4650, Q7-4735, SE-4524U*: This new generation of HTV silicone evaluated by Bell⁷ which showed improved physical and mechanical properties compared to MDX4-4210 and MDX4-4514 (RTV silicone elastomers.)

Foaming Silicones

Silastic 386: A form of RTV silicone that has limited use in maxillofacial prosthetics is the foam – forming variety. 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 silicone is processed, the gas is eventually released leaving a spongy material. The formation of the bubbles within the mass can cause the volume to increase by as much as seven-fold.

The purpose of the foam—forming silicone is to reduce the weight of the prosthesis. However, the foamed material has reduced strength and is susceptible to tearing. This weakness can be partially overcome by coating the foam with another silicone.

Siphenylenes: Siphenylenes are siloxane copolymers that contain methyl and phenyl groups. These exhibit improved edge strength, low modules of elasticity and color ability over the more conventional polydimethyl siloxane.

NEW MATERIALS

Silicone block copolymers: Silicone block copolymers are new materials under development to improve on some of the weaknesses of silicone elastomers, such as a low tear strength, low elongation and the potential to support bacterial and fungal growth. They are more tear resistant than conventional cross-linked silicone polymers.

Polyphosphazenes: Polyphosphazene fluoroelastomers have been developed for use as resilient denture liners and have the potential to be used as maxillofacial prosthetic materials.

A-2186: A recently developed material initially showed improved physical and mechanical properties when compared to MDX4-4210. However, it has been reported that after subjected to environmental variables this elastomer did not retain its improved physical and mechanical properties when compared to MDX4-4210.

Dow corning MichA-2186

Factor Zinc ariz, Cosmosil- principally UK.

Materials of the 3rd Millennium

Remerdale EH stated that the materials of the 3rd millennium are expected to be translucent and should have pigmentation ability to match any skin color, they should have:

- Increased elongation and tear strength.
- Should be easily moldable.
- They should readily accept extrinsic coloration.
- High temperature – metal molds should not be necessary.

Other Products

Primers: Since, the introduction of urethane – lined silicone prostheses, there has been an increased interest in primers used for promotion of bonding between silicone and other maxillofacial prosthetic material 1200, 1205, S-2260,4040.

Adhesives: A variety of adhesive systems have been employed to retain facial prostheses in position. They are commonly classified by the method in which they are dispensed: Parts, liquid, emulsions, sprayers and double sided tapes. Double sided tape is the most commonly used (41%) among patients with facial prostheses because of its ease of application, removal and maintenance.⁸ Most cured silicone, because of their low solubility and low surface energy, will not adhere to conventional tissue adhesive. The single component RTV silicones were developed to serve as adhesives for silicone prostheses (medical adhesive type A).

CONCLUSION

Materials currently available do not completely meet our needs. There are certain advantages and disadvantages of materials. Lots of clinical testing and researches needs to be put on so, that we can get ideal material for facial rehabilitation. Future research should concentrate on two major goals. Firstly, improving the physical and mechanical properties of the material so, that it will behave more like human tissues and increase the service life of the prosthesis.

Secondly, finding the color- stable agents for coloring facial prosthesis and developing a scientific method of color matching to human skin.

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