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Maxillofacial Prosthetic Materials- An Overview

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Abstract

Congenital and acquired defects of the face create an unfortunate condition for the affected individual. To lead a comfortable life patient requires facial rehabilitation. To perform rehabilitation of such patients, reassessment of materials used in the field of maxillofacial prosthesis seems desirable. Maxillofacial material should best suit the ideal selection criteria to satisfy the functionality, biocompatibility, aesthetics as well as the durability. While the new materials have exhibited many desirable properties they have also exhibited some frustrating deficiencies. This article presents a review of the materials used for maxillofacial prosthesis.

Keywords: Maxillofacial rehabilitation; Prosthetic materials

Introduction

Facial defects can be due to congenital, trauma or tumor. Surgical reconstruction may not be possible at all times. In such cases, prosthetic rehabilitation would be an ideal choice of treatment as it restores the normal anatomy and appearance with great psychological benefits to the patient. Different materials have been elaborated in the past literature including ivory, wax, metal, wood and recently polymers. Maxillofacial prosthetic materials are classified in two main groups: Extraoral and Intraoral prosthetic materials. Among extraoral prosthetic materials vinyl chloride polymers, poly (methyl methacrylate), silicone, and polyurethane are discussed for use in facial prosthetics. At present silicones and polyurethane materials are considered most desirable for their strength, even though both are difficult to color.

Intraoral prosthetic materials include silicones, poly methyl methacrylate, Tantalum, Ticonium, Vitallium, and Titanium mesh materials. Here again, silicone is particularly valued for its tissue tolerability. Metallic mesh materials have the advantage of permitting granulated tissue to migrate through the mesh.

Properties

1. Color, texture and translucency must duplicate the missing structure.
2. Material should be light in weight and dimensionally stable.
3. It should be compatible to the tissues.
4. It should be easily cleansable.
5. It should not cause any allergies.
6. It should be easily cleansable with disinfectants.
7. It should be resistant to stains.
8. Material should be stable when exposed to insults like ultraviolet rays, oxygen and adhering material.
9. Material should be easily processed and it should have an increased working time.

Prosthetic Materials

Acrylic Resin

Acrylic resins are a group of related thermoplastic or thermosetting plastic substances derived from acrylic acid, methacrylic acid or other related compounds [1]. Its chemical name is Poly Methyl Methacrylate and is generally called acrylic resin or methacrylic resin [2-5].

Advantages: Better stain protection (washability), Water resistance, Better adhesion, Better blocking ('strap down'), Resist cracking and blistering better, Resistance to alkali cleaners.

Disadvantages: Rigidity, High thermal conductivity.

Acrylic Co Polymer

These are soft and elastic but have not received wide acceptance because they possess poor edge strength, Poor durability, Subject to degradation when exposed to sunlight, Processing coloration is difficult and they are thermal, chemical and photo initiated.

Polyvinyl Chloride and Copolymer (PVC)

PVC was accidentally discovered at least twice in the 19th century, first in 1835 by French Chemist Henri Victor Regnault and then in 1872 by German Chemist Eugen Baumann. It was the most widely used plastics for maxillofacial prostheses.

Advantages: Rigid plastic, Clear, tasteless and odorless, Glass transition temperature higher than room temperature.

Disadvantages: Extend processing time, Shrinkage.

Recently, a co-polymer of 5 to 20% vinyl acetate with the remaining percentage being vinyl chloride has been introduced with greater flexibility but apparently less chemically resistant than polyvinyl chloride itself. The vinyl acetate makes it more stable to heat and light.

Chlorinated Poly Ethylene

Lewis and Castleberry reported similarity of this material to polyvinyl chloride in both chemical composition and physical properties. The processing procedure involves high heat curing pigmented sheets in metal molds.

Polyurethane Elastomers

Polyurethane elastomers contain urethane linkage. The reactants are a polymer terminating with hydroxyl group and others terminating with isocyanate in the presence of a catalyst.

Advantages: Elasticity, they can be colored extrinsically and intrinsically.

Disadvantages: Isocyanate is moisture sensitive, Water contamination is difficult to control, No stable color, Poor compatibility of this material with adhesive systems.

Silicone Elastomers

The silicones were introduced in 1946, but have been used in the fabrication of maxillofacial prosthesis only for the past few years.

Silicon + methyl chloride -> Dimethyl dichlorosiloxane + H2O forms a polymer.

Silicones have a range of properties from rigid plastics through elastomers to fluids. Silicon can be cured at room temperature or heat.

Types

1. Heat vulcanizing.
2. Room temperature vulcanizing.

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.

Room Temperature Vulcanizing Silicones

They are supplied as single - paste systems that are colored by addition of dyed rayon fibers, dry earth pigments and oil paints. They are not as strong as heat vulcanized silicones and they are generally monochromatic.

SILASTIC 382, 399: Viscous silicone polymers, Color stable, Biologically inert.

MDX4 – 4210: Not heavily filled, hence translucent, Adequate tensile strength, Non- toxic, Color stable, Biologically compatible [6].

SILASTIC 891: Udagma and Drane first reported its use, also known as silastic medical adhesive silicone type A and it is compatible with wide range of colorants [7].

Heat Vulcanizing Silicones (HTV)

They are supplied as semi solid or putty like materials that require milling, packing under pressure and a 30-min heat application cycle at 180 degree Celsius. Pigments are milled into these materials as a result intrinsic color can be achieved. They display better strength and color stability than room temperature vulcanizing silicones.

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.

Foaming silicones

Silastic 386 is a form of RTV silicone. The gas forms bubbles within the vulcanizing silicone. After the silicon is processed, the gas is eventually released leaving a spongy material. Formation of bubbles within the mass can cause the volume to increase by as much as seven fold [8]. Purpose of the foam silicon is to reduce the weight of the prosthesis.

Siphenylenes are siloxane copolymer that contain methyl and phenyl groups.

- Improved edge strength.
- Low modules of elasticity.
- Color stability.

New Materials

Acrylic resin copolymer (Palamed - Kulzer)

- Vinyl polymers and co-polymers (Realistic – prosthetic services)

- Polyurethane elastomers – (Epithane – 3 Daro Products)

- Silicone elastomers – RTV and HTV (MD x 4- 4210)

- Silastic 372, 373, Dow corning Mich A-2186 Factor Zinc ariz, Cosmosil – principally, UK).

Silicone Block Copolymer

They are new materials under development to improve on some of the weakness of silicone elastomers such as low tear strength, low elongation and potential to support bacterial and fungal growth.

Materials of the 3rd Millennium

Remerdale EH stated that the materials of the 3rd millenium are expected to be translucent and should have pigmentation ability to match any skin color.

- Increased elongation.
- Increased tear strength.
- Should be easily moldable (clay like consistency).
- Cured with light.
- They should readily accept extrinsic coloration
- .High temperature – metal molds should not be necessary.

Adhesives

A variety of adhesive systems have been employed to retain facial prosthesis in position. They are classified as

a) Pastes, b) Liquids, c) Emulsions, d) Spray-on, e) Double sided tapes.

Cross linking agent – methyl tri acetoxy siloxane

An alternate to reduce the dependency on medical skin adhesives is the use of osseointegrated implants to retain the facial prosthesis.

Coloration

- Coloration of the prosthesis varies with the material used and the preference of the clinician.

Coloration techniques are divided into 3 types:-

a) Extrinsic.

b) Intrinsic, long lasting.

c) Combinations of both is more widely used because it produces prosthesis with a more natural appearance.

Craniofacial and intraoral implant

A review of literature shows that intraoral implants have been designed in a vast array of different sizes, shapes and biomaterials.

Intraoral Prosthesis

With craniofacial implants, one difference is that craniofacial bone sites will differ from intraoral bone sites, as they are thinner, comparatively. The effective implant length in craniofacial sites is often only 3-4 mm [9-13]. The location of the implants is determined based on the surgical template and the availability of bone in the intended area of implantation. If bone replacement is necessary, free bone grafts can be used successfully for augmentation or reconstruction of defects of up to 5 cm in the mandible if the soft tissue bed is sufficient and no irradiation is planned [14]. The implants can be placed immediately at the time of reconstruction or 3 months after bone grafting. In general, a two-stage procedure is used with exposure of the implants and restoration after a healing interval of 3 to 4 months to allow for osseointegration. Dentoalveolar bone and soft tissue defects: eg. In clefts, can also be addressed successfully with distraction osteogenesis prior to placement of osseointegrated implants for dental rehabilitation [15].

Extraoral Prosthesis

Auricular Prosthesis

For fixation of an auricular prosthesis, two to three implants are inserted in a semi lunar fashion as a basis for a bar retained prosthesis. The fitting of the prosthesis can be performed 6 to 10 weeks after implantation [16].

Orbital Prosthesis

An implant-based orbital prosthesis becomes an option if the eyelids cannot be preserved during tumor resection and eye prosthesis alone cannot rehabilitate a patient. The primary locations for the insertion of osseointegrated implants for orbital prostheses are the lateral orbital and infra orbital rims because the bone is sufficiently thick and wide in these areas[17].

Nasal and Midfacial Prosthesis

The aesthetic results of nasal or midface prosthesis depend on the extension of the defect into areas of higher motility in the face where gapping can occur and reveal the margins of the prosthetic device. It can become necessary especially in cases of partial defects to remove tissue. Eg: alar rims, to improve the aesthetic outcome. The adjacent skin is fixed to the underlying periosteum. The residual frontal bone and the zygomatic arches can be used for implantation. Long implants are available for insertion into the zygoma, which provide excellent stability.

Nano Ceramic Fiber Reinforced Silicone Maxillofacial Prosthesis

Surface-treated silica fillers with an increased surface area and a small particle size are an important factor to enhance the physical and mechanical properties of silicone elastomers, which was made using silica fillers essential for enhancing tensile and tear strength, elongation at fractures. Nano ceramic fiber fillers have a large surface area with 200 nm in length and 20 nm in width. However

they have not been investigated to reinforce silicone maxillofacial materials.

Conclusion

Materials currently available do not meet our needs. There are certain advantages and disadvantages in every material. Future research should concentrate on two major goals.

1) Improving the properties of materials, so that it will behave more like human tissue.

2) Color-stable coloring agents for coloring facial prosthesis.

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