Review Article

Materials in maxillo-facial prosthesis

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ABSTRACT

The increase in research in various maxillo-facial materials is due to increase in the prevalence of oral cancer. Materials used for rehabilitation of congenital or acquired defects of patients should fulfill the requirements such as function, longevity, and esthetics. This article provides the evolution, current trends, and future requirements in maxillofacial materials for ensuring psychological well-being.

Key words: Coloring, maxillo-facial prosthesis, silicone

INTRODUCTION

Maxillofacial prosthetics is the branch of prosthodontics concerned with the restoration and/or replacement of the stomatognathic and craniofacial structures with the prosthesis that may or may not be removed on a regular or elective basis (Glossary of Prosthodontic Terms).[1]

Classification of maxillofacial materials:
1. Surgical reconstruction (alloplastic implantable material).
2. Prosthetic reconstruction.

Materials for the surgical reconstruction are Dimethylsiloxane, polyethylene, polyesters, polyamide, acrylic, metals - stainless steel, vitalliun, titanium, and cyanoacrylate.

Prosthetic reconstruction includes materials for Impression phase, modeling phase, and fabrication phase.

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IDEAL REQUISITES FOR MAXILLO-FACIAL MATERIALS

1. Materials used should be biocompatible.
2. Flexibility: Should be flexible at temperatures from 4.4°C to 60°C.
3. Color and Translucency: Color should blend with the adjacent skin as close as possible.
4. Chemical and environmental stability.
5. Thermal conductivity: Poor conductor of heat.
6. Ease of processing and ease of duplication.
7. Weight: Light and easily retained in position and be comfortable to the patient.

HISTORY

Before 1600 AD

Artificial eyes, nose, and ears constructed from waxes, clay, and wood were found by archeologists in the ancient Chinese culture. Artificial eyes have been found in the Egyptian mummies.

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1600-1800 AD

Tycho Brahe replaced his lost nose with an artificial one made of silver and gold, whereas Ambroise Paire[2] is considered to be the first to use obturators to close palatal perforations. In 1728, Pierre Fauchard used the perforations in the palate to retain artificial dentures.

1800-1900 AD

William Morton[2] — fabricated nasal prosthesis using enameled porcelain. Ceramic material was used to fabricate nasal prosthesis by Claude Martin in 1889. Tetamore, in 1894, made artificial nose made of "very light plastic material" which were secured by bow spectacles.

1900-1940 AD

Fabrication of nasal and auricular prosthesis from the vulcanite rubber by Upham. In 1905 Ottofy, Baird, and Baker[2] used black vulcanite rubber. In 1913 gelatin-glycerin compounds were introduced, during the same period Kazanjian used celluloid paints for coloring vulcanized rubber facial prosthesis.

1940-1960 AD

In 1937 Acrylic resin introduced. Tylman[2] introduced resilient vinyl copolymer acrylic resin fonder used auto-polymerizing acrylic resin painted with oil paints for the fabrication of the nasal prosthesis. Clarke (1945) introduced the Latex.

1960-1970

Silicone elastomers were introduced. Banhart[2] was the first person to use silicone rubber for constructing and coloring the facial prosthesis. Tashma used dry earth pigments dispersed in colorless acrylic resin polymer powder for intrinsic coloring of silicone facial prosthesis. During the same time period, Schaaf used artist's oil paint tattooed into the surface of silicone facial prostheses to simulate freckles, blood vessels, and general shading.

1970-1990 AD

Lontz used modified polysiloxane elastomers, the use of isophorone polyurethane was documented by turner. Udagama and Drane[3] introduced the use of Silastic Medical Adhesive Silicone Type A for fabrication of facial prostheses.

1990-present

Advances in polymer chemistry have renewed interest in developing new materials for the facial prostheses. New generations of acrylic resins are being investigated by Antonucci and Stansbury polyphosphazenes for the facial prostheses. Silicone block copolymers are also being evaluated.

MATERIALS

Acrylic resins

Polymethyl methacrylate was used before on the facial defects where the little movement occurs in the tissue bed during the function. Advantages of the material are compatible with most of the adhesive systems; the strength of the material enables feather exposed margins.

Plasticizedmethylmethacrylate

It has been formulated with a foaming agent. As a result of heat or an initiating chemical, a foaming agent releases a gas that is incorporated into the material as it cures. The resulting product is spongy, with a solid skin wherever the material contacts the mold surface. Disadvantage: Tackiness of the surface of the finished prostheses which creates the affinity for the collection of dust, necessitating special cleaning with benzene.

Vinyl polymers and copolymers

Introduced in the mid-1940s as plastisols. Most widely accepted are realistic (polyvinyl chloride) and mediplas (polyvinyl acetate chloride), they are susceptible to the degradation or destruction by UV light, ozone, peroxide, and tetraethyl lead and they are relatively rigid and must be made flexible by the use of a plasticizer.[4]

Chlorinated polyethylene

Described by Lewis and Castleberry, involves high heat curing of pigmented sheets of the thermoplastic polymer in metal molds and coloration using oil soluble dyes. Gettleman reported thermoplastic chlorinated polyethylene 726/19-15 as a potential maxillofacial material. The disadvantage is the use of metal molds.[4]

Polyurethane

Three components of polyurethane are Part A — polyol, Part B — isocyanate, and Part C — initiators such as dibutyltin dilaurate or stannous octoate. Three components must be accurately proportioned and carefully mixed to produce a usable product. The presence of moisture in the air leads to the production of carbon dioxide resulting in the porous elastomer. Linotype metal molds are necessary to control the moisture contamination.[5,6]

Silicones[7]

Long chain molecules composed of alternating chain of silicone and oxygen atoms, by adjusting the length of this silicon-oxygen chain silicones can be produced in the form of fluids, resins, or elastomers (rubbers). They have better physical and chemical properties. The extraordinary properties of silicones are due to the special characteristics of the silicon-oxygen bonds in their backbone. Because the silicon-oxygen bond is much stronger than the carbon-carbon bond of organic polymers, silicones make better electric insulators and are more resistant to oxidation.

Silicones are divided into type main types based on vulcanizing temperature: Room temperature vulcanizing (RTV) silicones and high-temperature vulcanized (HTV) silicones.[5]

Room temperature vulcanizing — silicones

They set by condensation polymerization, stannous octoate is the catalyst, and ortho-alkyl silicate is the cross-linking agent. They are easy to process and allow intrinsic coloration.[8]

Silastic 382, 399

Viscous silicone polymer consists of a filler, stannous octoate as a catalyst, and ortho alkyl silicate as a cross-linking agent. They are color stable, biologically inert, poor edge strength, and difficult to color.

Foaming silicones (Silastic 386)

The form of RTV silicone has limited use in maxillofacial prosthetics. Volume is increased by as much as sevenfold the purpose is to reduce the weight of the prosthesis. It has reduced the strength and susceptible to tearing.

High-temperature vulcanized — silicones

Requires heat for vulcanization, they are highly viscous, white, and opaque. Available as one or two component putty. Catalyst or vulcanizing agent is dichlorobenzoic acid (for condensation polymerization), platinum salts (for addition polymerization). These silicones require advanced equipment for processing and have better physical properties.

PDM siloxane (HTV silicone)

Have improved physical and mechanical properties. The drawback of the material are opaqueness, difficulty in intrinsic coloration, it has high superficial surface hardness, difficulty in processing and does not readily accept extrinsic coloration.[9]

MDX 4-4210

Most common among maxillofacial clinics. Moore reported that it exhibited improved qualities relating to coloration and edge strength. It is not heavily filled, making it translucent. Platinum acts as a catalyst; the cross-linking agent is hydro-methylsiloxane. It has high tensile strength (compared to other RTV silicones). It shows increased elongation and resistance to tear.[10]

Silastic 891: (Silastic Medical Adhesive Type A)

Udagama and Drane first reported the use of this material, also known as Silastic Medical Adhesive Silicone Type A, for the fabrication of the facial prosthesis. They are translucent, nonflowing paste which polymerizes at room temperature in contact with moisture in the air. Metal molds are not used because its surface may react with acetic acid, which is liberated as a by-product of polymerization.[11,12]

RECENT ADVANCEMENTS IN MATERIALS

Silicone block copolymers

To improve some of the weakness of silicone elastomers such as low tear strength, low-percent elongation, and the potential to support bacterial or fungal growth.

Polyphosphazenes

Polyphosphazenes fluoroelastomer has been developed for use as a resilient denture liner and has the potential to be used as a maxillofacial prosthetic material.[16]

Cosmesil

High flexibility with high tear strength contains condensation RTV silicone elastomer. Newer version SM4 is very flexible and very high tear strength.

A-2186 (factor II)

Physical properties better than MDX4-4210. The mechanical properties of A-2186 were less affected than cosmesil by accelerated aging.

Machinable bioactive glass ceramics

Employed in maxillofacial augmentation as a substitute for bone grafts and studies show no inflammatory reaction and rejection of the implant.

OTHER MATERIALS

Adhesives

A material used to adhere external prosthesis to skin and associated structures around the periphery of an external anatomic defect. A single component RTV has been developed to serve as adhesives for silicone prosthesis. Additional research is needed to determine the compatibility of commercially available medical adhesives with different types of maxillofacial elastomers. The compatibility of cleansing solvents with maxillofacial elastomers.

Primers

They Promote bonding between silicone and other maxilla facial prosthetic material. Example: S-2260, A-4-4, 1205, 4040, Z-6032, Z-6076.

Colours

The realistic coloration of external facial prostheses is an important feature for the patient satisfaction and acceptability. Three basic techniques:

1. Extrinsic.
2. Intrinsic.
3. Combination of both.

According to Chalian (1972, 1974), intrinsic coloring in HTV silicones is accomplished with a milling machine. Metallic oxides/pigmented silicone concentrates are generally used and red fibers may be incorporated to simulate the blood vessels. Coloring in RTV silicones (MDX 4-4210) is accomplished by adding various dry earth pigments.[13,14]

Bartlett *et al*. (1971) recommended extrinsic coloring of the maxillofacial prosthesis using medical adhesives. Ouellete (1969) described spray coloring of silicone elastomer maxillofacial prosthesis. According to Schaaf (1970), the color easily peels off or rubs off during manipulation of the prosthesis or during daily cleansing.

Craig evaluated the color stability of 6 MF materials (PVC, polyurethane, Silastic 382, 399, 4-4210, & 4-4515) PVC became lighter after 100 h. Polyurethane disintegrated after 600 h. He concluded that all the silicones exhibited good color stability especially Silastic 4-4210.

CONCLUSION

When reviewing the advantages and disadvantages of each of these materials, it is obvious that no single material is ideal for every patient. Some of the problems inherent in all these materials are[15]:

1. The continued effect of sunlight and vascular dilation and contraction on the natural tissues, which cannot be duplicated in the prosthesis.
2. The variations of skin tone when the patient is exposed to different light sources (e.g., incandescent, fluorescent, and natural light).
3. Emotional factors which cause color changes in the skin.
4. The inability of the prosthesis to duplicate the full facial movement of the nondefective side.
5. Lack of predictability of the life of the prosthesis, because of the variations among the patients (i.e., secretions, smoking and environment).

The ultimate challenge to a maxillo-facial prosthetic material is its clinical performance, Future research should concentrate on two major goals.[17] First: Improving the physical and mechanical properties of the material, so that it will behave more like human tissue and increase the service life of the prosthesis. Second: Finding color-stable coloring agents for coloring the facial prostheses and developing a scientific method of color matching to human skin.

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Conflicts of interest

There are no conflicts of interest.

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