REVIEW ARTICLE

Materials of facial prosthesis: History and advance

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Abstract

The purpose of this paper is to review information regarding prosthetic materials used in the construction of extra oral maxillofacial prosthesis that used to restore missing or defective ear, nose or eye, and their surrounding tissues. There are variety of materials used including acrylic resin and silicon with advanced modifications in recent years.

Keywords: Acrylic resin, facial prosthesis, silicon materials

Introduction

Ear, nose, and eye defects can result from traumatic injuries, surgical resections, acquired infections, congenital anomalies, and burns. Restoration of facial defects can be achieved either by surgical or prosthetic approach or in some complex cases through a combination of both.

In contrast to the small facial defect that can properly restored surgically , large facial defects are challenging for both the maxillofacial surgeons and prosthodontists . When surgical reconstruction is not possible, Prosthetic restoration of the facial defect is a treatment of choice. Pre-surgical records such as photographs, mounted diagnostic casts, and facial cast if available, could facilitate the fabrication of the prosthesis.

The success of the prosthetic rehabilitation of the facial defect limited by mechanical and physical properties of the material selected for that purpose.

Commonly used materials for construction of facial prostheses include but not limiting to: Acrylic resins and its co-polymers, vinyl polymers, polyurethane elastomers, and silicone elastomers, unfortunately none of them fulfill all the ideal requirements for a satisfactory prosthesis.

Review of Literature

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.[1]

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. According to Beder, the first obturator was described in 1541 by Ambrose pare. It consisted of a simple disc attached to sponge.[1]

Tycho Brache (1546-1601), who used an artificial nose made from gold to replace his own nose. Pierre Fauchard (1678) made monumental contributions to prosthetic facial reconstruction. William Morton was credited with the fabrication of a nasal prosthesis from enameled porcelain to match the complexion of a patient.[1]

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 the 19th century, vulcanite rubber was widely used by the dental profession and was adapted for use in the 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. Gelatin-glycerin compounds were introduced in 1913 for use in facial prosthesis to mimic the softness and flexibility. Kazanjian described the use of celluloid prints for coloring vulcanized rubber facial prosthesis.[1]

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 the facial prosthesis. Tashma used dry earth pigments dispersed in colorless acrylic resin polymer powder for intrinsic coloring of a silicon facial prosthesis.[1]

In 1970-1990, Gonzalez described the use of polyurethane elastomer. Lewis and Castelberry described the potential use of siphenylene for the facial prosthesis.[1,2]

Ideal maxillofacial extra oral materials properties

In general, the ideal material for extra oral prostheses include: Biocompatible not irritate the surrounding tissues, yet it should be strong enough about the periphery to endure, be translucent, lightweight, easy to process, and easy to manipulate prior to processing. It should be resistant to various chemicals such as ether and oils and to sunlight, heat, and cold.[2]

Ideal physical and mechanical properties of the maxillofacial materials include

High edge strength, high elongation, high tear strength, softness, compatible to tissue, and translucent.[3]

Ideal processing characteristics of the maxillofacial materials include

Chemically inert after processing, ease of intrinsic and extrinsic coloring with commercially available colorants, long working time, no color change after processing, reusable molds and Retain intrinsic and extrinsic coloration during use.[3]

Ideal biological properties of the maxillofacial materials include

Non-allergenic, cleansable with disinfectants, color stability, inert to solvents and skin adhesives, and resistance to growth of microorganisms.[3]

Materials available for facial prosthesis

Acrylic resin

Acrylic resin, this is used in fabricating both intra- and extra-oral prostheses. In powder form, these resins can be injection and compression molded; or in dough form, they can be molded in gypsum molds. These acrylic resins are derivations of ethylene. The degree of polymerization varies with the conditions of polymerization, such as temperature, method of activation, type of initiator used, and purity of chemicals. Poly (methyl methacrylate) is a transparent resin of remarkable clarity. It is a hard resin with a known hardness number of 18-20.[4]

The resin is extremely stable, it will not discolor in ultraviolet (UV) light, and it exhibits remarkable aging properties. Like all acrylic resins, poly (methyl methacrylate) tends to take up water by a process of imbibition. Since both absorption and adsorption are involved, the term “sorption” is generally used to include the total phenomenon. The sorption of water is nearly independent of temperature from 0 to 60°C but is markedly affected by the molecular weight of the polymer-the greater the molecular weight, the smaller the weight increase. Sorption is reversible if the resin is dried. The prosthesis is usually attached either to the framework of spectacles or to a clip attachment. It is used particularly in those cases in which little movement of the tissue bed takes place during the function.[2]

The material consist of acrylic powder: Polymethyl methacrylate and liquid: Methyl methacrylate and colors that can used: Acrylic base paint used in monomer or chloroform solvent. Heat polymerized is preferred when compared to auto-polymerized because of no residual monomer is more color stable and is free of tertiary amine activator.[2]

Advantages of acrylic resin: Durable, color stable, cosmetic and can be relined or repaired. Disadvantages of acrylic resin: Rigidity, the duplicate prosthesis is not possible, because of the destruction of the mold during processing and Water sorption that cause increased weight 0.5% after 1 week.[2]

Acrylic co-polymers

Although this material are soft and elastic, they have not received wide acceptance due to the poor edge strength, poor durability, subject to degradation when exposed to sunlight, processing coloration is difficult, completed restoration often become tacky, predisposing to dust collection and staining.[3]

Antonucci and Stansburry reported that the new generation of acrylic monomers, oligomers, and macromeres. They are thermal, chemical and photoinitiated. They can eliminate the short comings of traditional acrylic co-polymers.[5]

Polyvinyl chloride co-polymers

In the past, vinyl polymers and co-polymers were popularly and widely used for facial restoration. It consists of a combination of polyvinyl chloride and plasticizer (a hand clear resin that is tasteless and odorless).

Advantages of polyvinyl chloride co-polymers of polyvinyl chloride co-polymers: Flexible, adaptable to both intrinsic and extrinsic coloration, and acceptable initial appearance.[6]

Disadvantages of polyvinyl chloride co-polymers: Plasticizer migration and loss resulting in discoloration, edges tear easily, can be stained easily but degrade when exposed to UV light, absorbs sebaceous secretions, they compromise the physical properties, and require metal molds for curing at high temperature.[6]

Chlorinated polyethylene

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.[4]

Polyurethane elastomers

Polyurethane elastomers serve a variety of commercial uses (epithane-3 facial restorations). They can be synthesized with a wide range of physical properties. They arise from 2 major reactants. In the presence of a catalyst, polymer terminating with an isocyanate is combined with one terminating with a hydroxyl group. The physical properties of final products will change by varying a number of isocyanates.[7]

Advantages of polyurethane elastomers: They can be made elastic without compromising strength, can be colored extrinsically and intrinsically, and superior cosmetic results can be obtained, surpassing the other materials currently available. Disadvantages of polyurethane elastomers: Difficult to process consistently, moisture sensitivity of isocyanate, water contamination is difficult to control and not color stable, poor compatibility of this material with adhesive systems.[7]

Silicone elastomers

The silicones were introduced in 1946 but have been used in the fabrication of maxillofacial prosthesis only for the past few years. Silicones consist of alternate chains of sodium and oxygen which can be modified by attaching various organic side groups to the silicon atoms or by cross-linking the molecular chains.[3]

Silicones have a range of properties from rigid plastics through elastomers to fluids. They exhibit good physical properties over a range of temperatures. Silicon can be cured at room temperature or heat.[8]

Silicones are classified into 4 groups according to their applications:

Class I: Implant grade, this material should undergo extensive testing, and must meet FDA requirements.

Class II: Medical grade, this material is used for construction of maxillofacial prosthesis.

Class III: Clean grade.

Class IV: Industrial grade commonly used for industrial applications.[2]

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Silicones consist of chains of alternate silicone and oxygen atoms which can be modified by attaching various organic side groups to the silicone atoms or by crosslinking the molecular chains. Silicones range from rigid plastics through elastomers to fluids. As a material for maxillofacial prostheses, silicones exhibit weathering properties and maintain good physical properties over a wide temperature range.[3]

Room temperature vulcanization (RTV) silicones

The RTV silicone rubbers are composed of comparatively short chain silicone polymers which are partially end-blocked with hydroxyl groups. Fillers are added to strengthen the final rubber. Gypsum molds are used in fabricating prostheses from RTV silicone. Among RTV silicone materials, Silastic 382 and Silastic 399 (Dow Corning Corp.) are most widely used.[3]

Silastic 382 is an opaque white fluid with a viscosity like that of thick honey. It sets up to a rubber with the evolution of heat within a few minutes after its catalyst, stannous octoate, is incorporated. Silastic 399 resembles white vaseline in its raw state. It is easily spatulated but is non-flowing. When mixed with catalyst 1, the crosslinking agent, it becomes somewhat milky, but it can be worked for several hours. When catalyst 2 is added, it sets up to a translucent rubber in 10-15 min. This was especially devised at the request of the maxillofacial prosthetist for a version of Silastic 382 that would be tougher, translucent, no flowing, and easier to handle. Color can be introduced either intrinsically or extrinsically, and the prosthesis is attached by means of an adhesive.[3,4]

Heat-vulcanizing silicones

The Dow Corning Center for Aid to Medical Research recently developed the heat-vulcanizing "clean room" Silastic MDX4-4514, MDX4-4515, and MDX4-4516 for use in maxillofacial prosthetics. General Electric also produces heat-vulcanizing silicones for the same purposes.[10]

Formation of a heat-vulcanizing silicone rubber involves the use of a diorganopolysioloxane, such as polydimethylsiloxane heated with benzol peroxide. Thus, the two polymers are cross-linked with benzoic acid formed by a by-product.[11]

Recent advances in facial restoration materials

Silicone block co-polymers

It has been introduced to improve some of the weaknesses of silicone elastomers (e.g. decreased tear strength, low percent elongation and its susceptibility to bacterial growth).

Polyphosphazenes: Fluroelastomer developed for use as a resilient denture lining material, and as a maxillofacial prosthetic material. Cosmesil: It is an RTV silicone showing a high degree of tear resistance.[1]

Foaming silicones

Silastic 386 is a form of RTV silicone. The gas forms bubbles within the vulcanizing silicone. When the silicon is processed, the gas is eventually released; leaving a spongy material. The advantage of this silicon type: Bubbles formation within the mass causing the volume to increase by as much as seven-fold. The purpose of the foam silicon is to decrease the weight of the final prosthesis.[1]

Pigments used with extra-oral maxillofacial prosthesis materials

Supplied in: Base Shades: For basic skin color and compliments color: For alteration. Clean room heat-vulcanizing silicone comes in a milky color to be used for extraoral prostheses, it should be colored to match the skin; and there are two ways of doing this: Extrinsic and intrinsic. In extrinsic coloring, the pigments in the form of paints or dyes are applied directly to the surface of the finished prosthesis.[3]

In intrinsic coloring, the pigments are added directly to the silicone prior to curing, and this produces a far more satisfactory color and texture. In fact, the intrinsic method of coloring is very similar to nature's way of imparting color to skin. Skin color is not produced by pigments at the surface of the skin, but by the color of blood and pigments within the tissues of the skin.[3]

A prosthetic restoration colored by the intrinsic method will retain its color. Furthermore, there is no risk of the pigments wearing off of the surface of the prosthesis. Almost any color is possible in silicone rubber when the pigments used are heat-stable, do not react with vulcanking agents on the properties of the finished rubber parts, and do not contain so much filler or additive material as to overpower the coloring properties.[2]

Pigments used with silicone rubber are nearly always inorganic compounds such as metallic oxides. Determining the concentration of pigments needed to obtain the desired color is primarily a trial-and-error procedure.[2,3]

The pigment is placed in a small quantity of silicone rubber and run through the mill until it is thoroughly incorporated. The different color pigments are added until the desired skin tone is attained. Since the silicone should not be contaminated while being packed into the mold, the operator's hands should be clean or gloves should be used.[3,6]

Thixotropic agent and silicone fluid

The viscosity of the chosen silicone elastomer may not always suit the handling requirements of the prosthetist. By addition thixotropic agent, a higher viscosity may be achieved which will afford greater control of the material and a reduction of trapped air voids. The addition of silicone fluid will lower the viscosity of silicone elastomer.[2]

Characterization materials

Hair: Sometimes it difficult to provide the depth of hair volume by incorporation of hair. It is easier to create the illusion of hair by providing a base of shade for the hair that will be incorporated.

Moustaches, Beards hair can be pre-made: Hair attached to nylon-netting or hand-made that gives a superior result.[2]

Adhesives for facial prosthesis

A variety of adhesive systems has been employed to retain the facial prosthesis in position. They are classified as (a) Pastes, (b) Liquids, (c) Emulsions, (d) Spray-ons, and (e) double sided tapes with last one most common used (41%) among patients with facial prosthesis because of its easy manipulation.

An alternative to reduce the dependency on medical skin adhesives is the use of osseointegrated implants to retain the facial prosthesis.[2,3]

Conclusion

- The success of the prosthetic rehabilitation of the facial defect limited by mechanical and physical properties of the material selected for that purpose.
- Commonly used materials for construction of facial prostheses include but not limiting to: Acrylic resins and its co-polymers, vinyl polymers, polyurethane elastomers, and silicone elastomers, unfortunately none of them fulfill all the ideal requirements for a satisfactory prosthesis.

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