Review Article

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Every Tick of a Clock Formulates History: Past to Present Maxillofacial Prosthetic Material: A Review

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ABSTRACT

Background: Increasing demand for a better appearance in patients with disfigured or missing part of the maxillofacial skeleton has encouraged dentists and researchers to come up with newer technologies and material. Maxillofacial prosthesis was first described by French surgeon Ambrose Pare in 1575.Today, with the advent of newer techniques, material, enhanced skill and knowledge; it is easier to rehabilitate oral and facial defects. Although there is a tremendous improvement in the material science and technologies still the quest continues for an ideal biomimetic material.

Keywords: Maxillo-facial materials, room temperature vulcanized, silicone block co-polymer, silicones.

INTRODUCTION

Face is an image of self, delineated in terms of approved social attributes. As the father of Indian surgery Sushrutha Samhitha said hundreds of years ago, "The love of face is next only to the love of our life". Thus, people having severely disfigured or missing parts of the maxillofacial skeleton or the face in particular come up for a normal appearance by artificial restorations to us[1].

The history of masking maxillofacial defects dates centuries back when the Egyptians and Chinese used wax and resins to reconstruct missing portion of the head and neck region. Maxillofacial prosthesis was first described by French surgeon Ambrose Pare in 1575[2]. Hence the quest for an ideal material started since 1500 A.D. Today, with the advent of newer techniques, material, enhanced skill and knowledge, it is easier to rehabilitate oral and facial defects.

HISTORY OF ORAL AND MAXILLOFACIAL PROSTHETICS:

Before 1600 A.D:

The origin of prosthetic reconstruction of facial defects has not been documented by historian, but archaeologists have found artificial nose, eyes and ears constructed from waxes, clay and wood in ancient Chinese culture. In 1510-1590, a famous French surgeon, Ambroise Pare, was the first to describe the fabrication of nasal prosthesis using gold, silver, paper and linen cloth glued together. He gave us an excellent description of a simple and very practical obturator for closing a perforation of a hard palate. In one of the variation he used dried sponge which was attached to the upper surface of the obturator, such that when it gets moist it expands and is held in position. In other variation he used a mechanical button to lock the obturator in place. Tycho Brahe (1546-1601) used an artificial

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nose made from gold to replace his own nose which was lost in a duel[3].

1600-1800:

Pierre Fauchard made a monumental contribution to prosthetic facial reconstruction[3, 4]. He made a silver mask to replace the lost portion of the mandible for a French soldier, Alphonse Louis. The silver prosthesis was painted with oil paint and margin of the prosthesis was covered by facial hair.[3]

1800-1900:

William Morton (1819-1868) fabricated a nasal prosthesis using enameled porcelain to match the patient complexion. Kingsley (1880) described a combination of nasal-palatal prosthesis.[3, 4, 5] Claude Martin (1889) fabricated nasal prosthesis using ceramic material[3, 5].

1900-1940:

By the end of 19th century, vulcanite rubber was widely used by dental profession. Upham describe the use of vulcanite to fabricate nasal and auricular prosthesis [3, 5.] In 1905 Ottofy, Baird and Baker all reported using black vulcanite as a foundation for nasal prosthesis. The rigidity of the vulcanite rubber presented a problem when adapted to facial skin.[3] In 1913- gelatin glycerin compound were introduced for use in facial prosthesis in order to mimic the softness and flexibility, of human skin[3,4] but there life span was too short for practical clinical application.[3,5]

1940-1960:

Acrylic resin was replaced by vulcanite rubber in 1937[3, 5]. It attracted most of the clinician because of its colorability and ease of processing, inspite of its rigid behaviour. To overcome the rigidity problem of acrylic resin, Tylman introduced the use of a resilient vinyl copolymer acrylic resin. Henry Bigelow used transparent photographic paints for coloring an acrylic resin facial prosthesis.[3]

1960-1970:

Various elastomers had arrived which brought about a change in the fabrication of facial prosthesis. Silicon elastomers had gained popularity among clinician. Barnhant was the first to use silicon rubber for constructing and colouring facial prosthesis[3].

1970-1990:

Lontz used modified polysiloxane elastomers. Gonzalez described the use of polyurethane elastomers.[3] Turner used isophorone polyurethane for facial prosthesis. Lewis and Castleberry described the use of siphenylenes for facial prostheses.[3, 5]

1990 till present:

New generation of acrylic resins are being investigation by Antonucci and Stansbury. Gettleman described the use of Polyphosphazenes for facial prostheses. Silicon block copolymers are also being evaluated. Advanced technology like CAD –CAM technology are being introduced and being extensively used in field of maxillofacial prosthesis.[3]

CLASSIFICATION OF MAXILLOFACIAL PROSTHESES MATERIAL:

According to Beumer [4, 7]

1) Acrylic resin
2) Acrylic copolymer
3) Polyvinyl chloride and copolymer
4) Chlorinated polyethylene
5) Polyurethane elastomers
6) Silicones elastomers-HTV, RTV, Foaming Silicones
7) New material- Silicone block copolymer, Polyphosphazenes

MATERIAL USED IN MAXILLOFACIAL PROSTHESIS

Acrylic resins:

Mainly used in situations where there is little movement of tissue bed during function such as orbital or ocular etc[8]. According to Andreotti AM et al, nano particle incorporation in acrylic resin directly influenced the acrylic resin properties, providing general higher color stability and micro hardness values and lower flexural strength values, after accelerated aging[9]. Visible light cured resin is also being used. Which has organic filler made of acrylic resin beads of different sizes that become part of the polymer network structure upon curing?

The matrix is a urethane dimethacrylate with micro fine silica and contains a camphoroquinone amine as photoinitiator[5].

Advantages.[2, 4, 5,8,10]

1) Easy availability.
2) Colour stability.
3) It can be relined and repaired.
4) It has good strength.
5) It can be fabricated with feather margin.
6) Good shelf life of about two years.

Disadvantages-[2, 4, 5,8,10]

1) They are rigid.
2) Have water absorption that causes increased weight 0.5%after 1 week.
3) Duplication is not possible.

Acrylic Copolymers (Palamed, Polyderm):

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[9,10]. New generation of acrylic monomers macromere and oligomers are thermal, chemical and photo initiated and can eliminate the short comings of traditional acrylic co-polymer[10].

Polyvinylchloride and copolymer-

A clear, tasteless and odorless material and has been used widely for maxillo-facial applications with advantages like being flexible, adaptable to both intrinsic and extrinsic staining. Plasticizers are added to produce an elastomeric effect at room temperature. Other ingredients include cross-linking agents for added strength and ultraviolet stabilizers for colour stability [2]. Disadvantages of polyvinyl chloride co polymer: Edge tears easily, absorb sebaceous secretion, they compromise the physical properties, it requires metal molds for curing at high temperature[11].

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.[12] Chlorinated polyethylene elastomer appears to be a suitable substitute for silicones for the fabrication of extra oral maxillofacial prosthesis in situations where cost of silicone is prohibitive[13].

Polyurethane elastomers:

Polyurethane elastomers contain a urethane linkage. The reactants are a polymer terminating with isocyanate group and others terminating with hydroxyl in the presence of a catalyst. They can be synthesized with a wide range of physical properties by varying the reactants and their amounts [10, 14].

Advantages: [15]

1) They can be made elastic without compromising strength,
2) It can be colored extrinsically and intrinsically,
3) Superior cosmetic results can be obtained, surpassing the other materials currently available

Disadvantages [15]

1) Difficult to process consistently,
2) Moisture sensitivity of isocyanate.
3) Water contamination is difficult to control and
4) Not color stable,
5) Poor compatibility of this material with adhesive systems.

Silicones:

Silicones are probably the most widely used materials for facial restoration nowadays. It was introduced first time by Barnhart in (1960) for making, extra-oral prosthesis. Chemically, they are termed as polydimethyl siloxane[8,9].Silicones are categorized into implant grade, medical grade, clean grade and industrial grade based on application. Facial prosthesis is primarily made of medical grade silicones. Silicon is combined with methyl chloride to form dimethyl dichlorosiloxane, which when reacts with water forms a translucent watery, white polymer, Poly Dimethyl Siloxane[9]. Fillers are added to increase the strength of the polymer. Cross linking agents are added to silicones to make it resistant to degradation when exposed to

environmental factors. The process of cross linking is called vulcanization. Depending whether the vulcanizing process uses heat or not, silicones are available as heat vulcanized (HTV) or room temperature vulcanized (RTV) [9]

CLASSIFICATION OF SILICONE [7]

A) Based on the Mechanism.
1) Room temperature (RTV)
2) High temperature (HTV)
B) According to Application
1) Implant grade
2) Medical grade
3) Clean grade
4) Industrial grade
C) Based on chemistry
1) Polydimethyl siloxanes
2) Methyl vinyl /dimethyl siloxanes.
3) Phenyl methylsiloxanes
4) Fluoro dimethyl siloxanes

RTV Silicones:

It is a viscous silicon polymer in which stannous octate is used as a catalyst; filler used is diatomaceous to increase strength of final rubber and orthoakyl silicate as cross linking agent [5, 8]. They are used more often than any other silicon It is a type of silicone rubber made from a two-component system available in a hardness range of very soft to medium .gypsum mould are used in fabricating prostheses from RTV silicones.[9]

Types of RTV

1) condensation type:

- Orthoalkyl silicate crosslinking agent.
- Stannous octate catalyst.

2) Addition type:

- Hydro-methyl siloxane cross-linking agent.
- Chloroplatinic acid catalyst

Advantages –

1) Esthetics
2) Ease of coloring
3) Ease of manipulation
4) Thin margin possible
5) Adhesive compatibility

Disadvantages-

1) Discoloration over time
2) Technique sensitivity
3) Extrinsic colour peel/fade
4) Lack of reparability.

EG: Silistic 382,399, foaming silicone (silastic 386), MDX 4-4210

A-2186(factor II), Cosmesil

Silastic 382,399:

They are viscous in nature and it require stannous as a catalyst and ortho alkyl silicate as a cross linking agents and filler such as silica or diatomaceous earth are added to increase the tensile strength[6].Polymerization occurs via condensation reaction[9].

Advantages [6]:

1) Biologically inert.
2) Colour stability.
3) Easy to process.

Disadvantages [6]:

1) Poor edge strength.
2) Difficult to colour.

MDX 4_4210:

It is a Low temperature, vulcanizing silicone polymer and is provided as a two component kit. The polymerization reaction take place by addition reaction with no by product is formed .In a survey by Andres, 41% of clinicians used this material for maxilla prosthesis fabrication. Moore reported that it exhibits improved qualities relative to coloration and edge strength[5].

Advantages:

1) Adequate tensile strength.
2) Non-toxic
3) Color stable and
4) Biologically compatible.

Cosmesil/silskin2 system:

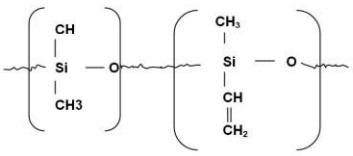
G L Polyosis stated that ,cosmesil k10 showed physical properties similar to those of MDX4-4210.cosmesil is acceptably biocompatible for its intended use where there may be contact with internal tissue space that are contagious to external surface[17]. Begara et al studied that addition of Zn nano-oxides in lesser concentrations provided significant and consistent ultraviolet protection in Cosmesil elastomers [18]. Akash et al suggest that

incorporation of nano-oxides improved the color stability, ZnO-incorporated Cosmesil specimens showed minimal or no color change and proved to be most color stable after being subjected to outdoor weathering[19]. As describe by Woofaardt this material can be processed to varying degree of hardness. According to Mohammad S. A et al polyhedral silsesquioxane (POSS) nanoparticles have the ability to provide reinforcement to maxillofacial materials and potentially to other elastomeric

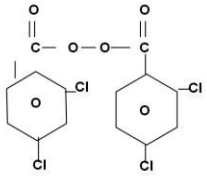
Systems. Liu Q et al characterized its biomechanical properties of a modified silicone elastomers filled with expancel hollow microspheres and concluded that composite with a volume fraction of 5% exhibited the optimal properties for use as a maxillofacial prosthesis, though its tear strength was markedly lower than that of silicone. Wang et al studied the cytotoxicity of Nano-TiO2 Silicone Elastomers after artificial aging and showed preliminary long-term biocompatibility of the composite[18].

HTV:

It is usually white, opaque material with a high viscous and a putty like consistency .The vulcanisation is achieved by addition reaction The component of heat vulcanized silicones are a polymethylvinyl siloxane copolymer with approximately 0.5% vinyl side chain,2-4-dichlorobenzoyl peroxide as an initiator, catalyst used is platinum salt and a silica as filler obtain from burning methyl silane[2].



Polydimethyl Vinyl Siloxane



2.4 dichloro benzoxl peroxide

HTV silocones have better physical properties especially tear strength than RTV silicones. This material is not as elastic as then MDX 4-4210 as it is not applicable in situation like mobile tissue beds. They exhibit excellent thermal and color stability when it is exposed to u.v light. Harbi et al studied the mechanical behaviour and colour changes of HTV (Tech Sil S25) and RTV (A-2186) elastomers after outdoor weathering in a hot and humid climate. Then heat polymerizes elastomers shows better mechanical durability and color stability then room temperature polymerizes material[9].HTV require advanced equipment for processing.

Advantages: [2]

1) Excellent tear strength
2) Excellent thermal and chemical stability
3) Excellent colour stability

Disadvanges: [2]

1) Poor esthetics due to opacity
2) Low edge strength
3) Less elasticity
4) Technique sensitive

Important HTV's include:

1) Silastic 370, 372, 373, 4-4514, 4-4515
2) PDM siloxane
3) Q7-4635, Q7-4650, Q7-4735, SE-4524U

Silastic 370, 372, 373, 4-4514, 4-4515:

This is white opaque material; highly viscous and putty like consistency .it is compose of dichlobenzoyl peroxide or platinum salt as a catalyst and silica as filler. It has excellent thermal stability and colour stability and biologically inert[4].

PDM SILICONES:

It was developed by veterans administration and was reported by LONTZ and SCHWEIGER.[4].It has improved physical and mechanical properties with high superficial surface hardness the drawback of this material is that it is difficult in processing and difficult in intrinsic and extrinsic coloration[6].

Q7-4635, Q7-4650, Q7-4735, SE-4524U:

This is a new generation material and was evaluated by Bell and is available as a single component system .It shows improved physical and mechanical properties as compared to RTV's[20].

Recent advancement in facial restorative material is:

1) Silicone Block Co-Polymer
2) Foaming Silicones

3) Polyphosphazenes
4) Factor Ii (A-2186)

SILICONE BLOCK CO-POLYMER:

It is introduced to improve some of the drawbacks of silicone elastomers, such as decreased tear strength, low percent elongation & bacterial growth over prosthesis [4, 10]. In this block of polymer other then siloxane are positioned with the traditional siloxane polymer in an attempt to modify the current physical properties of conventional silicones .The foreign and hydrophobic nature of silicones has been proven to cause problem by interacting with the body on a molecular level, and thus can leads to foreign body reaction ,silicone block copolymer can to some extent overcome these problem by incorporating amphiphilic polymer, hydrophilic portion of which provides improved wettability and thus tissue compatibility[8,17].

POLYPHOSPHAZENES:

It has been developed for the use as a resilient liner and has the potential to be used as a maxillofacial prosthetic material. Research in new Orleans dealt with the maxillofacial prosthetics ,have found that compounding polyphosphazenes with little or no filler and decrease the ratio of acrylic to rubber yield a softer rubber with a HD_A of 25, similar to human skin[9,16].

Foaming silicones:

Silastic 386:

The purpose of this material is to reduce the weight of the prosthesis. I t is a type of RTV silicone which when mixed with stannous octate (catalyst) gas is released. The formed gas produce bubbles within the vulcanized silicone. When 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 7 times[4]. However the formed material has reduced strength and is susceptible to staining leading to weakning of the material. This weakness can be overcome partially by coating foam with another silicone which adds strength but increases stiffness[5].

Siphenylenes:

siphenylenes are siloxane co-polymer that contain methyl and phenyl group These polymer are transparent even when it is reinforced with silica filler. These polymer posses many desirable properties that of RTV silicones, in addition they exhibit improved edge strength, low modulus of elasticity and colourability[21].

A-2186 (Factor II):

It is a clear-to-translucent two-part (10:1 base: catalyst) pourable silicone. A fast polymerization rate version of A-2186 with higher platinum content, "A-2186F," became commercially available in 1987, though it was not a very preferred material for prosthesis purpose. In 2000, Factor II introduced A-2000 as the first generation of a 1:1mixture platinum silicone followed by A-2006 in

2006. Sara M. Zayed et al concluded that the incorporation of surface treated SiO2 nano particles at concentration of 3% enhanced the overall mechanical properties of A- 2186 silicone elastomers. A-2186, which is made by modification of the polymer chain, had greater tear resistance, tensile strength, a larger percentage of elongation and also proved to be softer at the surface than HTV silicones and many other RTV silicones. It also demonstrated absence of cytotoxicity in the cell culture tests[9].

ADJUVANTS

PRIMER: [22]

They promote bonding between silicone and other maxillofacial prosthetic material[5].

EX----S-2260, A-4-4, 1205, 4040, Z-6032, Z-6076

ADHESIVES: [22]

It is a material used to adhere external prosthesis to skin and associated structures around the periphery of an external anatomic defect. 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. A single component of

RTV has been developed to serve as adhesive for silicone prosthesis.

Coloration

Color matching has always been a challenge to the maxillofacial prosthodontists. Matching accurate color information of human skin is an important step in the fabrication of facial prosthesis. Colorants are dyes or pigments that give color to otherwise colorless objects or modify perceived color. When prosthesis is indiscernible to the surrounding skin, there will be best esthetic outcomes[23].

Coloration techniques can be divided into 3 groups:

1) Extrinsic
2) Intrinsic or
3) Combination technique

The combination technique is widely used because it produces prosthesis with a more natural appearance. The color match of the prosthesis depends largely on the skill of the clinician, color activity of the individual and light source.

INTRINSIC COLORATION

Intrinsic coloration is the color applied within the mold during the casting procedure. Knowledge of primary, secondary and complementary colors is helpful in selection of chroma.

Primary colour

A) Red
B) Yellow
C) Blue

Secondary colour

a) orange
b) green
c) violet

Combination colour

a) red-green
b) yellow-violet
c) blue-orange.

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. Bartlett et al. (1971) recommended extrinsic coloring of the maxillofacial prosthesis using medical adhesives [23].

Ouellete (1969) described spray coloring of silicone elastomers maxillofacial prosthesis. According to Schaaf (1970), the color easily peels off or rubs off during manipulation of the prosthesis or during daily cleansing [6]. 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 [21].

CONCLUSION

Prosthetic restoration of maxillofacial defects is an ancient art, in which success has always been limited by the unavailability of adequate materials. Although there is a tremendous improvement in the material science and technologies, there is still no ideal material that resembles or duplicates human skin.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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