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LITERATURE REVIEW

Reconstructing Smiles: Maxillofacial Prosthesis

Prachi [a], Peela Prasuna [a], Shafath Ahmed [b], V Vidyashree Nandini [b]

ABSTRACT

Maxillofacial prosthesis are required for the reconstruction of head and neck deformities in patients with congenital anomalies or defects which are accquired like trauma, surgery, infection, burns, or cancer . These defects might need both extraoral and intraoral prosthetic rehabilitation .These deformities negatively affect the quality of life. These defects might be anything from cosmetic imperfections to serious practical limitations. In addition to addressing the functional and aesthetic impairment, the prosthodontic therapy of these patients should focus on ensuring psychological wellbeing. An evaluation of the materials used in maxillofacial prostheses is required for facial rehabilitation. We have encountered a variety of materials up to this point, each of which has both great qualities and drawbacks. The various materials utilised in maxillofacial prosthetics will be reviewed in this article.

Key words: Bionic, Maxillofacial defect, Rehabilitation, Silicone, Siphenylenes, Polyphosphazenes.

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INTRODUCTION

The art and science of reconstructing maxilla, mandible or facial regions which are deficient or missing due to developmental or congenital malformations, trauma, pathology, surgical intervention, by using artificial substitutes to restore the form, function and aesthetics is known as maxillofacial prosthetics.[1]

Success in the field of maxillofacial prosthodontics depends greatly on having the right knowledge of the associated dental material sciences, just like it does in any other dental specialty. A capable dentist would use this knowledge to create prostheses with the highest possible longevity, functionality, and aesthetics. Facial and body prostheses are made of a variety of materials. The complete spectrum of chemical structures is covered by the materials used for maxillofacial prosthetic reconstruction and physical characteristics which ranges from hard and stiff materials like alloys, ceramics and polymers to soft and flexible polymers such as plastisols and latex.[2]

Efforts have been made in recent years to identify more palatable materials and increase the calibre of maxillofacial prosthetics materials. In this article, the materials utilised in maxillofacial prosthetics are in-depth reviewed.

IDEAL REQUIREMENTS OF MAXILLOFACIAL MATERIAL

Important standards for maxillofacial prosthetic materials were established in 1971 by Chalian, Drane, and Standish. These standards included retention and durability, ease in application, colour stability, being non-toxic, having strong periphery, translucency of material, easy to clean, light in weight, easy to fabricate, and having inert physical and chemical properties .[3] (Fig 1)

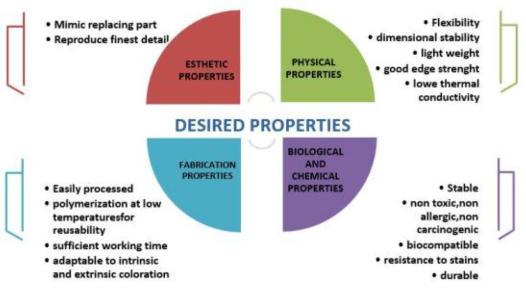

Figure 1: Ideal Requirements of Maxillofacial Material

HISTORY

The history of maxillofacial materials can be traced back to ancient times when Egyptians and Chinese used waxes and resins for the reconstruction of missing portions of maxillofacial complex.[4] (Fig 2) Ambrose Pare, a surgeon in the French military services, used prosthesis for the first time in the history of maxillofacial rehabilitation. He made use of leather, metal bands, leather, and silver. He is referred to as the Father of Facial prosthesis.[5]

[a] Intern, Department of Prosthodontics, SRM Kattankulathur Dental College, SRM University, Kattankulathur, India
[b] Professor, Department of Prosthodontics, SRM Kattankulathur Dental College, SRM University, Kattankulathur, India

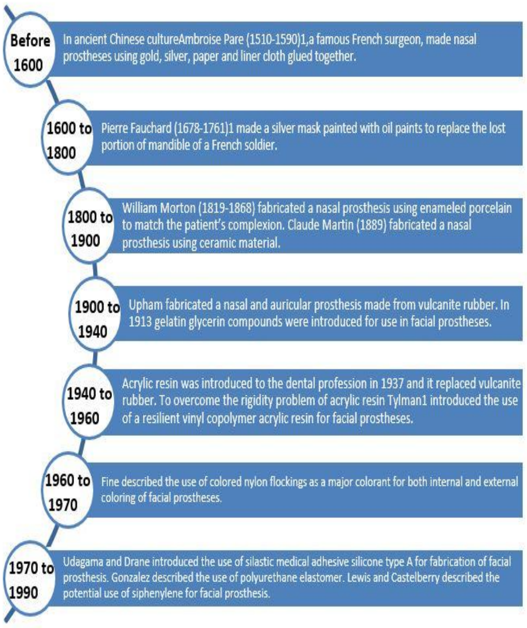

Figure 2: History of Maxillofacial Material

CLASSIFICATION OF MAXILLOFACIAL MATERIAL (Fig 3)

ACRYLIC RESIN AND COPOLYMER

Acrylic resin:

Historically, maxillofacial prosthesis frequently employed polymethyl methacrylate, which is still used at times to create prosthetic facial components. It can be used to treat certain types of face deformities, especially when there is minimum movement of tissue bed (such as fabrication of ocular prostheses).[2]

The ease of availability, colour stability, relining and reparability, high strength, and shelf life of acrylic resin are its benefits. Low edge strength and durability, and degradation upon exposure to sunlight are drawbacks of acrylic resin.

Acrylic copolymer:

Acrylic copolymer consists of esters of acrylic and methacrylic acid. It is in liquid form in the monomer state which on processing convert to polymeric form. It has a sponge like centre and a continuous skin like covering.[9] These materials are soft and elastic.

Disadvantages include poor durability, weak edge strength, and vulnerability to disintegration when exposed to sunlight. Additionally, full restoration is frequently tacky, making it more susceptible to direct collection and stains.[24]

Acrylic copolymer can be:

i. Mediplast – It is a heat cured plastisol that is a polyvinyl organic compound. It comes in premixed base colours which can be tinted to match the patients' skin tones. Fine margins can be produced with mediplast.[10]

ii.Realastic – It is a polyvinyl chloride compound in plasticizer which solidifies into a flexible material when heated. It is available in 16 different basic skin colour shades from pallid to Negroid. It takes both extrinsic and intrinsic stains.[4]

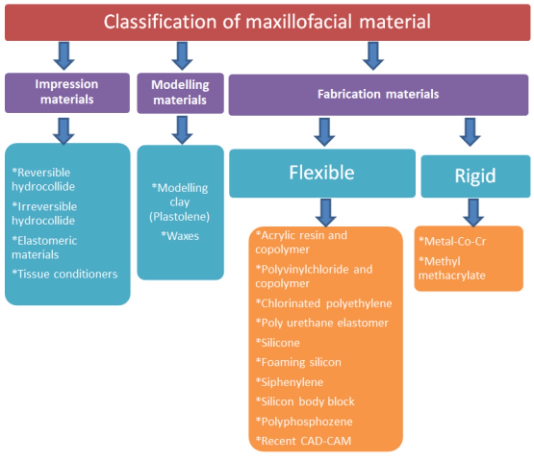

Figure 3: Classification of Maxillofacial Material

POLYVINYL CHLORIDE AND COPOLYMER

Polyvinylchloride was frequently utilised for maxillofacial applications. It has never been replaced completely because of material with better qualities. Clear, odourless, and stiff polyvinyl chloride has a glass transition temperature that is greater than room temperature.

According to Clarke, the first developed vinyl resin was in 1833. Ivan Ostromislensky invented the resin from plasticized form of polyvinyl chloride in 1929. The first Polyvinyl Chloride designed for prosthetic purpose was produced by Vrenon Ben shoff Co. in 1943 as lightly packed plasticized resins. This substance, which is now the most popular in the arena of facial and stomatognathic prosthesis, can replace the structure of the face in an attractive and simple way.[11]

Recently, copolymer comprising of 5 - 20% of vinyl acetate and the remainder percentage vinyl chloride was developed. This copolymer has higher flexibility than polyvinyl chloride alone; it appears to be less chemically resistant. It is more heat- and light-resistant thanks to the vinyl acetate.[2] Adequate flexibility and adaptability to intrinsic and extrinsic coloration are benefits.

The disadvantages include the loss of plasticizer which leads to discoloration and hardening in the margin area, inadequate dimensional stability. When exposed to UV light, these materials are easily stained and degraded. They require metal moulds for high-temperature curing, lacks natural translucency and has a tendency to absorb sebaceous cosmetics and solvents. If the edges are thin, they may need to be reinforced with nylon fabric. They have a shorter lifespan of 3 -6 months.[25]

CHLORINATED POLYETHYLENE ELASTOMER

A thermoplastic elastomer of industrial quality, it was created by Dow Chemicals and first offered by Lewis and Castleberry. These work well as silicone substitutes.[1]

Less toxic, non-carcinogenic, and less irritation to the mucosa are benefits.

POLYURETHANE ELASTOMER

A urethane linkage is present in polyurethane elastomers. In the presence of a catalyst, reactants present are polymers that end in hydroxyl groups and those that end in isocyanates. By changing the reactants and their concentrations, a wide range of physical characteristics can be synthesized. Chemical structure includes an extended chain of aliphatic diisocyanate groups, a chain of polyol groups (a mixture of polyesters), and an organotin catalyst for the process of polymerization as maxillofacial prosthesis frequently need improved softness and flexibility.[26]

It is suitable for defects with movable tissue beds.

Calthane and Epithane-3 are the polyurethanes which are available presently for maxillofacial prosthesis material.[12]

Advantages include Environmental stability, higher tear resistance, Good ultimate tensile strength and accept intrinsic colouration.

Whereas the drawbacks are poor stability of colour, inferior compatibility with adhesive, sensitivity to moisture and toxicity (diisocyanate).

SILICONES

These are arguably the most popular materials used for reconstruction of facial structure. But these materials have unfavourable characteristics that make it difficult for all clinician to employ them.

They were first used for maxillofacial applications in the late 1960s after being introduced in the middle of the 1940s. By fusing silicone rubber foundation material along with acrylic resin polymer stains, Barnhart (1960) was the first to employ silicone rubber for creating and colouring face prosthetics.[1]

They are made up of organic as well as inorganic substances.

Chemically, it is referred to as polydimethyl siloxane. Silica is converted to elemental silicone as the mechanism of action. The silicone is next mixed with methyl chloride to form dimethyl dichlorosiloxane, which when combined with water produces a polymer.

Silicone Elastomers are mainly of two types:

1. RTV- Room temperature vulcanizing
2. HTV- Heat vulcanizing

ROOM TEMPERATURE VULCANIZING SILICONE ELASTOMERS

These consist of a filler, a stannous octate catalyst, and an orthoalkyl silicate cross-linking agent. They are viscous silicone polymers. Diatomaceous earth is typically used as a filler to increase strength. RTV rubbers can employ either stannous octate or dibutyl tin dilaurate as a catalyst. While vulcanization occurs quickly with stannous octate, dibutyl tin diaurate takes longer to set.[6]

The benefits are Use of stone molds, Ease of colouring and Biological inertness. Drawbacks include hydrophobic nature, Selective adhesive property and lack extrinsic colouration

Some examples include:

•**Silastic 382, 399**:

They are physiochemically inert and colour-stable viscous silicone polymers. The different silicones include a cross-linking agent, an orthoalkyl silicate catalyst, and a filler. Condensation reactions lead to the formation of polymers. To increase strength, fillers like diatomaceous earth are used. HTV silicones have characteristics comparable with the earliest RTV silicones (Silastic 382, 399). [11]

• **MDX4-4210**:

41% of clinicians who responded to Andres' survey[13] said they used this material to make maxilla prostheses. Moore[14] claims that it has better edge strength and colouring properties. Because it is not tightly packed, the substance is translucent. It is compatible with living organisms, nontoxic, colour-stable, and has a suitable tensile strength.

This high-grade silicone elastomer is preferred by doctors, according to their feedback. According to Andreas' survey findings, 41% of doctors employed this substance to create prosthesis for maxillofacial region.[11]

• **Silastic 891**:

Udagama and Drane[15] were the first to describe how it was used. There are numerous colorants that are compatible with silicone type A silastic medical glue.

The chemical, also called silastic medical adhesive silicone type A, which was initially utilised to create facial prostheses, was first described by Udagama and Drane. It is a translucent, non-flowing paste that, when in contact with moisture, polymerizes at ambient temperature. Additionally, it can be treated using a gypsum mould. Metal moulds shouldn't be used since acetic acid, a polymerization by-product, may react with them. Compatibility with a variety of colorants and the lack of a catalyst requirement are its advantages.[11]

• **Cosmesil:**

According to Woofaardt16, it is an RTV silicone that may be treated to different degrees of hardness.

The Cosmesil system, introduced in the UK in 1982, is made up of silicone elastomer, RTV sealant, colouring agents, and other elements required to create facial and body prosthesis.[11]

HEAT-TEMPERATURE VULCANIZING SILICONE ELASTOMERS

Occasionally, these are used in maxillofacial prosthesis. It typically takes the form of a white, opaque substance with a viscosity similar to putty. The vulcanization mechanism is created via an addition reaction. Heat-vulcanized silicones consist of silica filler produced by burning methyl silane, 2,4-dichlorobenzoyl peroxide as an initiator (vulcanizing agent), and polydimethylvinyl siloxane copolymer with roughly 0.5% vinyl side chains. The HTV catalyst is platinum salt, also referred to as chloroplatinic acid salt.[1]

Specifically, because it contains the essential catalyst for cross-linking, this type of polymer requires more exact mechanical machining than the soft putty RTV silicone. Higher tear resistance is intended for engineering applications.[2]

According to Roberts, three main vulcanizing medical grades of silastic are available[4]:

i) MDX4 -4514 soft rubber

ii) MDX4 -4515 Medium hardness rubber

iii) MDX4-4516 Hard rubber.

Advantages are excellent tear strength, high tensile strength, biological inertness and high elongation percentage.

Disadvantages include poor aesthetics, low elasticity, low edge strength and technique sensitivity.

Examples include:

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

They often consist of an opaque white material that is extremely viscous and putty like. Dichlorobenzoyl peroxide serves as the catalyst. They are physiologically inert and have great thermal stability, but they lack the flexibility needed to work in moveable tissue beds.[17]

• **PDM siloxane**:

Veterans' administration developed this HTV silicone, according to Lontz and Schweiger. Abdelnnabi reported on independent examinations of mechanical and physical qualities.[17]

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

Comparing this new generation of HTV silicone to MDX4-4210 and MDX4-4514 (RTV silicone elastomers), it is found that it has better physical and mechanical characteristics.[2]

FOAMING SILICONES

Silastic 386: The foam-forming variant of RTV silicone, known as Silastic 386, is only occasionally used in maxillofacial prosthetics. When the catalyst, stannous octoate, is added, the basic silicone has an addition that causes a gas to be emitted. The silicone vulcanizing gas produces bubbles inside the silicone. The gas is eventually expelled from the silicone during processing, leaving a spongy substance behind. Up to a sevenfold increase in volume can result from the production of bubbles inside the material.[23]

The silicone foam-forming material is used to lighten the prosthesis' weight. The foamed material is vulnerable to tearing and has diminished strength. By applying another silicone coating to the foam, this flaw can be partially remedied.[20]

By itself, this silastic foam is inappropriate for a facial prosthesis. It can be used in immediate prosthesis, especially orbit exenteration.

SIPHENYLENES

Siphenylenes are methyl and phenyl group-containing siloxane copolymers. Compared to the more common polydimethyl siloxane, these have better edge strength, low modulus of elasticity, and colorability.[18]

They resist deterioration when exposed to heat and UV radiation.[4]

SILICONE BLOCK COPOLYMERS

The creation of silicone block copolymers addresses few of the shortcomings of silicone elastomers, including their poor tear strength, lower elongation, and tendency to sustain bacterial and fungal growth. Compared to traditional cross-linked silicone polymers, they are more tear-resistant.[18]

They aid in preventing responses to foreign bodies because the increased hydrophilic component of these hydrophilic polymers enhances wettability and, consequently, tissue compatibility.

POLYPHOSPHAZENES

Maxillofacial prosthetic materials made of polyphosphazene fluoroelastomers have the potential to be utilised as durable denture liners. A softer rubber with an HAD-hydroxyl decanoic acid of 25, comparable to human skin, is produced by mixing polyphosphazenes with little to no fillers and less acrylic.[18]

ADVANCED MATERALS

A-2186: When compared to MDX4-4210, this newly created material originally had better physical and mechanical qualities. In contrast to MDX4-4210, it has been claimed that this elastomer lost some of its improved physical and mechanical qualities when exposed to environmental factors. [21]

Ferreira predicted the creation of novel prosthesis that can replace bone tissue without the need for bone grafts using CAD-CAM, 3D printing, and digital imaging.[7]

Bionic ears, noses, and eyes prosthesis that can perceive sensory stimuli similar to natural sense organs are made of microchips, transducers, semiconductors, polymers, electronic arrays, and radio transmitters have been made possible by bio engineering.[8]

To match patient skin for prosthetic applications, the E-Skin spectromatch spectrometer uses a digitised library of around 20,000 skin tones. Each entry in the electronic library has a colorant recipe. After scanning a user's skin tone, the E-Skin device immediately searches its database for a colorant recipe that matches their skin tone and shows it on its screen. [8]

RIGID MATERIAL

Metals like Co-Cr are used in the construction of definitive prosthesis. Methyl methacrylate are indicated in those facial defects where little movement takes place in the tissue bed during functioning, e.g., fabrication of ocular prosthesis, nasal prosthesis and intraoral prosthesis. They show good stability of form and colour. [22]

MATERIALS OF THE 21ST CENTURY

According to Remerdale EH, materials for the third millennium should be translucent and able to change colour to match with any skin tone. They should also have better tear and elongation resistance, easily moldable, should accept extrinsic colouring easily and metal molds shouldn't be required at high temperatures. [19]

CONCLUSION

For the prosthodontist, treating patients with maxillofacial deformities has always been a mystery. The operator's issues have been made worse by the defect's unpredictable nature and its unclear likelihood of recurrence.

Although there have been notable improvements in method and materials over the past few years, maxillofacial prosthodontics has not yet reached its full potential. There isn't a single substance that satisfies every need. In order to hasten the rehabilitation of patients with maxillofacial abnormalities, new materials must be developed along with relevant basic and clinical research.

They can only appear normal, feel normal, and eat normal with the on-going work of honest, committed, and skilled maxillofacial prosthodontists engaged in their rehabilitation.

CONFLICT OF INTEREST

There is no conflict of interest

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Corresponding Author: Prachi, Intern, Department of Prosthodontics, SRM Kattankulathur Dental College, SRM University, Kattankulathur, India 603203
E-mail: pra0808chi@gmail.com , Ph.No.: +91 9065950421