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Review Article

Maxillofacial Prosthetic Materials: A Review

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ABSTRACT

A number of materials are available and have been used for facial prosthesis. These include wood, wax, metals, and in recent times, polymers. For facial rehabilitation assessment of materials used in maxillofacial prosthesis is necessary. While the new materials have shown some excellent properties, they also have shown some deficiencies. This article will review various materials used in maxillofacial prosthesis.

Keywords: Maxillofacial Prosthetics, Facial Defects, Rehabilitation.

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INTRODUCTION

Maxillofacial prosthetics is defined as that branch of prosthodontics that is concerned with restoration and replacement of both of stomatognathic and associated facial structures by artificial substitutes that may or may not be removed. (GPT8)[1] Materials for maxillofacial prosthetic reconstruction span the full range of chemical structures, with physical properties ranging from hard, stiff alloys, ceramics and polymers to soft, flexible polymers and their formulation as latex and plastisols.[2]

HISTORICAL BACKGROUND

Before 1600: Ambroise Pare (1510-1590), a famous French surgeon, made nasal prostheses using gold, silver, paper and liner cloth glued together.[3]

1600 to 1800: Pierre Fauchard (1678-1761) made a silver mask painted with oil paints to replace the lost portion of mandible of a French soldier, by making margins inconspicuous using facial hair.[3]

1800 to 1900: William Morton (1819-1868) fabricated a nasal prosthesis using enameled porcelain to match the patientís complexion.[3] Kingsley (1880) made a combination nasal prosthesis using ceramic material. Claude Martin (1889) fabricated a nasal prosthesis using ceramic material.[4]

1900 to 1940: By the end of the 19th century, vulcanite rubber was being used. Upham fabricated a nasal and auricular prosthesis made from vulcanite rubber. In 1913 gelatin glycerin compounds were introduced for use in facial prostheses to mimic the softness and flexibility of human skin, but their lifespan was too short for practical clinical application.[3]

1940 to 1960: In 1937 acrylic resin was introduced and replaced vulcanite rubber. Tylman introduced the use of resilient vinyl copolymer for facial prosthesis.[3] Adolph Brown used colorants certified by the Food and Drug Administration for coloring facial prostheses.[3] Braiser used acrylic resin polymer stains for intrinsic coloring and oil colors mixed with acrylic resin monomer for external tinting of facial prostheses.[3]

1960 to 1970: Various kinds of elastomers were introduced. Barnhart (1960) introduced silicone rubber for constructing facial prosthesis.[3]

1970 to 1990: Lontz used modified polysiloxane elastomers.[3] Gonzalez described the use of polyurethane elastomers.[5] Lewis and Castleberry described the use of siphenylenes for facial prosthesis.[6] Turner documented the use of isophorone polyurethane.[7,8] Udagama and Drane introduced the use of Silastic Medical Adhesive Silicone Type A for fabrication of facial prosthesis.[9,10]

1990 to present: A new generation of acrylic resins are being investigated by Antonucci and Stansbury.[3] Gentleman described the use of polyphosphazenes. Silicone block copolymer is also being evaluated.[3]

The several important criteria have been listed for an ideal material. Generally, these criteria fall under two categories.[11-14]

1. PROCESSING CHARACTERISTICS

2. PERFORMANCE CHARACTERISTICS

Processing Characteristics[11-14]

The basic requirement of a prosthetic material is that, it

1. Should allow inexpensive fabrication.
2. Should be castable and shrinkage free.
3. Should have adequate pot life (working time).
4. Should have adequate viscosity.

Performance Characteristics[11-14]
Tensile strength, elongation at break, modulus, and tear strength together define resistance of prosthesis to rupture. Although, high values of strength, toughness, and tear strength, or low values of hardness and modulus, are desirable, highest or lowest values of these are not a goal, because a material possessing these properties in extreme would be unacceptable for use.

Ideal Physical and Mechanical Properties[2,15-17]
1. High edge strength allowing thin margins
2. High elongation, abrasion resistance, tear and tensile strength
3. Low glass transition temperature imparts flexibility
4. Low specific gravity, surface tension and thermal conductivity
5. Non-inflammable
6. Non-absorbent
7. Translucent
8. Light weight

Ideal Processing Characteristics[2,15-17]
1. Adjustability
2. Post-processing chemical inertness
3. Dimensional stability during and after processing
4. Longpot life
5. Low processing temperature and short processing time
6. Long shelf life

Ideal Biological Properties[2,15-17]
1. Non-toxic, non-allergenic and non-carcinogenic
2. Inert to solvents and adhesives
3. Permeable to moisture release from underlying tissue
4. Resistance to growth of microorganisms
5. Maintained consistency during use

CLASSIFICATION OF MAXILLOFACIAL PROSTHESIS MATERIALS

Beumer[18] classified materials used for fabricating maxillofacial prosthesis as under:
1. Acrylic resins.
2. Acrylic copolymers.
3. Polyvinyl chloride and copolymers.
4. Chlorinated polyethylene (CPE).
5. Polyurethane elastomers.
6. Silicone elastomers - HTV, RTV, and foaming silicones.
7. New materials - silicone block copolymers and polyphosphazenes.

Acrylic Resin
Polymethyl methacrylate was once commonly used for maxillofacial prostheses and is still used occasionally to make artificial facial parts. It can be successfully employed for specific types of facial defects, particularly those in which little movement occurs in the tissue bed during function (e.g., fabrication of orbital prostheses). Acrylic resin is easily available, easy to stain and color, has good strength to be fabricated with feather margin and a good life of about 2 years. Its rigidity and high thermal conductivity is a drawback.[19]

Acrylic Copolymer
Acrylic copolymers are soft and elastic but have poor edge strength, poor durability and being subject to degradation when exposed to sunlight. In addition complete restoration is often tacky predisposing to direct collection and staining.[19]

Polyvinyl Chloride and Copolymer
Polyvinylchloride has been used widely for maxillofacial application, but it has been replaced by never material with superior properties. It was the most widely used plastics for maxillofacial prostheses. Polyvinyl chloride is a rigid plastic that is clear, tasteless, and odorless, with a glass transition temperature higher than room temperature. For maxillofacial application plasticizers are added to produce an elastomer at room temperature. These additives however, extended processing time and predisposed to undesirable shrinkage. It is processed at 150°C and metal mold are generally used. Recently, a copolymer of 5 to 20% vinyl acetate with the remaining % being vinyl chloride has been introduced this copolymer is more flexible but apparently less chemically resistant than polyvinyl chloride itself. The vinyl acetate makes it more stuble to heat and light.[19]

Chlorinated Polyethylene (CPE)
Lewis and Castleberry[6] reported testing of CPE, a material which is similar to polyvinylchloride in both chemical composition and physical properties. The processing procedure involves high heat curing of pigmented sheets of the thermoplastic polymer in metal molds. Coloration, using oil-soluble dyes and repeated molding, is possible. However, the use of metal molds is a disadvantage of the system.[14]

Polyurethane Elastomer
Polyurethane elastomers contain a urethane linkage. The reactants are a polymer terminating with hydroxyl group and others terminating with isocyanate in the presence of a catalyst. They can be synthesized with a wide range of physical properties by varying the reactants and their amounts. They have excellent properties like elasticity and ease of coloration but have certain deficiencies like isocyanate and are moisture sensitive leading to gas bubbles when water contaminated. According to Gonzales they also cause local irritations.[19]

Silicone Elastomers
It is chemically termed as polydimethyl silicone. Silicones were introduced around 1946, but only in the past few years, they have been used in the fabrication of maxillofacial prosthesis. Silicone elastomers were first used for external prosthesis by Barnhart in 1960, Silicones are currently the most popular of all of the facial prosthetic materials. Silicones consist of alternate chain silicone and oxygen atoms, which produce little or no inflammatory response in animals.[20]

HTV Silicones (Silastic 370, 372, 373 MDX 4-4514, MDX, 4–4515-4516)
Heat vulcanizing silicones are translucent, milky white, semisolid materials. The material may be supplied as one component or two component putty. The catalytic or vulcanizing agent of HTV silicones is Dichlorobenzoyl peroxide or platinum salt, depending upon the type of the polymerization used (condensation reaction or addition reaction). These silicones can be preformed into various shapes of alloplastic implantation for facial prosthesis.

Advantages
a. Excellent thermal stability.

b. Colour stable when exposed to U.V. light.
c. Superior strength.
d. Biologically inert.

Disadvantages

a. Low edge strength requires nylon reinforcement at the margins.
b. Opacity and life appearance.
c. Extrinsic coloration is difficult.
d. Requires milling device for incorporation of internal colorants.[20]

RTV (Room-Temperature-Vulcanizing) Silicones

They are viscous silicone polymer including filler, a stannous octate catalyst and an orthoalkyl silicate cross linking agent. Fillers are usually diatomaceous earth which improves strength.

- **Silastic 382, 399:** They are viscous silicone polymers which are color stable and biologically inert.[3]
- **MDX4-4210:** In a survey by Andres, 41% of clinicians used this material for maxilla prosthesis fabrication.[12] Moore reported that it exhibits improved qualities relative to coloration and edge strength. The material is not heavily filled; hence it is translucent. It exhibits adequate tensile strength, is nontoxic, color stable and biologically compatible.[21]
- **Silastic 891:** Udagama and Drane first reported its use, also known as silastic medical adhesive silicone type A and it is compatible with wide range of colorants.[9]
- **Cosmesil:** It is a RTV silicone which can be processed to varying degree of hardness as described by Woofaardt.[22]

Heat-temperature Vulcanizing Silicone Elastomers (HTV): Designed for higher tear resistance in engineering applications, this type of polymer requires more intense mechanical milling of the solid HTV stock elastomers compared with the soft putty RTV silicone, especially for incorporating the required catalyst for cross link.

- **Silastic 370, 372, 373, 4-4514, 4-4515:** They are usually white, opaque material with a highly viscous, putty-like consistency. The catalytic agent is dichlorobenzoyl peroxide. They exhibit excellent thermal stability and biologically inert but do not possess sufficient elasticity to function in movable tissue beds.
- **PDM Siloxane:** This HTV silicone was developed by Veterans' administration and reported by Lontz and Schweiger. Independent evaluations of physical and mechanical properties were reported by Abdelnnabi.[23]
- **Q7-4635, Q7-4650, Q7-4735, SE-4524U:** This new generation of HTV silicone evaluated by Bell7 which showed improved physical and mechanical properties compared to MDX4-4210 and MDX4-4514 (RTV silicone elastomers.)[23]

Foaming Silicones

- **Silastic 386:** A form of RTV silicone that has limited use in maxillofacial prosthetics is the foam – forming variety. The basic silicone has an additive so that a gas is released when the catalyst, stannous octoate is introduced. The gas forms bubbles within the vulcanizing silicone. After 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 seven-fold. The purpose of the foam—forming silicone is to reduce the weight of the prosthesis. However, the foamed material has reduced strength and is susceptible to tearing. This weakness can be partially overcome by coating the foam with another silicone.
- **Siphenylenes:** Siphenylenes are siloxane copolymers that contain methyl and phenyl groups. These exhibit improved edge strength, low modules of elasticity and color ability over the more conventional polydimethyl siloxane.[24]

New Materials

Silicone Block Copolymers: Silicone block co polymers are new materials under development to improve some of the weakness of silicone elastomers. It has been found that silicone block co polymers are more tear resistance than conventional cross-linked silicone polymers.[25]

Polyphosphazines: Polyphosphazines flouroelastomers has been developed for use as a resilient denture liner and has the potential to be used as a maxillofacial prosthetic material. Modification of physical and mechanical properties of Polyphosphazines may be needed to satisfy the requirement for fabrication of maxillofacial prosthesis.[25]

CONCLUSION

Maxillofacial prosthesis is replacement of the missing facial parts by artificial substitutes. Anciently prosthetic restoration of facial defects was limited due to unavailability of adequate materials. Almost none of the commercially available materials satisfy all the requirements of an ideal maxillofacial material. Each has its own advantages and disadvantages.

REFERENCES

1. The glossary of prosthodontic terms. J Prosthet Dent 2005;94(1):10-92
2. Mahajan H, Gupta K. Maxillofacial Prosthetic Materials: A Literature Review. J Orofac Res 2012; 2(2):87-90.
3. Beumer 3rd J, Curtis TA, Marunick MT. Maxillo Facial Rehabilitation. Prosthodontic and surgical considerations. St Louis. Tokyo. Ishiyaku Euro America, Inc; p. 377- 454.
4. Bulbulian AH. Maxillofacial prosthetic: Evolution and practical application inpatient rehabilitation.J Prosthet Dent1965;15:544-69.
5. Gonzalez JB, Chao EY, An KN. Physical and Mechanical behavior of polyurethane elastomer formulations used for facial prostheses. J Prosthet Dent 1978;39:307-18.
6. Lewis DH, Castleberry DJ. An assessment of recent advances in external maxilla facial materials. J Prosthet Dent 1980;43:42-5.
7. Turner GE, Fischer TE, Castleberry DJ, Lemmons JE. Intrinsic color of isphorone polyurethane for maxillofacial prosthetics, Part I: Physical properties. J Prosthet Dent 1984;51:519-22.
8. Turner GE, Fischer TE, Castleberry DJ, Lemons JE. Intrinsic color of isophorone polyurethane for maxillofacial prosthetics Part II: Color stability. J Prosthet Dent 1984;51:673-5.
9. Udagama A, Drane JB. Use of medical grade methyl urethane silane cross linked silicone for facial prosthesis. J Prosthet Dent 1982;48:86-8.
10. Udagama A. Urethane-linked silicone facial prosthetics. J Prosthet Dent 1987;58:351-4.
11. Lewis et al. New and Improved Elastomers for Extraoral Maxillofacial Prostheses (Abstract). J Dent Res, 1977;56(special issue A):174.

12. Andres et al. Effects of Environmental Factors on Maxillofacial Elastomers: Part I – Literature Review. JPD, Aug 1992; 68 (2): 327-30.

13. Andres et al. Effects of Environmental Factors on Maxillofacial Elastomers: Part II – Report of Survey. JPD, Sept 1992; 68(3): 519-22.

14. Lewis D. H, Castleberry D. J. An Assessment of Advances in External Maxillofacial Materials. JPD, April 1980;43(4):426-32.

15. T. D. Taylor. Clinical Maxillofacial Prosthetics, 1st ed. Quintessence Publishing Co. Inc, Illinois, 2000.

16. Chalian V. A. Maxillofacial Prosthetics: Multidisciplinary Practice. The Williams and Wilkins Co., Baltimore, 1971.

17. Tariq Aziz, Mark Waters, Robert Jagger. Analysis of the Properties of Silicone Rubber Maxillofacial Prosthetic Materials. J Dent 2003;31:67-74.

18. Beumer J, Curtis TA. Maxillofacial Rehabilitation Prosthodontic and Surgical Considerations. St. Louis, MO: Ishiyaku Euro America, Inc.; 1996

19. Gonzalez JB. Polyurethane elastomers for facial prosthesis. J Prosthet Dent 1978;39:179-87.

20. Lewis DH, CastleberryDJ, Fischer TH. New and improved elastomes for extraoral maxillofacial prosthesis. J Dent Research 1977;51:23-8.

21. Moore DJ, Glaser ZR, Tabacoo MJ, Linebaugh MG. Evaluation of polymeric materials for maxillofacial prosthetics. J Prosthet Dent 1977;38:319-26.

22. Wolfaardt JF, Chandler HD, Smith BA. Mechanical properties of a new facial prosthetic material. J Prosthet Dent 1985; 53: 228-34.

23. Abdelnnabi MM, Moore DJ, Sakumura JS. In vitro comparison study of MDX-4-421 and polydimethyl siloxane silicone material. J Prosthet Dent 1984;51:523-26.

24. Chen M, Udagama A, Drane JB. Evaluation of facial prosthesis for head and neck cancer patients. J Prosthet Dent 1981;46: 538-44.

25. Borle RM, Nimonkar PV, Rajan R. Extended nasolabial flaps in the management of oral submucous fibrosis. British Journal of Oral & Maxillofacial Surgery 2009; 47 (5): 382-5. https://doi.org/10.1016/j.bjoms.2008.08.019.

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