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MAXILLOFACIAL PROSTHETIC MATERIALS: CURRENT STATUS, RECENT ADVANCES, INFLUENCE OF FILLERS, AND GROWING TENDENCY TOWARDS SILICONE MATERIALS – A REVIEW.

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ABSTRACT-

Maxillofacial prosthetic materials are used to replace facial parts lost through disease or trauma. Body anomalies or deformities that impair form, function, or esthetics are enough to render a person incapable of leading a normal life. Maxillofacial deformity can be caused by a congenital defect, trauma, or tumor surgery. Multiple times, surgical reconstruction may be impossible due to the size, location, or medical state of the patient, so prosthetic rehabilitation is necessary. However, the physical and mechanical qualities of the materials utilized have a substantial impact on the outcome of prosthetic rehabilitation. Acrylic resins, acrylic copolymers, vinyl polymers, polyurethane elastomers, and silicone elastomers are common materials utilized to make facial prosthesis these days. There has always been a quest for a maxillofacial prosthetic material that closely matches the defect tissues in appearance and properties. This article focuses on changing trends in materials, and future aspects of various materials used in rehabilitation of maxillofacial defects with their limitations and modifications. Silicones and acrylic resins are currently the most often utilized materials in the fabrication of personalized prostheses.

KEYWORDS – MAXILLOFACIAL MATERIALS, RECENT ADVANCES, REHABILITATION, SILICONES.

INTRODUCTION-

Maxillofacial deformities are embarrassing to patients and may negatively affect their physical and psychological health, potentially resulting in serious psychiatric, familial, and social problems. Ackerman described maxillofacial prosthesis in 1953 as the branch of dentistry that heals and artificially replaces elements of the face following traumas or surgical intervention. This concept does not include the use of prostheses to cure congenital craniofacial abnormalities or to improve appearance. Implanting artificial substitutes for intraoral and extraoral features such as the eyes, ears, nose, maxilla, mandible, esophagus, cranial bones, and palate is known as maxillofacial reconstruction. Maxillofacial prostheses are primarily made of acrylic resin and/or silicone, depending on the patient's facial anatomy. A variety of systems hold the prostheses in place and support them, including osseointegrated implants, the residual skin with or without adhesive, body cavities, and teeth. Maxillofacial prostheses not only correct a variety of orofacial deformities, but they also improve patients' quality of life. Although the current clinical scenario for maxillofacial prosthesis is promising, future advances in material quality and procedures for maxillofacial prostheses may be expected to produce improved results in patient care. There have been continuous researches in the field of dental materials to best meet the optimum selection criteria to satisfy the functionality, biocompatibility, aesthetics, and durability as a maxillofacial material. Despite the fact that silicone is the most commonly used material, research is continuously being conducted to address its shortcomings and develop a substance that may be designated as the "ideal maxillofacial prosthetic material."

MATERIALS AND METHODS – Articles that discussed the history, types, materials, fabrication techniques, clinical implications, incorporation of filler particles and future expectations related to maxillofacial prostheses and reconstruction were included. The search was widened, as necessary, and references cited in the publications were also included as part of this study.

3. MATERIALS AND THEIR EVOLUTION –

a. **Acrylic resins (1940- 1960) -** Particularly used in cases where there is least movement of tissue bed during function. Various advantages being, its ready availability, colour stability, can be relined and repaired, have good strength, can be fabricated with feather margin and a good shelf life of about two years. However, they are rigid, have water absorption and duplication is not possible.
b. **Polyvinylchloride and copolymer-** A clear, tasteless and odorless material and has been used widely for maxillofacial 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.
c. **Chlorinated polyethylene-** Processing involves high heat curing pigmented sheets in metal molds. Dow chemicals' chlorinated polyethylene elastomer is an industrial grade thermoplastic elastomer. It is less irritating to the mucosa than silicone, less toxic than thermosetting silicone materials and non -carcinogenic. Chlorinated polyethylene elastomer appears to be a suitable substitute for silicones for the fabrication of extraoral maxillofacial prosthesis in situations where cost of silicone is prohibitive.
d. **Polyurethane elastomers (1970 to 1990)-** This material is chemically composed of an extended segment of aliphatic diisocyanate groups and a segment of polyol groups (a mixture of polyesters) and an organotin catalyst for the polymerization process to occur.
e. **Thermoset urethane elastomers -**They are produced through introduction of primary chemical crosslinks. If reactants are combined in Stoichiometric ratios and reactions are preferentially catalyzed, a known controlled morphology can be developed. In one study polyurethane was greatly affected by aging.

SILICONES AS MAXILLOFACIAL PROSTHETIC MATERIAL –

Silicones, were introduced in 1946, but were used for the first time by Barnhart (1960) for extra-oral prosthesis and became more popular over other materials also known as polydimethyl siloxane.It is the most successful maxillofacial prosthetic material till date and the new advances are being made to this material to overcome their weaknesses. These became more popular over other materials as they have a range of good physical properties (such as excellent tear and tensile strength) over a range of temperature, easier to manipulate, high degree of chemical inertness, low degree of toxicity, and high degree of thermal and oxidative stability. Further they can be stained intrinsically and/or extrinsically to give them more lifelike natural appearance. When adequately cured, silicones elastomers resist absorbing organic materials that lead to bacterial growth and so with simple cleaning these materials are relatively safe and sanitary compared to other materials.

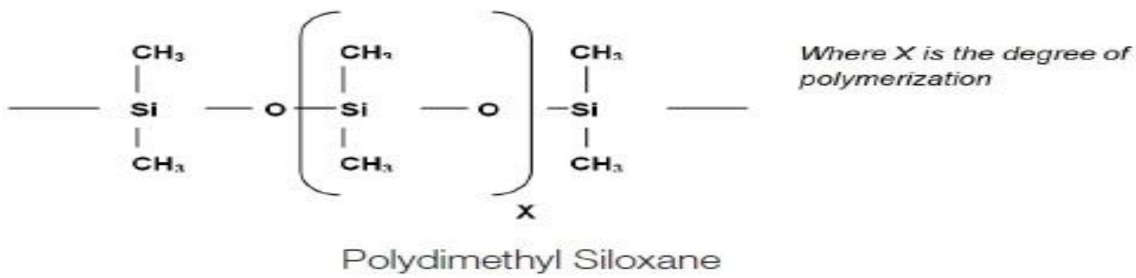

Fig.1 – Chemical formula of silicone.

ALTERNATE MATERIALS

Foaming silicones: Silastic 386 – in it is a type of RTV material. The basic silicone has an additive which release gas when the catalyst (stannous octoate) is introduced. The purpose of the foam forming silicones is to reduce the weight of the prosthesis. However, the major disadvantage of foamed material is reduced strength and is susceptible to straining, leading to weakening of the material. This weakness can be overcome partially by coating foam with another silicone which adds strength but increase stiffness. Purpose of the foam silicon is to reduce the weight of the prosthesis.

Siphenylenes: These are siloxane copolymers that contain methyl and phenyl groups. These exhibit improved edge strength, low modulus of elasticity and colour stability over the more conventional poly-dimethyl siloxane.

Silicone Block copolymers: In this block of polymers other than siloxane are positioned with the traditional siloxane polymers. The hydrophobic nature and foreign nature of silicones has been proven to cause problems, especially with regard to the interaction with the body on a molecular level. This can lead to the induction of foreign body reactions and the development of infections particularly at the interface between silicone and tissue. These silicone block copolymers can to some extent overcome these problems as the more hydrophilic part of these amphiphilic polymers provides improved wettability and thus tissue compatibility. An example of this is the intertwining of poly methyl methacrylate into the chains of siloxane.

Polyphosphazenes: Researchers in New Orleans dealt with maxillofacial prosthesis, have found that compounding polyphosphazenes with little or no fillers and decreasing the ratio of acrylic to rubber yields a softer rubber, with a HDA of 25, similar to human skin. The rubber is compounded with pigments for appropriate matching with the patients' skin.

Creative uses in prosthetics dentistry include implant denture retention and stability by processing the rubber over the implant head. The major advantage of these over the mechanical devices is being the freedom of movements of the denture towards the tissue similar to periodontal membrane around natural tooth.

When a stable and reasonably priced source of polymer becomes available, these might become the material of choice for many biomedical uses.[2]

COLOUR IN MAXILLOFACIAL PROSTHESIS –

Coloration of the prosthesis varies with the material used and the preference of the clinician. The basic shade selected for a patient should be slightly lighter than the lightest skin tone of the patient because the prosthesis will darken as color is added. The color effect of human skin is a result of light reflected, refracted and scattered directly. There are three essential factors for perception and measurement: the spectral power distribution of the light source, the reflectance curve of the object, the response curve of the human observer or instrumental detector. These factors explain the function of the spectrophotometer, which is the instrument used in studies dealing with color or color-changes. The ideal maxillofacial materials must accept and retain both intrinsic and extrinsic coloration without changes in the general appearance of the prostheses and preserving the initial mechanical properties. There are many advantageous characteristics of silicone prosthetics that consecrate silicone as the most suitable material for facial prostheses such as good biocompatibility and bio durability, wide service temperature range, non-adhesive properties, low toxicity, possible optical transparency, low chemical reactivity and excellent resistance to attack by oxygen, ozone and sunlight.

Dry earth pigments, rayon flocking fibers (most commonly used), artist's oil pigments, or a combination of these materials for intrinsic tinting. Kaolin material was commonly used as an opacifier. The most-used extrinsic colouring method was Medical Adhesive Type-A mixed with Xylene as a retarder/thinner tinted with dry earth pigments or artist's oil pigments applied to the surface of the prosthesis in a thin layer.

FILLERS IN MAXILLOFACIAL PROSTHESIS -The addition of nanoparticles at various concentrations may improve the physical and mechanical properties and color stability of the prosthesis made from the silicone elastomers. The review suggested that 1.5% $ZrSiO_4$, 3% SiO_2, 1.5% Y_2O_3, 2–6% TiO_2, 2–2.5% ZnO, 2–2.5% CeO_2, 0.5% $TiSiO_4$ and 1% Ag-Zn Zeolite can be used to reinforce and help the materials better withstand mechanical degradation.

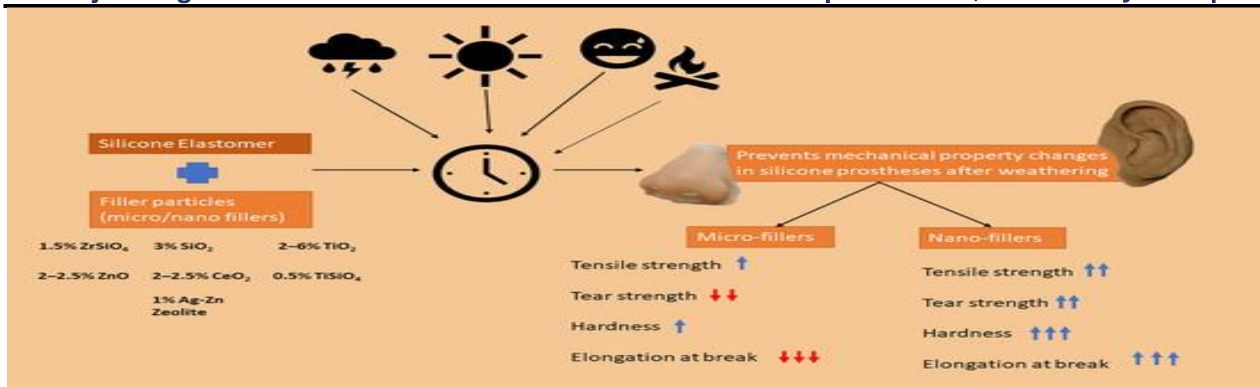

Fig.2 – Types of filler particles.

FUTURE - With the advancement in medical sciences and incorporation of engineering concepts have resulted in development of prosthesis capable of perceiving sensory stimulus similar to natural sense organs. These organs have been termed as Bionic organs. The term 'BIONIC' means - having or denoting an artificial, typically electromechanical, body part or parts. A Bionic organ is an engineered device or tissue that is implanted or integrated into a human interfacing with living tissues to replace a natural organ, to duplicate or augment a specific function or functions so the patient may return to a normal life as soon as possible. Research in the maxillofacial region have led to the development of Bionic eye, nose and ear which consist of microchips, transducers, polymers, semiconductors, electronic arrays and radio transmitters. Various models and systems are already available and further research and development is under process.

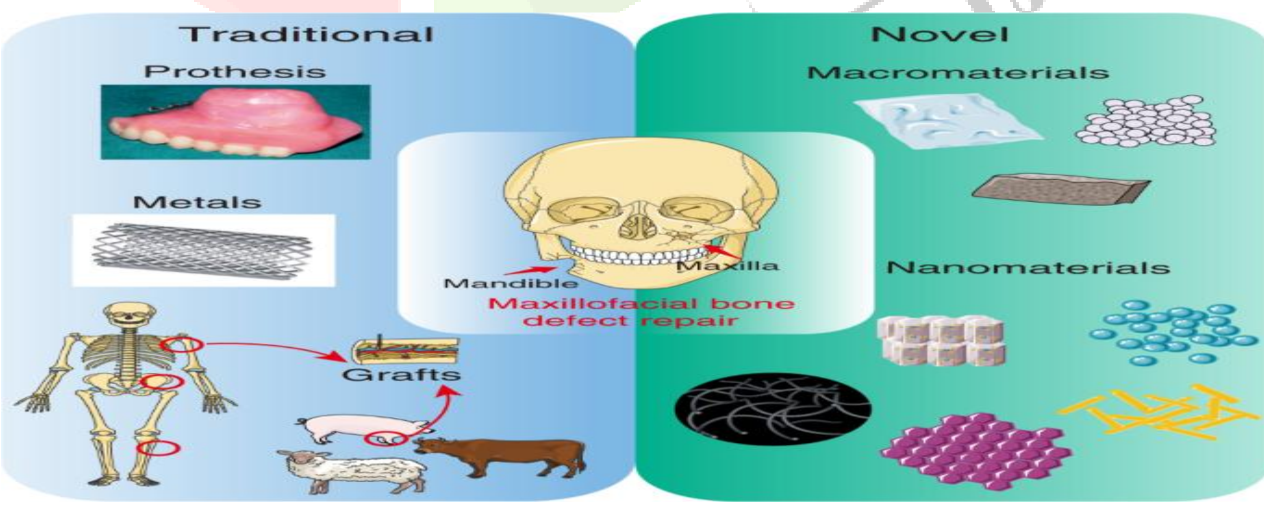

Fig.3 – Traditional vs novel methods of regeneretaion

Also, the advancement in digital technology particularly Rapid prototyping and CAD/CAM has opened new avenues for time efficient, life like prosthesis. Multiple studies are focused on production of 3D printed silicone for fabrication of prosthesis. The CAD/CAM or 3D Printing can be joined with E-Skin spectromatch spectrometer uses a digital library of nearly 20,000 skin tones to match to patient skin for prosthetic applications. All entries in the digital library have a matching colorant recipe. The E-Skin instrument measures skin color and instantly retrieves and displays on its screen a matching colorant recipe from its database.

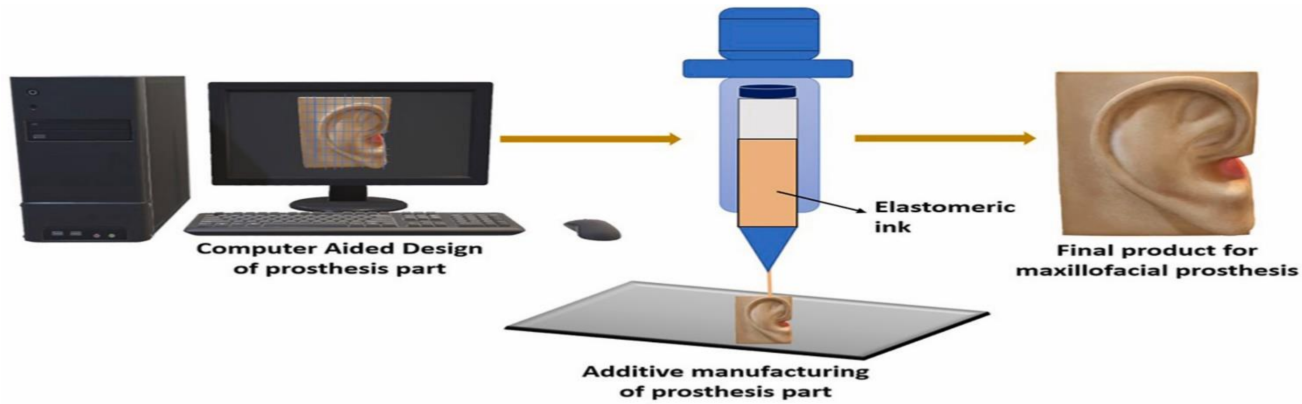

Fig.4 – CAD – CAM Procedure

CONCLUSION –

To make maxillofacial prostheses, the shape, volume, position, texture and transparency of the patient's features must be respected.

The most common materials currently in use for the fabrication of intraoral and extraoral prostheses are polymeric nature and they exhibit almost all desirable physical, biologic and clinical properties. The completed facial prostheses should be unnoticeable in public, faithfully reproducing lost structures in the finest detail. Its color, texture, form and translucence must duplicate that of missing structures and adjacent skin. To date, none of the commercially available materials satisfy all the requirements of the ideal material. Each of the material has strengths and weakness. It may seem like an impossible goal, but the possibility of fabricating a high-quality lifelike prosthesis directly on the face necessitates an excellent skill of the Prosthodontist as well as the role of a dental material scientist who can assist by providing a perfect material with improved properties and color stable coloring agents to rehabilitate the patient with maxillo-facial defect who deserves the best we have to offer.

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