INTRODUCTION:

Body abnormalities or defects that compromise appearance, function, and render an individual, incapable of leading a relatively normal life have usually prompted responses that seek to bring the person to a state of being acceptable normally. In response to congenital or acquired defects man has continually sought to cope with his debilities by using his intelligence and the material resources available for restoration. Facial disfigurement can be the result of a congenital anomaly, trauma or tumor surgery. Surgical reconstruction may not be possible owing to size or location of the defect. The patient's medical condition or personal desires may also preclude reconstructive surgery. In such cases, prosthetic rehabilitation is indicated. A facial prosthesis restores normal anatomy and appearance, protects the tissues of a defect, and provides great psychological benefits to the patient.

“Maxillofacial prosthetics is defined as that branch of prosthodontics concerned with restoration and replacement of both of stomatognathic and associated facial structures by artificial substitutes that may or may not be removed”. (GPT) It encompasses prosthetic rehabilitation of patients with oral or facial defects which may be naturally acquired or may result from disease or trauma. Facial prostheses were described by Ambrose Pare in 1575. Some accounts indicate that such replacements existed even earlier. Historically, these prostheses were made of cloth, leather, wrought or cast metal, vulcanite, porcelain and acrylic resin. Today most are made of medical grade silicone rubber. The constructed maxillofacial prosthetic aids and devices for these patients are considered less than optimal, with a fundamental problem of inadequate stability and retention of prosthesis. Facial prostheses can be retained by several methods. Where conditions permit, anatomic undercuts within the defect can be engaged. Although retention is relatively reliable, few defects have a configuration that lends itself to this method. Also, soft tissues with in the defect can become irritated by contact with the prosthesis. This is particularly true if the patient has undergone radiation therapy. In rare instances, the prosthesis can be retained by attachment to eye glass frames. This technique does not ensure that margins of prosthesis will be held securely and it is a problem if the patient has to remove the glasses in public. A more common method of retention for facial prosthesis has been with skin adhesives. These are acrylic resin or silicon based liquids that are applied to the margins of prosthesis before placement on face. Double sided tapes also can be used. Osseointegrated implants have been used to retain facial prosthesis since 1979. This technique is based on an original research by Branemark and it involves a direct structural and functional connection between ordered living bone and the surface of a load carrying implant. The success of this procedure is well documented, and the use of implants offer several advantages over adhesive retention.

First, the time and effort involved in actually applying the adhesive are eliminated. Second, edges of prosthesis can be made thinner to blend in better with the natural skin for a more life like appearance. Third, possible skin (reaction) irritation of adhesive is eliminated. Fourth, proper placement of the prosthesis in its precise position is ensured, and retention of the prosthesis is greater. Finally the patient is less dependent on assistance of others and feels as though the prosthesis is a natural part of the body. The scope of this article is in providing some background about the evolution and current trends in using the materials with the advent of osseointegration and bone integrated implants.1,2,3

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. 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. Tycho Brache (1546-1601), who used an artificial nose made from gold to replace his own nose. 1600 to 1800:- Pierre Fauchard (1678) made monumental contributions to prosthetic facial reconstruction. 1800 to 1990:- William Morton was credited with fabrication of a nasal prosthesis using enameled porcelain to match the complexion of a patient. 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 1900 to 1940:- In the nineteenth century, vulcanite rubber was widely used by the dental profession and was adapted for use in facial prosthesis. Upham described the fabrication of nasal and auricular prosthesis made from vulcanite.
In 1905, Ottof, Baird and Baker all reported using black vulcanized rubber.
In 1913 – Gelatin-glycerin compounds were introduced for use in facial prosthesis in order to mimic the softness and flexibility.
Kazanjian described the use of celluloid prints for coloring vulcanized rubber facial prosthesis.
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 facial prosthesis.
Tashma used dry earth pigments dispersed in colorless acrylic resin polymer powder for intrinsic coloring of a silicon facial prosthesis.
In 1970 to 1990:- Gonzalez described the use of polyurethene elastomer. Lewis and Castelberry described the potential use of siphenylene for a facial prosthesis.

IDEAL PHYSICAL AND MECHANICAL PROPERTIES:
- High edge strength.
- High elongation.
- High tear strength.
- Softness, compatible to tissue.
- Translucent.

IDEAL PROCESSING CHARACTERISTICS:
- Chemically inert after processing.
- Ease of intrinsic and extrinsic coloring with commercially available colorants.
- Long working time.
- No color change after processing.
- Reusable molds.
- Retain intrinsic and extrinsic coloration during use.

IDEAL BIOLOGICAL PROPERTIES:
- Non-allergenic.
- Cleansable with disinfectants.
- Color stability.
- Inert to solvents and skin adhesives.
- Resistance to growth of microorganisms.

MATERIALS AVAILABLE4-5

1. ACRYLIC RESIN:
It is used particularly in those cases in which little movement of the tissue bed takes place during function.
Acrylic powder: Polymethyl methacrylate
Liquid: Methyl methacrylate
Colors used:
Extrinsic – Acrylic base paint used in monomer or chloroform solvent.
Intrinsic
Heat polymerized is preferred when compared to autopolymerized because of no residual monomer, is more color stable and is free of tertiary amine activator.

Advantages:
- Durable.
- Color stable.
- Cosmetic.
- Can be relined or repaired.

Disadvantages:
- Rigidity.
- Duplicate prosthesis is not possible, because of destruction of the mold during processing
- Water sorption – increased weight 0.5% after one week.

2. ACRYLIC CO-POLYMERS:
These are soft and elastic but have not received wide acceptance.

Because,
- They possess 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.

Antonucci and Stanbury reported the new generation of acrylic monomers, oligomers and macromers.
- They are thermal, chemical and photoinitiated.
They can eliminate the short comings of traditional acrylic co-polymers. Polyvinyl chloride co-polymers: (Realistic, mediplast, proteotype III). At one time vinyl polymers and co-polymers were popularly and widely used for facial restoration. It consists of combination of polyvinyl chloride + plasticizer (a hand clear resin that is tasteless and odorless).

Advantages:
- Flexible.
- Adaptable to both intrinsic and extrinsic coloration.
- Acceptable initial appearance.

Disadvantages:
- Plasticizer migration and loss resulting in discoloration.
- Edges tear easily.
- These compound can be stained easily but degrade when exposed to UV Light.
- Absorbs sebaceous secretions, they compromise the physical properties.
- Require metal molds for curing at high temperature.

3. CHLORINATED POLYETHYLENE:
- Lewis and Castelberry 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 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. Varying amount of isocyanates will change the physical properties of final products.

Advantages:-
- They can be made elastic without compromising strength.
- They can be colored extrinsically and intrinsically.
- Superior cosmetic results can be obtained, surpassing the other materials currently available.

Disadvantages:-
- Difficult to process consistently.
- Isocyanate is moisture sensitive.
- Water contamination is difficult to control.
- Not color stable.
- Poor compatibility of this material with adhesive systems.

5. SILICONE ELASTOMERS:
The silicones were introduced in 1946, but have been used in the fabrication of maxillo-facial 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.
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
Silicon is a combination of organic and inorganic compounds.

Silicon + methyl chloride -> Dimethyl dichloro siloxane + H2O forms a polymer.

Silicones are classified into 4 groups according to their applications:

**Class I:** Implant grade, which requires the material to undergo extensive testing and must meet FDA requirements.

**Class II:** Medical grade, which is approved for external use. This material is used for fabrication of maxillofacial prosthesis.

**Class III:** Clean grade

**Class IV:** Industrial grade commonly used for industrial applications.

### 6. HTV Silicones:

- Silastic 370, 372, 373, 4-4514, 4-4515.
- HTV silicone is usually a white, opaque material viscous and putty like in consistency.
- 1-component or 2-component putty.
- Catalyst / vulcanizing agent of HTV is Dichlorobenzyl peroxide/platinum salt.
- Various amounts of fillers are added depending on the degree of hardness, strength and elongation.
- Silica – Filler Size 30
- Copolymerization of silica with small amount of methyl, vinyl, or methylphenyl siloxane radical.
- Polydimethyl siloxane may be added to reduce the stiffness and hardness of the prosthesis.

#### Various types of HTV Silicones:

- Silastic S-6508, 382 and 399 (Michigan).
- Silastic S-6508 in raw stage is similar to sticky modeling clay. It must be vulcanized at 2600F and formed in pressure molds.
- Silastic 382 is an opaque white fluid with a viscosity like that of a thick honey.
- Silastic 399 resembles white Vaseline in its raw state. Easily spatulated, but non-flowing.
- Silastic 382 is tougher, non-flowing, but easier to handle.

#### Advantages:

- Excellent thermal stability.
- Color stable.
- Biologically inert.

#### Disadvantages:

- Not adequately elastic in function.
- Low edge strength.
- Opaque, life less appearance.

It includes a filler – Diatomaceous earth particles.

A catalyst - stannous octate.

A cross linking agent - Ortho alkyl silicate.

Polymerization – condensation Silicon
- They are available as clear solutions that enable the fabrication of translucent prosthesis.
- RTV silicone is blended with suitable earth pigments; to produce the patients' basic skin color.

#### Procedure:

Material in fluid state
Molds – cure for 30 min
Chloroform (cleaning)
Uncured + xylene = Desired consistency

Surface is tinted with artistic brushes, allowed to stand over night Catalyst is gently applied with a brush (Stippling and other skin characterizations are done). Glossy surface is dulled with pumice using mild finger pressure. Prosthesis is fitted using medical grade adhesive. Cosmetic effect may be achieved by the patient with commercially available make up creams.

Quellette has recently described a new technique of spray-coloring a silicone elastomer.

#### Advantages:

- They are color stable.
- Biologically inert.
- Easier to process.
- Retain physical and chemical properties at wide ranges of temperature.
- Stone molds can be used.

#### Disadvantages:

- Poor edge strength.
- Costly.
- Cosmetic appearance of the material is inferior to that of polyurethanes, acrylic resins & polyvinyl chloride.

### 7. Commercially Available Newer Materials:

Newer materials representing a variety of polymer classes offering unique characteristics have recently been introduced which are as follows:

- Acrylic resin copolymer (Palamed - Kulzer)
- Vinyl polymers and co-polymers (Realistic – prosthetic services)
- Polyurethane elastomers – (Epithane – 3 Daro Products)
- Silicone elastomers – R.T.V. and HTV (MD x 4-4210)
- Silastic 372, 373, Dow corning Mich A-2186
- Factor Zinc ariz, Cosmosil – principally, UK). Materials of the 3rd Millennium: Remerade E.H. stated that the materials of the 3rd millennium are expected to be translucent and should have pigmentation ability to match any skin color. They should have, increased elongation.
- Increased tear strength.
- Should be easily moldable (clay like consistency).
- Cured with light.
- They should readily accept extrinsic coloration.
- High temperature – metal molds should not be necessary.

#### MDX 4-4210:

- This medical-grade silicone elastomer is popular among clinicians.
- Moore reported that it exhibits improved qualities relative to coloration and edge strength.
- The polymerization reaction is an addition reaction with no reaction by-products.
- The cured material has shown adequate Tear strength.
- Accelerated aging tests have shown that the elastomer is very color stable.

#### Adhesives:

A variety of adhesive systems have been employed to retain facial prosthesis in position.

They are classified as

- Pastes (b) Liquids (c) Emulsions (d) Spray-ons (e) Double sided tapes – most commonly used (41%) among patients with facial prosthesis because of its easy manipulation.

#### Cross linking agent – methyl triacetoxy siloxane

An alternate to reduce the dependency on medical skin adhesives is the use of osseointegrated implants to retain the facial prosthesis.

#### Coloration:

- 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.
- Coloration techniques are divided into 3 types:
  (a) Extrinsic. (b) Intrinsic, long lasting. (c) Combinations of both
is more widely used because it produces prosthesis with a more
natural appearance.
Discoloration of intrinsic and extrinsic coloration due to external
environmental factors:
Intrinsic color changes of elastomers.
Intrinsic color changes of colorants (pigments, flockings).
Discoloration of prosthesis due to loss of external coloration:
Loss of adhesion of extrinsic coloration to prosthesis.
Primers and adhesives.
Patient handling.
Staining (handling and other environmental factors).
Solvents.
Medical adhesives and cleansers.
Degradation of physical and mechanical properties:
Tear at margins (tear strength, fatigue).
Change in surface texture.
Elongation at margins (permanent deformation).
Compatibility with medical adhesives.
Weakening of margins by colorants, adhesives,
solvents, cleaners (colorants do not chemically adhere to
elastomer).

**RECENT ADVANCES**

**2 Silicone Block Copolymers :**
It has been introduced to improve some of the weaknesses of
silicone elastomers, such as decreased tear strength, low percent
elongation and its susceptibility to
bacterial growth.

**Polyphosphazenes:** Fluoroelastomer has been developed for use
as a resilient denture liner, and has the potential to be used as a
maxillofacial prosthetic material.

**Cosmesil:** It is a RTV silicone showing a high degree of tear
resistance.

**Foaming silicones :**
Silastic 386 is a form of RTV silicone.
The gas forms bubbles within the vulcanizing silicone. After the
silicon is processed, the gas is eventually released; leaving a
spongy material.

**Advantage:**
Formation of bubbles within the mass can cause the volume to
increase by as much as seven fold. Purpose of the foam silicon is
to reduce the weight of the prosthesis.

**Craniofacial and intraoral implant:**
A review of literature shows that intraoral implants have been
designed in a vast array of different sizes, shapes and
biomaterials. The particular design of threaded pure Titanium
Branemark implant is predicated on several key 7 principles,
including the biomechanical principles. With craniofacial
implants, one difference is that craniofacial bone sites will differ
from intraoral bone sites, as they are thinner, comparatively. The
effective implant length in craniofacial sites is often only 3-4
mm. A craniofacial implant has a flange above the threaded
portion which provides initial stability of implant design during
the healing period and especially helps in prevent tilting of the
implant under the action of lateral forces and movements. Also
the flange helps to prevent accidental perforation of the implant
through thin bone sites that may be encountered in craniofacial
anatomy.

**SUMMARY :**
The ideal properties of elastomers for maxillofacial prosthesis
were discussed. To date, none of the commercially available
materials satisfy all the requirements of the ideal material. Each
material has its own advantages and disadvantages. Future
research should concentrate on two major goals.

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1) Improving the properties of materials, so that it will behave
more like human tissue.

2) Color-stable coloring agents for coloring facial prosthesis.

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