*Review Article*

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# Intrinsic and Extrinsic Coloration of Maxillofacial Prosthesis: A Review Article

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**Abstract**

Maxillofacial deformities may be congenital, resulting from malformations or developmental disturbances, or acquired, caused by conditions such as necrotizing diseases, oncological surgeries, or trauma. Often, surgical reconstruction is not feasible due to factors like the defect's size, location, or the patient's medical condition, making prosthetic rehabilitation essential. The success of such rehabilitation heavily relies on the physical and mechanical properties of the materials used. Contemporary materials include acrylic resins, acrylic copolymers, vinyl polymers, polyurethane elastomers, and silicone elastomers. Over the years, researchers have sought materials that replicate natural tissues in appearance and properties. This article discusses the historical evolution, emerging trends, and future directions in materials used for maxillofacial defect rehabilitation.

**Keywords:** Maxillofacial defect, Prosthetic materials, Rehabilitation, Silicone.

**Key Message:** Maxillofacial prostheses serve as a critical tool for individuals with facial defects resulting from congenital anomalies, trauma, or medical interventions. These prostheses aim to restore form, function, and aesthetics, significantly enhancing the patient's quality of life. Silicone elastomers, introduced in the 1960s, have proven to be among the most effective materials, offering durability, biocompatibility, and a lifelike appearance.

## INTRODUCTION

Maxillofacial prostheses are invaluable in rehabilitating facial defects caused by congenital conditions, trauma, or surgical procedures. These prostheses not only restore aesthetics but also improve the functional and psychological well-being of patients. Introduced in 1960 by Barnhart, silicone elastomers have emerged as the material of choice due to their biocompatibility, elasticity, and life-like appearance. The success of a maxillofacial prosthesis, however, largely depends on shade matching, a process influenced by the subjective perception of color. This review provides a comprehensive overview of the materials, techniques, and advancements that underpin successful maxillofacial prosthesis fabrication, with an emphasis on coloration methods.

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### Historical Overview of Maxillofacial Coloration Materials

The study of color stability in maxillofacial materials has been an area of interest since the late 1970s. Early research by Craig *et al*. (1978) noted no significant changes in luminous reflectance in polyurethane and silicone materials with aging.[13] Haug *et al*.[14] later highlighted color changes due to weathering in various elastomer-colorant combinations. Kiat Amnuay *et al*. (2009) demonstrated that opacifiers such as titanium white provided significant protection against color changes, while yellow silicone pigments exhibited pronounced instability.[15] Subsequent studies, including those by Pesqueira *et al*. (2011), showed that ceramic pigments offered superior color stability compared to makeup pigments, particularly under conditions involving soap and effervescent cleaners.[16] Bangera and Guttal (2014) explored the use of nanotechnology, finding that Zn nano-oxides offered better UV protection at lower concentrations compared to Ti nano-oxides.[17] Bishal *et al*. (2019) further demonstrated the efficacy of TiO2 nanocoatings in reducing color degradation of silicone elastomers under artificial aging.[18]

### Concept of Coloration in Maxillofacial Prostheses

The success of maxillofacial prostheses depends heavily on the accurate replication of natural tissue colors. Chromism, a reversible color-changing process, plays a pivotal role in coloration. Researchers recommend selecting a base shade slightly lighter than the lightest skin tone of the patient to account for color darkening during pigment addition. The human skin's color results from light being reflected, refracted, and scattered. Coloration techniques are categorized into three types:

1. **Intrinsic Coloration:** Pigments are incorporated into the bulk material, forming the base color.
2. **Extrinsic Coloration:** Pigments are applied to the prosthetic surface for detailed finishing.
3. **Combination Techniques:** Integrating both methods for optimal results.

Lontz *et al*.[19] described the physiological details of human skin coloration, highlighting arterial red, venous red-purple, carotenoid yellow, melanoid brown, and opaque cellular lipids. Johnston *et al*. applied the Kubelka-Munk reflectance theory to establish translucency parameters, enhancing the understanding of color matching.[20]

### Intrinsic Coloration Techniques

Intrinsic coloration involves incorporating pigments directly into the silicone base. Lemon *et al*.[6] evaluated the efficacy of broad-spectrum UV light absorbers in maintaining the color stability of pigmented elastomers under artificial and natural weathering conditions. Their findings revealed perceptible color changes under varying radiant energy exposures. Aging, particularly temperature fluctuations, emerged as a significant factor influencing color stability.[21]

### Extrinsic Coloration Techniques

Extrinsic coloration uses silicone adhesives thinned with solvents like xylene to achieve a liquid consistency. These adhesives act as a medium for applying pigments to the prosthesis surface. Adjustments can be made by reapplying pigments or removing excess with chloroform.[21] Schaafis introduced tattooing as a coloring method, where fine needles deposit pigments beneath the prosthesis surface, enabling detailed characterizations.[22]

### Techniques of Coloration

Accurate coloration requires meticulous steps:

1. Lighting Considerations: Full-spectrum, color-corrected lighting minimizes metamerism. Shade matching is best performed under daylight, fluorescent, and incandescent lighting.
2. Base Color Identification: Pigments are mixed to achieve the desired base color. For Asian skin tones, white pigments are mixed with brown, umber, and sienna. Verification methods include photographs and preconstructed tissue shade guides.
3. Pigment Placement in Molds: Pigments are strategically loaded into molds, ensuring proper placement for accurate skin tone replication.

### Currently Available Materials

Selection of prosthetic materials depends on their functional and aesthetic properties:

1. Acrylic Resin: Widely used for facial defects with minimal tissue movement.[23]
2. Acrylic Copolymers: Flexible but limited by poor durability and edge strength.[24]
3. Polyvinyl Chloride: Adaptable to intrinsic and extrinsic coloring but exhibits poor tear strength and color stability.[25,26]

4. **Silicone Elastomers**: Introduced in 1946, these materials gained popularity due to their thermal stability and versatility. Heat vulcanized (HTV) and room temperature vulcanized (RTV) silicones are commonly used.[9,27–30]

Recent advances include silicone block copolymers, polyphosphazenes, and foaming silicones. These materials address issues such as tear strength, elasticity, and bacterial resistance.[31,32]

**Effects of Various Conditions on Color Stability:**

1. **Human Conditions**: Body secretions like sebum and perspiration can cause color changes, particularly under artificial daylight exposure.[33,34]
2. **Fabrication Procedures**: Mechanical mixing under vacuum conditions reduces porosity and enhances color consistency compared to manual mixing.[35]

## CONCLUSION

The integration of digital dentistry and CAD-CAM technology has transformed the fabrication of realistic maxillofacial prostheses. Understanding the properties of various materials is essential to achieving optimal outcomes. Future research should focus on developing color-stable agents and standardized methods for shade matching. Advances in silicone-based materials have significantly benefited prosthodontists, while human factors and patient adaptation remain critical to the success of maxillofacial prostheses. This article provides a comprehensive overview of coloration methods and their role in the fabrication of maxillofacial prostheses.

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