International Journal of Research in Health and Allied Sciences

Journal home page: www.ijrhas.com

Official Publication of "Society for Scientific Research and Studies" [Regd.]

ISSN: 2455-7803

Review Article

Materials and techniques used in maxillofacial defects: A review

[1]Dr. Renu Gupta, [2]Dr. Nikhil Kapila, [3]Dr. Divya Vashist, [4]Dr. Minal Kanwar, [5]Dr. Saloni Sharma

[1]Professor and Head, [2,4,5]PG student, [3]Professor, Department of Prosthodontics, HP Government Dental College & Hospital, Shimla, HP, India

Received Date: 29 April, 2024 Acceptance Date: 18 May, 2024

Corresponding author: Dr. Renu Gupta, Professor and Head, Department of Prosthodontics, HP Government Dental College & Hospital, Shimla, HP, India

This article may be cited as: Gupta R, Kapila N, Vashist D, Kanwar M, Sharma S. Materials and techniques used in maxillofacial defects: A review. Int J Res Health Allied Sci 2024; 10(3):32-38.

INTRODUCTION

Maxillofacial prosthetics is a subspecialty of prosthodontics that involves rehabilitation of patients with defects or disabilities that were present when born or developed due to disease or trauma. Maxillofacial prosthodontics are accustomed to working co-operatively with ENTs, Oral Surgeons, Neurologists, Radiation Oncologists, Speech Pathologists, Anaplastologists, and various ancillary personnel. The overall goal of all maxillofacial prosthetic treatment is to improve the quality of life.
Maxillofacial prosthesis are broadly classified into:

A) EXTRA ORAL PROSTHESIS

(i) Ocular Prosthesis (Replaces Eyes)
(ii) Orbital Prosthesis (Replaces Eyes & Surrounding tissues)
(iii) Auricular Prosthesis (Replaces Ear)
(iv) Nasal prosthesis (Replaces Nose)
(v) Mid facial prosthesis (replaces part of the face)
(vi) Somatic prosthesis (replaces a body part like fingers, hands, etc.)
(vii) Radiation shield

B) INTRA ORALPROSTHESIS

(i) Immediate or surgical obturator: Supports the surgical packing in resection cavity.
(ii) Interim obturator: Restores teeth and gums and has an extension which causes the defect to close.
(iii) Definitive obturator: Delivered after complete healing and remodeling to tissue.
(iv) Palatal lift prosthesis: Helps soft palate assume correct position for speech.
(v) Palatal augmentation (drop) prosthesis: Alter palate prosthetically for speech.
(vi) Mandibular Resection Prosthesis
(vii) Fluoride carrier: Helps to strengthen, protect and preserve compromised teeth

Objectives of maxillofacial prosthesis[1]

1. Restoration of form and function
2. Preservation of remaining hard and soft tissue
3. Restoration of esthetics
4. Therapeutic or healing effect
5. Psychologic therapy

MATERIALS

For centuries, prosthesis have been used to mask maxillofacial defects. Despite improvements in surgical and restorative techniques, materials used in maxillofacial prosthetics are far from ideal.[2]
The necessary properties of materials for maxillofacial prosthetics include:[3]

1. ease of moulding, as each case needs an individual mould.
2. ability to accept colors and shades to simulate the skin features of the patient.
3. flexibility to approximate the mechanical properties of the natural tissues.
4. chemical stability under ordinary weathering conditions.
5. resistance to tear and abrasion when moulded to a very thin edge.
6. color stability from radiation (sunlight) and the oils and fluids of the skin over extended length of time.

7. ease of making duplicates or replacements by nonprofessional technically trained persons.

MATERIALS

ROOM TEMPERATURE VULCANIZING SILICONES	Room temperature vulcanizing silicones are short-chain silicone polymers with cross linking agent such as tetra-ethoxysilane with stannous octoates catalyst. RTV silicones are designed for rapid room temperature curing.[4] They are characterized by a natural flesh-like appearance by using dyed rayon fibers, dry earth pigments, and/or oil paints [5] Room temperature vulcanizing silicones are further classified based on cross-linkage reaction: condensation reaction and addition reaction.
HIGH TEMPERATURE VULCANIZED SILICONES	Heat-vulcanized silicones are used occasionally for maxillofacial prostheses. It is usually a white, opaque material with a highly viscous, and putty like consistency. It is available as one component or two component putty. Catalyst of HTV is platinum salt (salt of chloroplatinic acid). The desired physical and mechanical properties can be achieved by altering the ratio of the matrix and the filler particles. Addition of opaque fillers increases strength but can compromise with translucency of prosthesis.[5] Examples: Silastic S-6508, 370, 372, 373,382, 379, Q7-4635, Q7- 4650, Q7-4735, and SE-4524
MDX-4-4210	This is a low-temperature, vulcanizing silicone polymer is provided as a two-component kit. Because of remarkable improvements over the older Silastic polymers, this material has recently become increasingly popular among maxillofacial clinics. MDX-4-42 10 elastomer is not opaque as are most of the Silastics and other highly filled silicones.[6]
POLYURETHANE	Polyurethane elastomers have great potential as maxillofacial materials. This hypothesis is based on their inherent environmental stability, high tear resistance, low modulus without the use of plasticizers, and good ultimate strength and elongation.[7] Polyurethanes possess excellent properties like flexibility, good edge strength, can be colored both intrinsically & extrinsically and good cosmetic results.[8]
CHLORINATED POLYETHYLENE	Chlorinated polyethylenes as described by Lewis and Castleberry, involves high heat curing of pigmented sheets of the thermoplastic polymer in metal molds and coloration using oil soluble dyes.[9] CPEs are much more resistant to environmental degradation; they can be produced to be soft, tough, elastomers, without the need of plasticizers; they are compatible with many polymeric materials and are readily alloyed with them to further increase their range of available properties; and they are stable thermoplastics and can be moulded to complex shapes at low temperature.[10]
PLASTICIZED METHYLMETHACRYLATE	The major advantage of using acrylic resin is that material is readily available, chemical properties and processing techniques are familiar to dentists. Extrinsic and intrinsic coloration can be utilized with acrylic resin.[8] It has been formulated with a foaming agent. As a result of heat or an initiating chemical, a foaming agent releases a gas that is incorporated into the material as it cures. The resulting product is spongy, with a solid skin wherever the material contacts the mold surface. Disadvantage: Tackiness of the surface of the finished prostheses which creates the affinity for the collection of dust, necessitating special cleaning with benzene.[9]
POLYPHOSPHAZENES	Gettleman was first to introduce use of polyphosphazenes for fabrication of maxillofacial prostheses. Polyphosphazenesfluoro elastomer has been developed for use as a resilient denture liner and has the potential to be used as a maxillofacial prosthetic material.[8]
FOAMING SILICONES	Firtell et al. introduced foaming silicone for fabrication of light weight prosthesis. When silicon is mixed with stannous octoate catalyst, releases a gas in the vulcanization process as bubbles are released with the resulting silicone mass being increased and density being decreased, which presents a much lighter material.[8]
SIPHENYLENES	Formulated as a pourable, viscous, room-temperature vulcanizing liquid they have copolymers that contain methyl and phenyl groups. In tactile response, silphenylene elastomers feel more like skin. These polymers are transparent even when reinforced with silica fillers. [8] They exhibit significant improvement with respect to edge strength, coloration, and low modulus of elasticity relative to other RTV silicones. [4]
COSMESIL	High flexibility with high tear strength contains condensation RTV silicone elastomer. Newer version SM4 is very flexible and has very high tear strength.[9]
PRINTABLE SILICONES	A 3D color image reproduction protocol has been developed for 3D printing of facial prostheses. It involves 3D scanning of the face using a photogrammetry system that captures both 3D topography and color information. Using a combination of software suites, raw scanned data can be modified and corrected by removing noisy polygons,

	along with color adjustment. [4]
SILCONE BLOCK CO POLYMERS	Silicone block copolymers are new materials under development to improve some of the weaknesses of silicone elastomers, such as low tear strength, low – percent elongation, and the potential to support bacterial or fungal growth.[8]

REHABILITATION OF MAXILLARY DEFECTS

Among all intraoral defects, maxillary defects must be the most common one that can appear in the form of communication between oral cavity and maxillary sinus or nasopharynx.

FUNCTIONS OF MAXILLARY OBTURATOR PROSTHESIS[11]

1. It serves as levin tube for feeding purpose.[12]
2. Helps to keep the wound or defective area clean.
3. It can enhance the healing of traumatic or postsurgical defects.
4. It re-establishes the palatal contour and/or soft palate, which can be helpful to restore speech of the patient
5. In important area of esthetics, the obturator can be used to correct lip and cheek positions.
6. It can benefit the morale of patient with maxillary defects.
7. It improves mastication and deglutition.
8. It prevents the flow of exudates into the mouth.
9. The obturator can be used as stent to the dressings or packs postsurgically in maxillary resections.

TYPES OF OBTURATORS [11]

SURGICAL OBTURATOR

It is a plate-type appliance. It is clear acrylic plate prepared from the preoperative impression cast and is inserted at the time of resection of the maxilla in the operating room. The basic purpose of this prosthesis is to restore form and function immediately after surgery and promote healing of the surgical wound.

TEMPORARY OBTURATOR

This obturator is prepared after initial healing of the surgical wound. It is fabricated from the postsurgical impression cast. On the oral side, the prosthesis will have contour for palate and alveolar ridge and usually without teeth. On the defect side, the prosthesis will have bulb, projecting into the defect. The bulb part is to be lined with soft lining material, which is to be changed at regular intervals. Because of the porosity of the lining materials, they are susceptible to bacterial contamination that can lead to undesirable odours and mucosal irritation. Usually, the patient reviewed at interval of every 2 weeks. During this time, the soft tissue may show rapid changes, which may require frequent adjustments in the prosthesis

DEFINITIVE OBTURATOR

Last active phase of rehabilitation of maxillary defect patients includes fabrication of definitive prosthesis. The definitive prosthesis has different rationale and designing aspects when compared to others. The timing for fabrication of such prosthesis depends on many factors.

The factors to be considered are the following:

- Size and location of the defect
- Healing of surgical wound
- Prognosis of tumour recurrence control
- Effectiveness of present obturator.

Fig. Definitive obturator retained by embrasure clasp in 16–17 and 26–27.

Usually, fabrication can be carried out at around 6 months after surgery. As far as remodelling of tissue at the wound is concerned, it can continue for 1 year after the surgery. The amount of remodelling will be highest in soft tissue, whereas bony tissue shows less amount of remodelling.

REHABILITATION OF SOFT PALATE DEFECTS

Velopharynx is a muscular sphincter located between the nasopharynx and the oropharynx that regulates passage of air during speech. The complete closure of this muscular valve is required for normal physiologic activities like speaking, swallowing, whistling, blowing and sucking. The closure of the sphincter usually involves the movement of soft palate, lateral and posterior pharyngeal wall.

Any abnormality in/of these structures may lead to velopharyngeal defects. Soft palate abnormalities can be grouped into three categories– congenital, acquired and developmental

PALATAL LIFT PROSTHESIS

This type of prosthesis is especially useful for patients with velopharyngeal incompetence. The objective is to displace the soft palate to the level of normal palatal elevation, thus enabling closure by pharyngeal wall action. If the length of the wall is insufficient to effect closure after maximal displacement, the addition of an obturator behind the displaced soft palate may be necessary.

PROSTHETIC REHABILITATION OF VELOPHARYNGEAL INSUFFICIENCY WITH PHARYNGEAL OBTURATOR PROSTHESIS[13]

A pharyngeal obturator prosthesis, which may also be called speech aid prosthesis, extends beyond the residual soft palate to create separation between the oropharynx and nasopharynx. It provides a fixed structure against which the pharyngeal muscles can function to affect palatopharyngeal closure.

REHABILITATION OF MANDIBULAR DEFECTS

TYPES OF MANDIBULAR DEFECTS

Acquired mandibular defects are generally divided into continuity and discontinuity defects.[14]

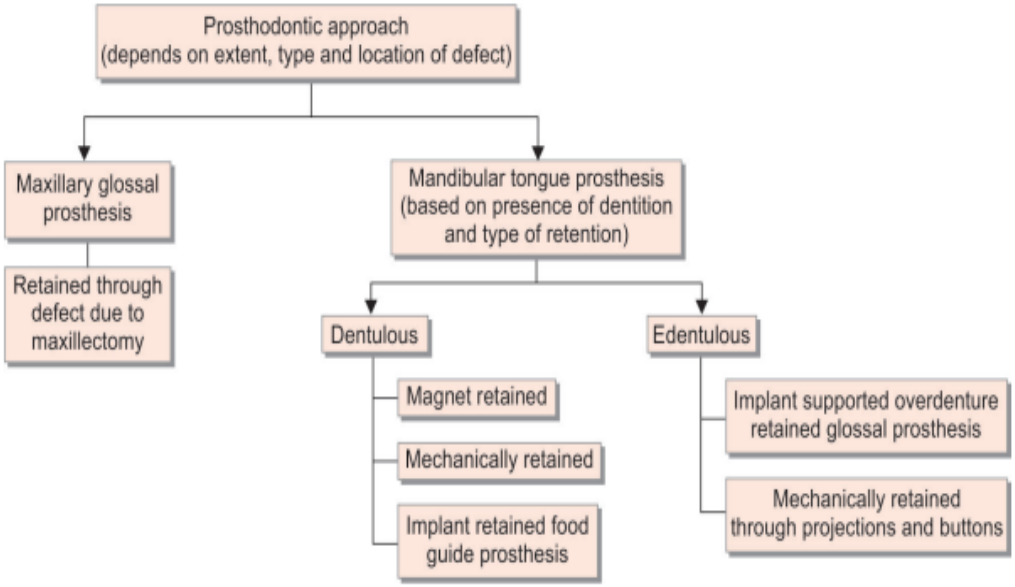
Loss of continuity of the mandible destroys the balance and symmetry of mandibular function, leading to altered mandibular movements and in Discontinuity defects the entire segment of the mandible is resected which leads to deviation of the residual fragment towards the surgical site apart from the other disturbances.[15]

Patient with discontinuity defects usually present with abnormal maxillomandibular relationships, thus preventing ideal placement of denture teeth over residual supporting structure Due to the unilateral forces of occlusion, the axis of rotation of the partial denture deviates from the norm. The location of the fulcrum line is dynamic in mandibular discontinuity defects, making it more difficult to predict movement patterns of the prosthesis during function.It is recommended that a mesial rest be placed on the terminal abutment on the non-defect side, such that it is possible to place a bracing component on this abutment that disengages from undercuts during occlusal loading, which occurs mostly on the non-defect side. This bracing component has to be placed on the height of contour of the abutment tooth or be sufficiently flexible such that undue stress will not be transmitted to the tooth during occlusal loadings Multiple occlusal rests should be placed to gain a tripod support from remaining teeth and supporting tissue. Maximum soft tissue coverage should be attempted. Altered cast impression procedures are recommended so that the manipulation of the cheeks and tongue movements allow border moulding and avoid interferences with functional tongue and cheek movements. At times, the bucco-lingual width of the residual ridge at the resected side may be insufficient to accommodate the width of the framework. Hence, it was suggested that the retentive elements of the prosthesis framework for acrylic resin be made vertical towards the lingual alveolar incline, rather than horizontal on top of the alveolar ridge. This design not only allows the width of the framework to be narrower to avoid impingement on the width of the mandible, it also imparts strength to serve as a major connector. For anterior defects, the framework design should allow border moulding and lip support assessment during speech and swallowing. The design principles of removable partial denture prostheses for partially dentate patients with mandibular continuity defects should be similar to that of non-surgical patients. Altered cast impression procedures are highly recommended to capture the details of the buccal, lingual, and labial contours of the residual tissues. This allows the contours of the final prosthesis to be accurately developed, which contributes significantly to the stability of the prosthesis. Prosthodontic intervention is usually recommended in the initial healing period of reconstructed mandible to prevent the rotation of the mandibular occlusal plane inferiorly and extrusion of the maxillary teeth and improve the masticatory efficiency. Depending on the nature and severity of the mandibular defects, several methods including intermaxillary fixation, prosthetic rehabilitation with conventional prostheses such as mandibular based guidance restorations, and palatal based guidance restorations or implant-supported prostheses have been advocated for the correction of mandibular deviation.

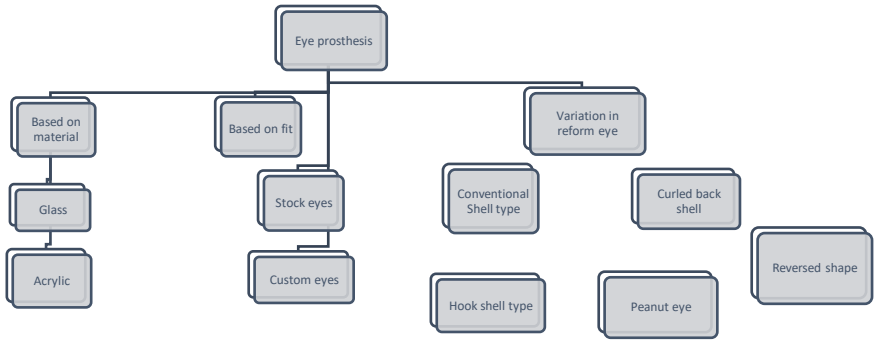
REHABILITATION FOLLOWING PARTIAL AND TOTAL GLOSSECTOMY

GOALS[16]

- Decrease the size of the oral cavity to enhance the resonance and quality of speech.
- Direct the food into the oesophagus
- Protection of the underlying fragile tissue
- Provide a surface for the residual tongue tissue to contact during speech and swallowing.
- Improvement in appearance and psychosocial adjustments



EYE PROSTHESIS REHABILITATION



OCULAR PROSTHESIS: A maxillofacial prosthesis that artificially replaces an eye missing as a result of trauma, surgery, or congenital absence; the prosthesis does not replace missing eyelids or adjacent skin, mucosa or muscle.

ORBITAL PROSTHESIS: A maxillofacial prosthesis that artificially restores the eye, eyelids, and adjacent hard and soft tissues;

FABRICATION TECHNIQUE

Patient evaluation

Impression: External tray impression technique[17],Molded shell/stock tray/conformer impression technique

Wax patternfabrication and try in.

Iris replication and placement

Fig: Before and after placement of prosthesis

REHABILIATATION OF NASAL DEFECTS

Nasal defects are mainly of two types:

1. Gross nasal defects
2. Deformity of shape

Gross nasal defects are rehabilitated mainly either by silicon prosthesis or PMMA prosthesis

Intranasal stents are used to:

1. Support of nasal alae that collapse on inspiration.
2. Expansion of nasal vestibules when soft tissue scar bands or deviated septums obstruct the airway.
3. Support of nasal tips or alae to improve facial appearance.
4. Partial or full occlusion of the nasal passages for patients with atrophic rhinitis.

RETENTION IN MAXILLOFACIAL PROSTHESIS

One of the most important factors that determines the success of a maxillofacial prosthesis is retention. Retention has always been a problem in prosthodontics. Increased retention improves comfort as well as the confidence in the patient while wearing a facial prosthesis at work and in social setting. Methods of Retention used for maxillofacial prostheses fall into four categories:

1. Anatomical, in which the retentive contours existing at the site of deformity are used to retain the prosthesis.
2. Chemical, in which adhesive materials are used to retain the prosthesis.
3. Mechanical.
4. Implant, in which implant fixtures anchored into the bone are used to retain the facial prosthesis.

RECENT ADVANCES IN MAXILLOFACIAL PROSTHESIS

Facial prostheses are customized medical-grade devices used to restore severe functional, cognitive, and esthetic alterations to positively impact the patient's daily living activities in a biopsycho-social way. Three significant steps are well described in the literature to produce facial prosthetics[11,18,19]. The analog manufacturing process starts with a molding of the facial defect. With the obtained gypsum working model, a sculpture can be fabricated with a thermoplastic material that will mimic the lost anatomy, respecting functional and esthetic principles. Once finished, a mold is created as a negative version of the sculpture. Multiple layers of intrinsically characterized medical-grade silicone are packed accordingly to replicate the patient's skin color. However, in most regions of the world, the prosthetic context requires manufacturing them by analog processes such as manual molding, sculpting, and coloring, as well as using acrylic resin materials, as has been done since the origin of this specialty, among other adaptations of the procedure to the local reality[11,21-23]. High learning curves exist to exact this technical task and to reduce the chances of a mistake or remakes of the prosthesis. To overcome this artisanal and time-consuming process, specialists have looked to digital technologies to assist or replace some steps in the process, like moulding and sculpting Face scans with techniques such as monoscopic photogrammetry, precisely executed, are getting closer in precision and accuracy compared to tomographic methods. Even so, in cases such as the evaluation of craniofacial implants, there is an opportunity to compose 3D scans with those of surface scans. In this way, it is possible to obtain the best advantages of multiple systems and technologies in a more digital and integrated treatment. There is no single best technology for every case. It is necessary to intelligently use all the available resources that the patient and the context allows

3D modelling Independent of the chosen technology for 3D facial scanning, the virtual 3D model needs to be manipulated within a CAD program.3D digital fabrication Different digital manufacturing technologies have been described for facial prosthetic digital workflows, from subtractive techniques of wax, metals, and polyether ether ketone (PEEK) to additive manufacturing with fused filament fabrication (FDM), stereolithography/liquid-crystal display/ digital light processing (SLA/LCD/DLP), polyjet, selective laser sintering (SLS), selective laser melting (SLM), and, more recently, silicone 3D printing.

REFERENCES

1. Boucher
2. Phillips 11th edition 755.
3. Sweeney WT, Fischer TE, Castleberry DJ, Cowperthwaite GF. Evaluation of improved maxillofacial prosthetic materials. J Prosthet Dent. 1972;27(3):297-305.
4. A. Gupta, A. Verma, R. Kapoor. Maxillofacial prosthetics part - ii: Materials and Technology. A review of past, present and future trends. Int. J. Adv. Res. 2020;8(4):915-925.
5. A. Mitra, S. Choudhary, H. Garg, Jagadeesh.G.H. Maxillofacial Prosthetic Materials an Inclination40. A. Goldberg, R. Craig, F. Filisko. Polyurethane Elastomers as Maxillofacial Prosthetic Materials. J Dent. 1978;57(4)563-9.Towards Silicones. Journal of Clinical and Diagnostic Research. 2014;8(12): ZE08-ZE13.
6. D. Lewis, D. Castleberry. An assessment of recent advances in external maxillofacial materials. 1980;43(4):426-32.
7. A. Goldberg, R. Craig, F. Filisko. Polyurethane Elastomers as Maxillofacial Prosthetic Materials. J Dent. 1978;57(4)563-9.
8. R. Lanzara, M. Viswambaran, D. Kumar. Maxillofacial prosthetic materials: current status and recent advances: A comprehensive review. International Journal of Applied Dental Sciences. 2021; 7(2): 255-259.
9. J. Reddy, B. Kumar, S. Ahila, S. Rajendiran. J Indian Acad Dent Spec Res s 2015;2:1-4

10. P. May. Maxillofacial Prostheses of Chlorinated Polyethylene. Journal of Biomedical Materials Research. 1978;12:421-31.
11. Meenakshi A, Shah D. The obturator prostheses for maxillectomy. SRM J Res Dent Sci.2012;3:193-7.
12. Chalian VA, Drane JB, Standish SM. Maxillofacial Prosthetics. Multidisciplinary practice. United States: The William & Wilkins Company; 1972, p. 133-48.
13. Kurien Varghese. Prosthetic Rehabilitation of a Congenital Soft Palate Defect. J Indian Prosthodont Soc. 2014;14(1):S181–S186.
14. Elvin W.J. Leong, Ansgar C. Cheng,1 Neo Tee-Khin2 and Alvin G. Wee. Management of Acquired Mandibular Defects— Prosthodontic Considerations. Singapore Dental Journal. 2006;28(1):22-33.
15. Suganna M, Chowdhary AK, Banerjee S, Sulok S, Kumar R, Ahmed R. Prosthodontic Rehabilitation of Cantor and Curtis Class II Mandibular Defect using Cast Partial Denture Therapy: A Case Report. J Adv Med Dent Scie Res 2019;7(4): 26-29.
16. Aramany M A, Downs JA, Beery QC, Aslan Y. Prosthodontic rehabilitation for glossectomy patients .J Prosthet Dent 1982;48(1):78-81.
17. Sajjad A (December 06, 2012) Ocular Prosthesis - A Simulation of Human Anatomy: A Literature Review. Cureus 4(12): e74. DOI 10.7759/cureus.74.
18. Cevik P, Dilber E, Eraslan O. Different Techniques in Fabrication of Ocular Prosthesis. J CraniofacSurg 2012;23: 1779-1781.
19. Yadav S, Narayan AI, Choudhry A, Balakrishnan D. CAD/CAM-Assisted Auricular Prosthesis Fabrication for a Quick, Precise, and More Retentive Outcome: A Clinical Report. J of Pros. 2017:1–6.
20. Salinas TJ, Sinha N, Revuru V, Arce K. Prosthetic rehabilitation of a maxillary defect with a bone anchored prosthesis: A clinical report. J Prosthet Dent 2018;121(1):173-178.
21. Sundaram, RK. Prosthetic rehabilitation of hemi-facial defects with silicone prostheses following chemical burn injury–a five years follow up. The Journal of Indian Prosthodontic Society.2018;18(2):p S109.
22. Gupta S, Gupta B, Motwani BK. Nasal prosthesis after partial rhinectomy. A case report. Clin Pract. 2020;10(1):1200.
23. Aponte-Wesson R, Knott J, Montgomery P, Chambers MS. Floor of mouth prosthesis with removable depressible tongue: A clinical report. J Prosthet Dent. 2022;128(1):107-111.