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Technical Considerations Associated with Mechanical and Chemical Retentive Aids in Maxillofacial Prosthodontic Rehabilitation: A Review

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Abstract Maxillofacial prosthesis (MFP) is a customised prosthesis; therefore, one requires a blend of multiple skills in individualising them for a specific patient. Retention of these prostheses largely depends on available hard and soft tissues, based on which the retention aids can be either mechanical or chemical. Most extraoral prostheses, irrespective of mechanical retention, cannot adhere to the skin for which chemical adhesives are used. While most of the published research focuses on materials, this review has been aimed at collecting evidence-based information on the technical aspects of both mechanical and chemical aids used to retain different types of MFP. Four medical databases were searched for relevant research articles using relevant terms in combination with Boolean operators. The search produced 137 research articles, and after careful evaluation of the articles, about 79 research articles fulfilled the criteria for this review. The technical considerations for the mechanical and chemical aids were further searched from relevant manufacturer catalogues. The review provides a comprehensive clinically oriented background of both in terms of clinical application.

Keywords: *oral cancers, maxillofacial prosthesis, maxillectomy, hemi mandibulectomy, maxillofacial implants*

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1. Introduction

Maxillofacial prosthetics entail reconstructing missing or deformed portions of the maxilla, mandible, and face due to surgical procedures, trauma, disease, or congenital or developmental malformations using non-living replacements. This process can be anatomical, functional, or cosmetic. [1,2] Anaplastology is the science and art of restoring lost, absent, or malformed parts of the body. [3] It is considered a craft as old as humanity. Earlier, the Chinese and the Egyptians used wax and clay to replace the missing body parts or areas. During the COVID-19 pandemic, there was a very high rise in rhino-orbital-cerebral mucormycosis, which is a flesh-eating fungus that reportedly affected more than forty thousand individuals, with more than four thousand being killed. [4] The fungus spreads locally within the facial complex from inside and eventually causes bone necrosis of the maxillary, orbital, and nasal bones. [5] The most appropriate treatment is surgical removal of an infection that results in subtotal or total maxillectomy. Facial disfigurement as a result of congenital or acquired diseases has been associated with the social death of individuals [6], and such patients need to be rehabilitated with a maxillofacial prosthesis that may be either individual or combined in design. Knowledge of materials, impression techniques, and prosthesis retention aids is essential in the fabrication of successful maxillo-facial prostheses. [7] The success of a prosthesis depends on the method of attaching the artificial substitute securely to its place without any discomfort or irritation. [8] Most prosthesis designs for maxillofacial defects must be made before surgical intervention, especially by the prosthodontist, to plan different types of prostheses (immediate, definitive, and interim). [9] Depending upon the nature and extent of surgery, the prosthodontist determines the prosthesis margins that must blend with the surrounding tissue. [10] One of the most difficult aspects of all MFP is margin blending with tissue. [11] The facial soft tissue, unlike other tissues, is extremely dynamic in terms of contours, and none of the contours lasts for long distances unless it is closely attached to the underlying bone [the nasal bridge]. [2,12] between extra and intraoral musculature, there is also a balance in certain regions (neutral zone) where prostheses that contain natural teeth can be more stable due to a lack

of dislodging forces in the region. [13]

A thorough evaluation of the defective site is of prime importance in the proper restoration of the prosthesis. [3,7] The retentive areas are to be identified and recorded so that they can be utilised to the maximum. While designing a definitive prosthesis, a prosthodontist must consider the possibility of different designs and exhaust all treatment options, including implant-supported and retained prostheses. [4,6,14]: Proper treatment planning is necessary in the fabrication of a maxillo-facial prosthesis. [15] This also includes scheduling multiple surgical procedures that are involved using a multidisciplinary approach that involves oral surgeons, oral physicians, and periodontists. [16] Major and minor oral surgeries are quite different from general surgical procedures in various terms [extent, intensity, postoperative care, and drugs used]. [16] For prostheses that are in the aesthetic zones, the prosthodontist must also determine the form of the prosthesis, its texture, and its coloration, which will not be discernible from surrounding tissues. [17] For every MFP, the prosthodontist chooses the retentive aids to be utilised at this point because they will determine how the impressions are taken, what needs to be changed in the current setup, and how the final prosthesis is made. [18] The aesthetic outcome is significantly influenced by the choice of the retentive aid. [19] For the prosthesis's prognosis and patient acceptance, retention is crucial. Retaining a facial prosthesis on the patient's skin is essential to its success, and the main tool for doing so without the need for mechanical means is medical skin adhesives. [20] Poor material and design choices of oral MFP, especially when opposed to natural teeth, result in prosthesis failure. [21]

This literature review was therefore initiated to appraise the recent literature on various mechanical and chemical retentive aids used in MFP rehabilitation. The aim of the review was to consolidate a comprehensive evidence-based literature and identify the technical considerations in their clinical use. The literature searched was from 2005 to 2024 on four different medical databases (Google Scholar, PubMed, Scopus, and Medline). After using multiple individuals and combinations of various terms with and without boolean operators, we found 137 relevant papers, which were screened further for cross-references, titles, keywords, and full texts. The final list of this review included 79 full-length papers, while the rest included non-evidence-based research articles.

Retentive Aids: According to Robert McKinstry, they have been grouped as mechanical, anatomical, implants, and adhesives. [22] Other more specific and broad classifications are based on whether they are intraoral or extraoral. [23] In intraoral, they can be mechanical, adhesives, anatomic, or implants; in extraoral, they can be anatomic (hard or soft tissue-based), mechanical (including spectacles, magnets, snap-on attachments), chemical (adhesives), implants (transosseous), or a combination of all. [23,24] The selection of a retentive aid is dependent on multiple factors that include biocompatibility, strength, ease of manipulation and handling, economics, minimum modification required, longevity, and finally, colour stability. [25,26]

Intra oral retention: The intraoral picture may either be completely or partially edentulous, associated with or non-associated with a maxillofacial defect. Using partial edentulous classifications for prosthesis design, a vast number of possible partial edentulous combinations may be present, with the chief one described by Kennedy into four classes. [27] The remaining teeth may provide either favourable or unfavourable undercuts for MFP retention, and a maximum number of retentive undercuts should be used. Intraorally, the anatomic undercuts of the defect are the ones that are provided by the patient's defect site and engaged by the dentist by the procedure of proper impression-making. [28] The success of intraoral retention relates to the size and location of the defect and the outcome of the surgery. Hard tissue undercuts include existing teeth and bones. Existing teeth may have large restorations, and in such teeth, one should carefully evaluate the possibility of the root or crown getting fractured by engaging the retentive terminal of a cast clasp. [29] Larger alveolar ridges and deep palatal vaults will provide more retention. Soft tissue undercuts are considered undercuts, although their competency in providing retention is limited by their non-firmness and mobility. On the other hand, the labial and cheek musculature aid in stabilizing the denture through their functional forces. [13] If a larger defect occurs encompassing both the maxilla and mandible, as in commando operation skill, then additional to these undercuts' retention is enhanced with proper occlusion, post-dam, and surface adhesion. [26,28] Presurgical considerations should be determined by an experienced prosthodontist, who evaluates the future of the prosthesis according to the local conditions. Generally, one must maintain as much hard palate, teeth, or residual alveolar ridge as possible. [2] At times, premaxilla should be preserved, if possible, except in cases where the existing lesion may require the removal of the whole premaxilla. If the resection extends towards the soft palate, the coronoid process should also be removed. [6] Palatal mucosa should be preserved so that it can be used to cover the exposed bony margins of the palatal vault. One must also take into consideration that post-surgery, there will be bone resorption, which will create prosthesis movements vertically tissue-ward in the midpalatine areas, especially if opposing teeth are intact. [30] Flexural forces are not well tolerated by acrylic resin prostheses and are bound to fracture during use.

Mechanical: The mechanical retention can be temporary or permanent. [31] Temporary mechanical retention of a prosthesis is given only for the healing period. [19] This may be an 18-gauge wrought wire clasp or Hawley labial bow that can be quickly adapted to the teeth to retain the temporary prosthesis during the healing period. Preformed stainless-steel bands or crowns, soldered bands, or brackets can be readily incorporated into the acrylic plate of an obturator or saddle in a lower prosthesis, or a previously existing old denture can be wired in place. [32,33] This wire fixation, or retention, is internal to the infraorbital or zygoma bones. Permanent mechanical retention is desirable for a long period of time, so it has to be more definitive and planned. [31] Retention is achieved from the remaining teeth by utilising the undercut through the use of cast clasps. A well-made and engineered clasp will offer reciprocation, bilateral bracing, splinting, and stability. [34] The cast clasps are most

successfully adapted with well-designed, surveyed, and fitted castings over the abutment teeth. This metal extension is best referred to as the direct retainer. [27] By its construction, the direct retainer has contact with and so engages the abutment tooth to extend around it by more than 180 degrees to resist displacement caused by dislodging forces. Various types of clasps are used: cast circumferential, combination clasp, roach clasp, ring clasp, and embrasure clasp. [32] Precision attachments are most aesthetic and retentive, but their fabrication is tedious. Mostly, they are used in cleft lip and cleft palate cases. Custom-made crowns and attachments made in them (key and keyway) or semi-precision attachments are more practical clinically and can be fabricated in any dental laboratory. [35] Various attachments that can conform to a prosthesis are snap-on attachment types like Dolder or Ackerson bars that connect the two abutment crowns. [31] Some tilted teeth can be used for retention by telescoping crowns or overlay crowns and screw attachments like a gate or swing lock device. [36] A movable labial or buccal bar, secured to the rest of the framework by a hinge at one end and a lock at the other, is the focal point of this design. Intermaxillary springs can be used as mechanical aids in cases where the patient is completely edentulous. Magnets as retentive aids are more versatile and can be placed in either complete or partial dentures. Other mechanical aids that can be used temporarily are suction cups and suction discs. Yojiro et al. [37] have given an innovative yet simple approach to obtaining adequate retention for a complete mandibular defect. It may be possible to retain this facial prosthesis by suspending rods made of clear acrylic resin from the patient's bilateral auricles.

Chemical (adhesives): Adhesives are largely based on sodium carboxyl-methyl cellulose and, in addition, may include karaya gum, tragacanth, polyethylene oxide, flavouring, and antimicrobial agents. Currently, tissue adhesives can be divided into three broad categories: biomimetic, synthetic/semi-synthetic, and natural tissue adhesives. [38] Their main adhesive mechanisms involve molecular bonding, thermodynamic adhesion, and mechanical coupling. [39] The hyrdogen bond contributes to interatomic and intermolecular forces at the surface of the tissue, while other forces [capillary, van der Waal, static electric, and covalent bonds] also contribute. [40]

Psychosocial impact of non-retentive MFP: Most MFPs are generally indicated for the rehabilitation of defects that are the result of oral cancer. Among all cancers, oropharyngeal-associated cancers due to alcohol and tobacco use are more common. [41] Due to their local spread, they invade surrounding oral tissues and cause extensive challenges during rehabilitation. While squamous cell carcinoma types can metastasize to distant organs, there are other tumours that can be self-limiting and undergo spontaneous regression (example, mucocutaneous keratoacanthoma). [42] The lack of retention of prosthesis in such cases can add to the already psychosocial impact that a particular patient is undergoing [43]. Therefore, retentive prosthesis improves quality of life, while a non-retentive prosthesis does the opposite. [44]

2. Technical Considerations

1. A considerable amount of soft tissue movement during the function of the mid-third of the face will only accentuate any pressure from the prosthesis. So, any intranasal extension requires great consideration. The midline septum can be engaged mechanically using a flexible spring like retentive component that holds the lower part of the septum. Since the lateral part of the nose (alae) are soft tissues, no retentive aid can engage and provide retention. Therefore, the nasal septum is the only source where mechanical retention can be planned. Too much extensions into the nose should be avoided since it can create intolerance. Orthodontic springs are good in providing mechanical retention while at the same time they can be tolerated as well. However, patients should be trained well, whenever they engage the septal part. The stainless-steel wire is made up of less thickness gauge which can easily deform. Incorrect removal will permanently deform the spring and render the spring useless in terms of function.
2. In the presence of unsatisfactory undercuts, one must either use an implant or a magnetically retained nasal prosthesis. [45] Depending upon whether the prosthesis is intra oral or extra oral, different implant systems can be utilized. Both intra oral and extra oral abutments are available. The craniofacial types of implants should be planned to maximize loading directly to the bone to influence positive bone remodeling and minimize bone resorption. Routine clinical and laboratory steps as that for intra oral implant systems fulfill the objectives. Computed tomographic investigations allow one to locate the implant site that is conducive to available bone types. Maxillary bone, zygomatic arch and the zygoma complex are ideal sites for extra oral implants. These sites are essentially used for primary retention whereas for secondary retention bone sites like temporal area, nasal fossa, buttress and medial orbit should be utilized. Technically, multiple implants are more complex and a common path should be established first. Since most of the cranial bones are contoured (convex or concave), the implants need to be placed at offset inclination to provide a common path. Bar and clip and ball clips are excellent means if conventional abutments cannot be designed.
3. Magnetically retained prosthesis are simple and less technically sensitive. Intra oral prosthesis should locate placing the magnet posterior to second molar area and anterior to first premolar. This allows the prosthesis to be more balanced. For extra oral prosthesis, one needs to devise a sectional prosthesis which carries two sets of magnets placed at different locations. In order to reduce the bulk and weight of the prosthesis, the space between the inner section and the outer section should be hollowed out. The inner section of the prosthesis should have adequate mechanical retention without causing any frictional contact, to avoid traumatizing nasal epithelium. The margins of both sections

should be merged to the available skin borders.

4. In large defects where anatomical retention is not adequate, mechanical retention is mandatory. Infants' elastic straps can be used for mechanical retention, while adults' ingenuity in the design of spectacle frames can achieve a great deal towards the aesthetic result of a facial prosthesis. [11,31] By fitting a patient with a well-designed frame, the margins of the prosthesis become less obvious, and the spectacles draw attention away from the prosthesis by providing a more acceptable focal point. [46] When designing custom frames, it is of great importance that the correct spectacle arm length is achieved so as to enable good positioning and tight retention of the arm in the ear. [47] Clinically, the measurements from different anatomical landmarks of the nasal bridge and the ear should be recorded. The nose pads and pad arms of the spectacle should also aid in retention. Since both are flexible in metal eye frames (spectacles), they provide an advantage of adjusting according to patient's comfort. Metal frames also have flexible temples and temple tips. The temple tips can be contoured to engage the external ear thereby providing mechanical means of retention. The temples will aid in mechanical retention if they are close to the lateral part of the cranium.
5. Although good retention is important, great care must be exercised with regard to the prevention of pressure points forming.
6. Retention of the auricular prosthesis with eyeglasses should be rarely used. If used, then the frame used should be completely rigid. Sufficient space in the crevice medial to the helix to receive the curving portion of the bow must be provided. [48] "Temple grip" arms can be a simple solution as they achieve retention by the spectacle arm being under tension so as to exert side pressure on the side of the head. [24,34,49] A superior alternative is that of a metal frame that includes sprung-loaded arms. The spring mechanism is built into the hinge of the frame and, when activated, will apply sufficient gentle pressure to the area in order that no movement of the frame occurs. [48]
7. Eyeglasses for nasal prostheses should have thick frames, as thin frames will not cover the junction. If the frame made of acrylic, then a chemical bond with the prosthesis material is possible. [11,46]
8. Supra-orbital ridges can be used for rest. Acrylic buttons are made out of an acrylic substructure that slides into the defect and one or more acrylic projections in the shape of mushrooms that are fastened to the substructure. [48] The final prosthesis will snap over the mushroom buttons for retention.
9. In defects with more than one path of closure, snap buttons or press buttons can be used, which are also based on the same principle. [13,21,23,24] Snap buttons are based on engaging the undercut while at the same time the engaged portion is small sized and flexible to enhance its removal with ease. The placement of snap buttons requires proper alignment between the two components which is technically sensitive as well as complex. The alignment of the male part of the snap button should be aligned with the help of the dental cast surveyor and attached to the prosthesis with self-cure resin.
10. An orbital prosthesis can be further retained by a band worn around the head. The band should have elasticity that is comfortable to wear. In order to gain extra retention, one should not select a band that is too tight. Tight bands are uncomfortable and affect the blood and nerve vessels.
11. Steel bands are a very primitive form of retention that have been used for ear prostheses. They are attached to the prostheses and pass over the crown of the head underneath the hair. [17,35,36]
12. Commonly, skin surfaces affected by radiation, chemotherapy, and surgery are covered with facial prosthetic adhesives. The interaction of adhesive material with skin tissue is not clearly understood. [20] Various types of skin adhesives are available. Examples of commercially available tissue adhesives [Pros-Aide Adhesive [Tronics Inc., Northvale, NJ], Secure Medical Adhesive [Factor I1 Ltd., Lakeside, AZ], Hollister Colostomy Adhesive [Hollister Inc., Libertyville, IL], and Secure2 Medical Adhesive Factor II, Inc., Lakeside, AZ] should follow the recommended manufacturer's instructions for use. [30,38]
13. The adhesive should adequately bond the prosthesis to the skin but be readily removable by the patient for hygiene. The adhesive should be non-irritating to the skin, easily manipulated by the patient, and readily removed from the prosthesis and skin to prevent buildup of the adhesive over time. [39]
14. The retentive strength of the adhesive is dependent on its constituents, thickness, viscosity, wetting, and permeability. [20,40]
15. The type of skin [dry, greasy, flaky, with excess perspiration] on which the adhesive is used should also be considered. [19,50]
16. The most common technique used for direct adhesion is to apply the adhesive to the last 6-7 mm of the periphery. [3] This will lead to fine edges continuously being cleaned and may break down. With selected patients with good manual dexterity, in order to prevent this destruction of the edges and increase the life of the prosthesis, we can reverse the procedure, which means applying adhesive up to the last 4 mm of the periphery. [51]
17. Petroleum jelly application on the margins of the prosthesis allows it to merge with the skin. [50]
18. Resin adhesives, when dispersed in a water solvent, leave a rubber-like substance upon evaporation. [40] The resin adhesive should be applied with a cotton-tipped applicator and allowed to dry when first applied. The second coat is applied and left until clear. The drying time ranges from 1 to 10 minutes. [39,51]
19. Adhesive is removed from the prosthesis by gently wiping with a cloth moistened in alcohol (epithane). [20]

20. Tissue hygiene, irrespective of extensions of prosthesis intra- or extra-orally, should be maintained. External surfaces of the skin should be wiped with alcohol, while the intraoral patient must clean with a brush. For patients with limited dexterity, adjunct chemical agents like mouthwash should be prescribed. [52]
21. Silicone adhesives are forms of room-temperature vulcanizing silicones that are dissolved in solvents. [53] They are the easiest adhesives to use with regard to ease of application and cleaning. The disadvantage is that they lose adhesiveness in the presence of moisture and thicken if the bottle is kept open. [40,51] This can be corrected by adding one or two drops of distilled water. No brush is supplied in the bottle.
22. To remove the prosthesis, lift the edge using a cotton bud or gauze soaked in the remover. Slowly work your way around and under the fitting surface, lifting the prosthesis away from the skin. [39,50]
23. To remove the adhesive from the skin, soak a piece of gauze in the remover, and by gently rubbing and turning the gauze constantly, use plenty of removers. Finish off by washing with soap and water. Finally, use the gauze-soaked-in remover to clean the fitting surface. [50,51]
24. Alternatively, the prosthesis side of the adhesive can be dipped in a remover for 1-2 minutes before being gently peeled off with the help of gauze. Care is taken to remove the acrylic eye before dipping. [39]
25. The problem that may arise in the use of adhesive is its compatibility with different skin types. Sensitivity to adhesives can result in allergy or rash. [38,50] To overcome this, a tissue conditioner can be used. Comfeel protective film is an easy solution to all these problems. [54] This film is available in two packages: a disposable sachet wipe and a roll-on applicator. When applied, Comfeel creates an elastic protective barrier in 2 minutes and provides an ideal surface for adhesive application. [55] This can be of particular use in areas of great mobility, for example, an ear prosthesis, which is sited at the temporomandibular joint region, and a prosthesis used to cover surgically created defects that result from the treatment of malignant melanoma of the leg.
26. Pressure-sensitive tapes are applied by finger pressure. [56] Backing strip composed of cloth, paper, film, foil, or laminate strip coated with pressure-sensitive adhesive. Adhesive is a rubber-type elastomer combined with a liquid and a solid resin tackifier component, plasticizers, fillers, and antioxidants.
27. Adhesive, when present on both surfaces (double-sided), doesn't require preparation and can be readily used. The disadvantage is that it doesn't adhere well to silicone materials, so liquid adhesive has to be used. [39] It is also difficult to manipulate as both sides are sticky and not given to patients with poor manual dexterity. [56] Other drawbacks are contamination on either side that loses adhesive effectiveness.
28. Rubber-based adhesives are basically latex produced by tapping the bark of the rubber tree. [28] Latex is soluble in organic solvents like benzene and petroleum spirits to form adhesives. [56] Vulcanization with sulphur converts it into a sticky adhesive in a hardened state. Bard appliance adhesive is an example of rubber adhesive. Composed of natural rubber, zinc oxide, titanium oxide, tackifier, and N-hexane, it turns into a white, watery paste that sets within 3 minutes after extrusion. It is opaque and can change the colour of the prosthesis. [55] It is not desirable for a facial prosthesis but has been used. Tack is a property of these natural rubber adhesives. It is the stress required to break bonds between two surfaces in contact for a short time.
29. Adhesion to silicone is poor unless used with polyethylene bracing.
30. Prosthesis: where retentive aids are not going to provide retention of the MFP, implant-supported MFP should be considered. Besides their applications in single tooth replacement and complete or partial prostheses, their use has been further extended to retain MFP. [57] Implants with specific sizes for auricular and nasal prostheses overcome the problem of retention associated with traditional MFP. [58]
31. The use of artificial intelligence-driven surgical robots has been introduced, which can carry out procedures like craniomaxillofacial osteotomies. [59] With precision being the main advantage, the extent of surgery can be limited, which will save the normal bone and soft tissue.

Conclusion: Irrespective of the retentive aid used in maxillofacial prosthesis, the proper fabrication of the prosthesis is more important. Accuracy of the prosthesis depends on the technique employed and the materials used. If the fit of the prosthesis is not proper, none of the retentive aids will be helpful. Before selecting a retentive aid, proper treatment planning should be done. In the choice of fixation used for the maxillofacial prosthesis, the most important point to consider is the need or requirement of the patient. Whatever method of retention is chosen, it must be patient-friendly. The golden rule is to keep it as simple as possible, and patients will be happy.

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