Prosthetic Nasal Reconstruction

Michelle K. Ruse, DDS, MDS[a], Michaela Calhoun, MS, CCA[b], Betsy K. Davis, DMD, MS[a,*]

KEYWORDS

• Nasal prosthesis • Facial prosthesis • Maxillofacial prosthodontics • Maxillofacial rehabilitation • Nasal defect • Nasal reconstruction • Rhinectomy

KEY POINTS

- Nasal defects can result from surgical tumor removal, trauma, or congenital conditions.
- A nasal prosthesis can be used alone or in conjunction with surgical reconstruction and can serve as an interim or definitive treatment. Nasal prostheses function by restoring form to the external nose, protecting exposed mucosa and sensitive tissue, supporting eyeglasses, and normalizing breathing and speech patterns. They improve patient esthetics, psychosocial well-being, and quality of life. Nasal prostheses require multidisciplinary care.
- Successful surgical reconstruction is dependent on patient factors like smoking and systemic health, along with the experience and skill of the surgeon. If surgical reconstruction is unlikely to provide a good esthetic and functional outcome, a prosthesis is recommended.
- Intentional surgical techniques and proper preparation of the defect can greatly influence the success of the nasal prosthetic rehabilitation. This may include removal of healthy hard and soft tissues. Collaboration between surgeons, maxillofacial prosthodontists and anaplastologists is the key.
- Creating realistic expectations with thorough patient education is critical for successful nasal prosthetic treatment.

INTRODUCTION

The nose is a prominent central landmark on the face. Individuals seeking prosthetic nasal reconstruction may be missing nasal anatomy due to a traumatic injury, congenital malformation, or complications from an infection, but the most common cause of rhinectomy is tumor resection.[1,2] Head and neck cancer is the 7th most common cancer worldwide, with the majority of cases being squamous cell carcinomas. Head and neck cancer claims approximately 325,000 lives annually; the incidence is expected to increase.[3] Those who live with the aftermath of head and neck cancer can be left with extremely disfiguring defects that affect quality of life and the ability to work and socialize with friends and family. These devastating facial defects can also impede speech, mastication, and oral function.[1,2]

Nasal anatomy is a complex and delicate arrangement of layers of skin, cartilage, bone and mucosa.[4,5] Nasal defects can involve both intraoral and extraoral tissue, and the success of a total nasal surgical reconstruction is dependent upon the anatomic deficits, the health of the patient, and the skill of the surgeon. Surgical reconstruction is extremely complex with regard to anatomy, esthetics, and functional breathing,[4,6] and is not always the best option for restoring optimum esthetics and patient function.[1]

Nasal prostheses can restore esthetics and reproduce normal contours of the external nose, which functions in many ways for patients.[1,2,7] A nasal prosthesis protects exposed mucosa and

[a] HCA Healthcare and Sarah Cannon Cancer Institute, 9228 Medical Plaza Drive, Charleston, SC 29406, USA; [b] Medical Art Resources, Inc and Prosthetics at Graphica Medica, 1880 Livingston Avenue, West Saint Paul, MN 55118, USA
* Corresponding author. 9228 Medical Plaza Drive, Charleston, SC 29406.
E-mail address: davisdkb@icloud.com

Facial Plast Surg Clin N Am 32 (2024) 327–337
https://doi.org/10.1016/j.fsc.2023.12.002

sensitive tissue, supports eyeglasses and face-masks, normalizes breathing by directing airflow through nostrils and away from the patient's eyes and eyeglasses, and in some cases normalizes speech. There are several methods of retaining a nasal prosthesis. The best retention method must be determined for each patient based on their anatomy, systemic health, lifestyle, and treatment goals. Creating a surgical defect that allows for ideal prosthetic design requires a team approach between the surgeon, maxillofacial prosthodontist, and anaplastologist. Additionally, a nasal prosthesis might be considered as a temporary treatment option while a patient awaits surgery.[1,8]

The journey to a finished nasal prosthesis involves 3 phases of patient care; the surgical and healing phase, possible interim prosthesis phase, and finally fabrication of the definitive prosthesis.[1,2] Typically, at least 6 weeks of healing is required before prosthesis fabrication can begin. While many traditional fine art methods and dental materials are employed in the design and fabrication of nasal prostheses, digital technology is streamlining the workflow for prosthetic rehabilitation.

HISTORY OF FACIAL PROSTHESES

Facial prostheses were first documented in the sixteenth century by French surgeon Ambroise Paré, who is considered the founder of maxillofacial prosthetics. He is credited with the fabrication of the first nasal prosthesis made of gold, silver, and "papier mâché." A string attached to the prosthesis was tied around the head for retention. During this time, most of the prostheses were made of a combination of gold, silver, or ivory which made the prosthesis stiff and heavy. It was not until the 19th century that the materials for facial prostheses improved with the use of vulcanite, which was lighter and more comfortable for patients.[9]

Toward the end of the 19th century, Claude Martin introduced the combination of surgery and prostheses to restore defects.[10] He fabricated nasal prosthesis from translucent ceramics. Karl Henning in Austria was credited with the making of a facial prosthesis with an impression. The impression was poured in plaster with the mockup of the prosthesis being made in wax on the plaster mold. The lost-wax casting method was used to melt the wax with gelatin and glycerin paste poured into the mold with vulcanite or rubber. The prosthesis was then glued with some mastic solubilized in ether which was the most aesthetic and comfortable prosthetic fabricated at the time. This method allowed a closer representation to human tissue than previous attempts.[9]

With World War I and the resulting disfigurement, the American sculptor Anna Coleman Ladd made facial masks for soldiers with injured faces. She, along with French sculptor Jane Poupelet, worked with the American Red Cross to operate workshops for the fabrication of these masks.[9,11–15] The second half of the 20th century was marked with great improvement in the materials for facial prostheses. The development of silicone evolving into the Silastic Medical silicone elastomers allowed doctors to have medical grade silicones for facial prostheses for patients. It is still used today for facial prostheses. The work of Per-Ingvar Branemark and Tomas Albrektsson on the osseointegration of craniofacial implants paved the way for implant-retained facial prostheses. In the late seventies, Anders Tjellstrôm was the first to treat a patient with an implant-retained auricular prosthesis.[9,16–19]

SURGICAL CONSIDERATIONS FOR TUMOR-RELATED DEFECTS OF THE NASAL COMPLEX

The most common causes of partial and total rhinectomies are squamous cell carcinomas (**Fig. 1**) and basal cell carcinomas.[5] Nasal reconstruction following removal of these tumors presents surgical and prosthetic challenges.[4] Surgical limitations include the experience of the reconstructive surgeon, as well as tissue availability and tissue health. Radiated tissue with compromised vasculature and fibrosis is particularly challenging.[1,20] Surgical reconstructive options may be further limited by the health of the patient, the need to monitor the area for recurrence, and individual patient desires to avoid additional surgery.[1] As a general rule, partial nasal defects are better served with surgical reconstruction and total nasal defects are better served with prosthetic reconstruction.[2] When possible, many patients prefer surgical reconstruction in order to avoid placing and removing a prosthesis daily.

Partial rhinectomies resulting in smaller defects can often be reconstructed prosthetically (**Fig. 2**) or surgically with great success. However, with a total nasal defect, it is often difficult to create a symmetric and esthetically pleasing result with surgical reconstruction if significant anatomic structures are removed due to the tumor.[1,2] In patients with aggressive tumors likely to recur, surgeons may prefer to have the patient wear a prosthesis instead of pursuing surgical reconstruction, so that they can monitor the surgical site closely. An interim prosthesis can be useful if a patient desires future surgical reconstruction.[8]

When the decision is made to pursue prosthetic rehabilitation, consideration should be paid to tissue quality, soft tissue mobility near the area of the

Fig. 1. Squamous cell carcinoma.

prosthetic margins, and possible retention options, as these factors will influence overall success and patient acceptance. In addition, careful surgical preparation of the defect greatly influences the success of the prosthesis. Surgical procedures, such as skin grafting, that reduce distortion to neighboring facial hard and soft tissues can enhance the prognosis of the prosthetic rehabilitation.[1,2] For example, if the upper lip is pulled posteriorly and superiorly during surgical closure, it will inhibit the ability to create a prosthesis with normal contours (**Fig. 3**). A retracted lip makes it difficult to conceal the lower margin of the prosthesis and can draw unwanted attention to the area. Creating a skin-lined defect is desirable in nasal defects, as unlined defects can compromise retention of the prosthesis due to delicate friable tissues, excess mucus production and drainage, and insufficient surface area for adhesive retention.[1,2] When the floor of the nasal defect is lined with a split thickness skin graft, the area can be used for excellent support of the nasal prosthesis and possible anatomic retention.

A treatment planning discussion between the surgeon and maxillofacial prosthodontist prior to surgery is crucial, as the removal of some tissues that are not affected by tumor is critical to ideal prosthetic rehabilitation (**Figs. 4** and **5**). Nasal ala

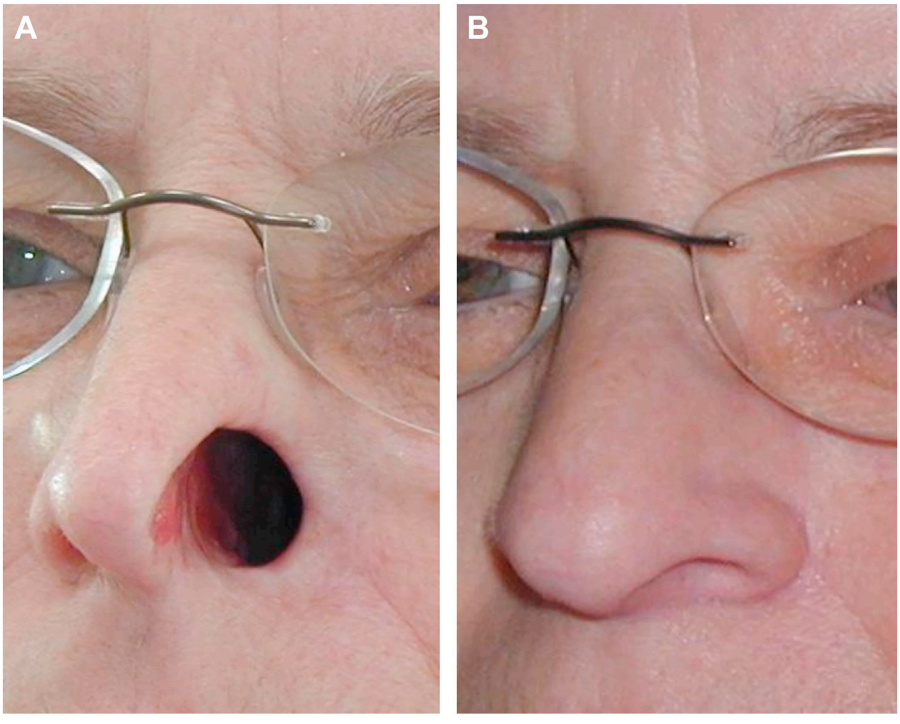

Fig. 2. (*A*, *B*): Partial nasal prosthesis.

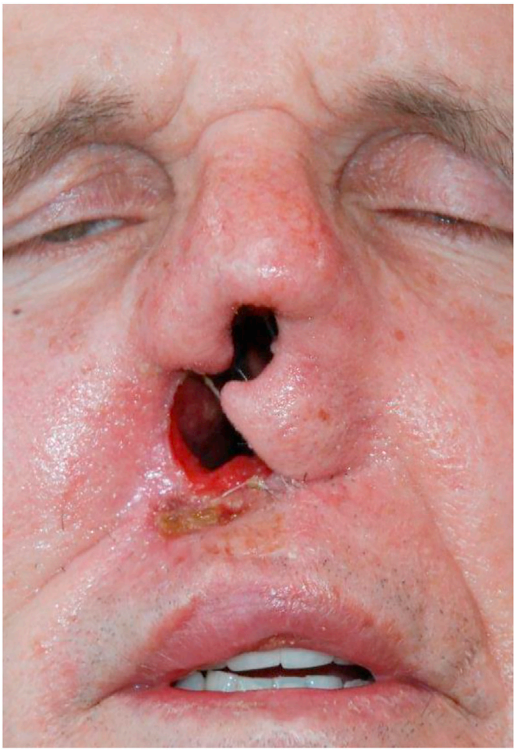

Fig. 3. Defect where tissue was left that prevents ideal prosthesis: bulky nasal bridge and retracted upper lip.

and nasal tip remnants often drift laterally and inferiorly when untethered from structural elements of the nose that are removed during rhinectomy like the septum and columella. This results in nasal structures that are positioned outside of the patient's original nasal form. Prosthetic rehabilitation for these patients requires esthetic compromises that can affect patient satisfaction. Removing otherwise-healthy nasal bones and septum can be advantageous in some instances.[1] When nasal bones and nasal bridge anatomy are retained on a partial rhinectomy patient, it is important that the soft tissues overlying these structures be as thin as possible. When the prosthesis is overcontoured over a bulky nasal bridge, the proportions of the prosthetic design can result in a restoration that is too large for the patient's facial structure. Designing a prosthetic margin over a bulky nasal bridge can also result in areas of silicone that are too thin and prone to tearing.[1] However, the decision to leave some anatomic landmarks to anchor or even retain a nasal prosthesis can be beneficial. In some cases, remnant nasal bridge and lateral sidewall structures create an anatomic undercut that can be utilized to engage a self-retained prosthesis. The nasal bridge can also provide good support for eyeglasses, which can help retain and disguise the prosthesis. Determining the ideal reconstructed nasal defect for each patient should involve collaboration between the surgeon, maxillofacial prosthodontist, anaplastologist, and other members of the healthcare team.

METHODS OF PROSTHESIS RETENTION

Nasal prostheses can be designed to be held in place by several methods, including mechanical-retention by engaging anatomic undercuts (**Fig. 6**); adhesive-retention using various liquid adhesives or tape (**Fig. 7**); implant-retention utilizing

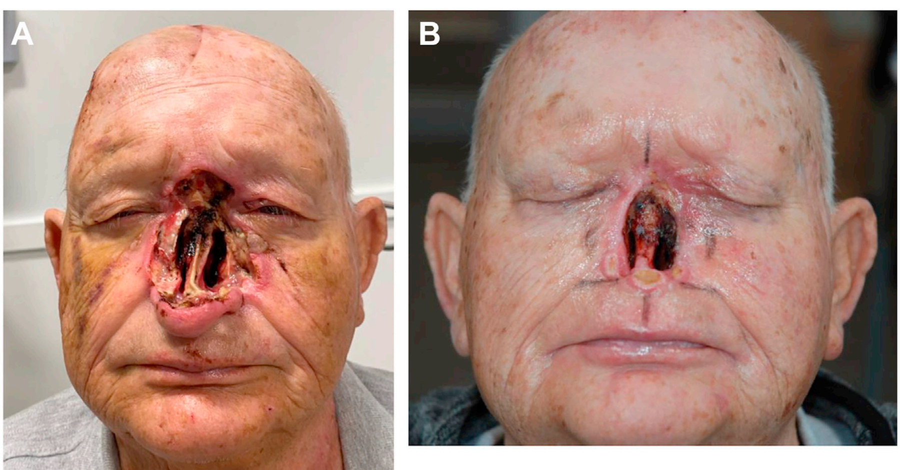

Fig. 4. (*A*, *B*): Excess tissue intentionally removed to create a defect that will allow good prosthetic outcome-requires pre-surgical collaboration.

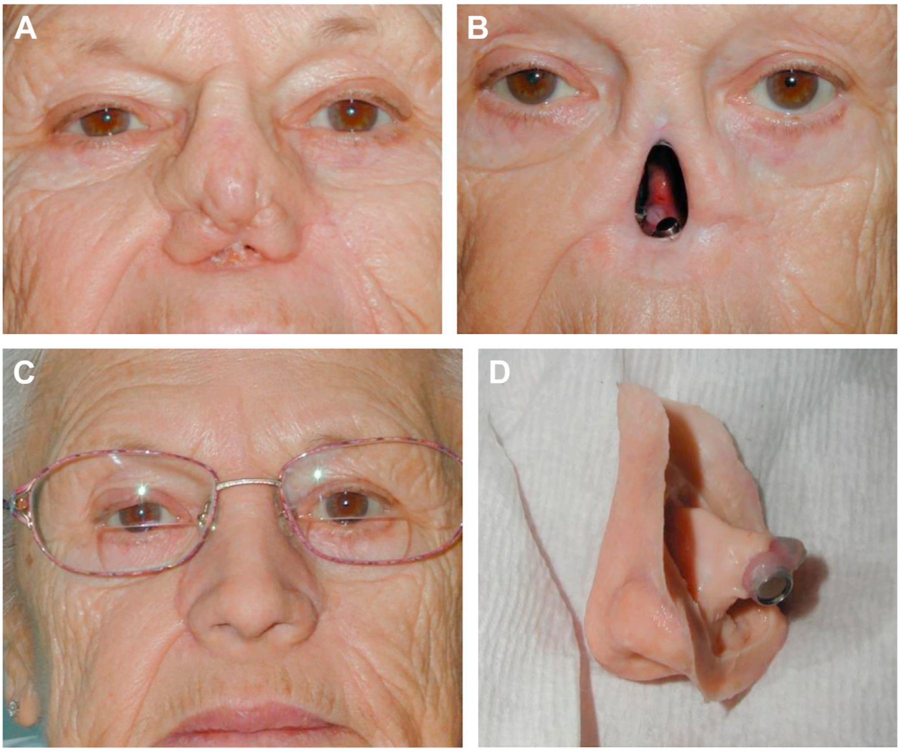

Fig. 5. (*A–D*): Excess tissue intentionally removed to create a defect that will allow good prosthetic outcome and breathing-requires pre-surgical collaboration. Magnet-retained prosthesis.

magnets (**Fig. 8**) or bar-and-clip structures (**Fig. 9**); or hybrid combinations of the earlier-mentioned methods. Each retention method has benefits and drawbacks and the best solution for each patient must be carefully assessed. When a self-retaining nasal prosthesis can be fabricated, this is often a highly successful and satisfactory solution. Self-retaining prostheses often include a nasal stent element, which not only holds the entire prosthesis in place, but also greatly improves breathing. However, these designs can be difficult for the maxillofacial prosthodontist and/or anaplastologist to perfect. Adhesive use is a common solution, particularly for cancer patients, but requires a considerable amount of work by the patient to apply and remove the adhesive on a daily basis. Careful cleaning of adhesive is required to avoid tearing the prosthesis or expediting silicone and color breakdown. The use of adhesives generally decreases the lifespan of the prosthesis. Implant-retained prostheses can provide improved patient satisfaction.[21,22] This type of prosthesis is easier for the patient to place and remove and often provides more reliable retention. However, not all patients are candidates for implant-retained prostheses. Patients with radiation to the site or poor systemic health may not be candidates for implant surgery. Patients who will not be compliant with diligent implant and tissue hygiene are likewise not good candidates for implant placement. Additionally, some patients may opt for fewer surgical procedures and therefore prefer rehabilitation with an adhesive-retained prosthesis. Hybrid retention options may be advantageous by minimizing the amount of glue necessary for successful retention and avoiding the application of adhesive on the silicone edges of the prosthesis, instead relying on an adhered acrylic plate which uses magnets to engage the silicone prosthesis.

CRANIOFACIAL IMPLANTS

Craniofacial implants employ the same design and principles of dental implants commonly used in the alveolar ridges of the maxilla and mandible. The reported success of craniofacial implants ranges widely. Studies have demonstrated implant survival rates of 93% to 100% for auricular implant, 83% to 93% for nasal implants, and 77% to 88% for orbital implants.[23–25] While some of these success rates are lower than those reported for intraoral dental implants, craniofacial implants can greatly improve retention of nasal prosthesis and

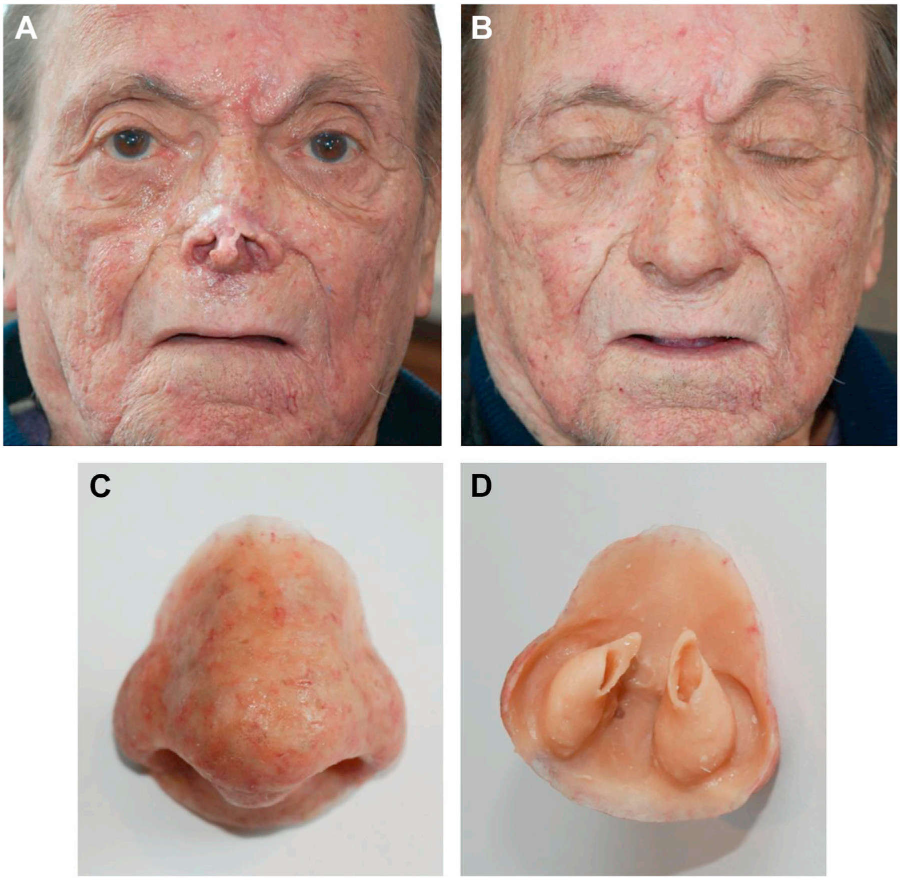

Fig. 6. (*A–D*): Anatomy-retained or self-retained prosthesis.

overall patient acceptance.[21,22,26] Implants should ideally be planned on a computed tomography (CT) or cone beam computed tomography (CBCT) scan with the maxillofacial prosthodontist prior to placement. Implants are placed with the prosthesis in mind to allow proper prosthesis contour and design.

Placing implants in areas with friable tissue can lead to soft tissue complications. When the anterior nasal floor is lined with a skin graft, it is a good site for implant placement. Traditionally, the best sites for placement of osseointegrated craniofacial implants are the floor of the nose and the glabella with the floor of the nose having a higher success rate. Nasal bones do not provide sufficient bone for implant placement. Therefore, if implants are planned in the glabella, the nasal bones should be removed. Implants in the nasal region have been shown to have survival rates ranging from 87.8% to 92.5%,[23–25] with radiation being a significant risk for implant loss.[27,28] More recent reports of using zygomatic implants to retain nasal prostheses have been published with promising success rates.[29] Zygomatic implants offer several advantages. They are more likely to be out of the field of radiation and they gain more stability than traditional craniofacial implants because they pass through 3 to 4 layers of cortical bone. However, the correct placement of zygomatic implants is technique sensitive and requires planning (**Fig. 10**).[30,31]

If implants are deemed appropriate, they are placed in the chosen bony site and covered with tissue for 3 to 6 months to allow for osseointegration. During this period, an interim adhesive-retained prosthesis can be worn. Following appropriate time for osseointegration, the implants are uncovered and engaged with components used to retain the prosthesis. Typically, craniofacial implants are restored with custom bars using clips for retention or with magnets. The magnets are a popular option for facial prostheses due to easier fabrication and maintenance. The use of implant components and the elimination of adhesive allows the patient to place and remove the prosthesis with ease. Eliminating adhesive also extends the lifespan of the prosthesis, as daily cleaning of adhesive makes the silicone edges more prone to tearing.

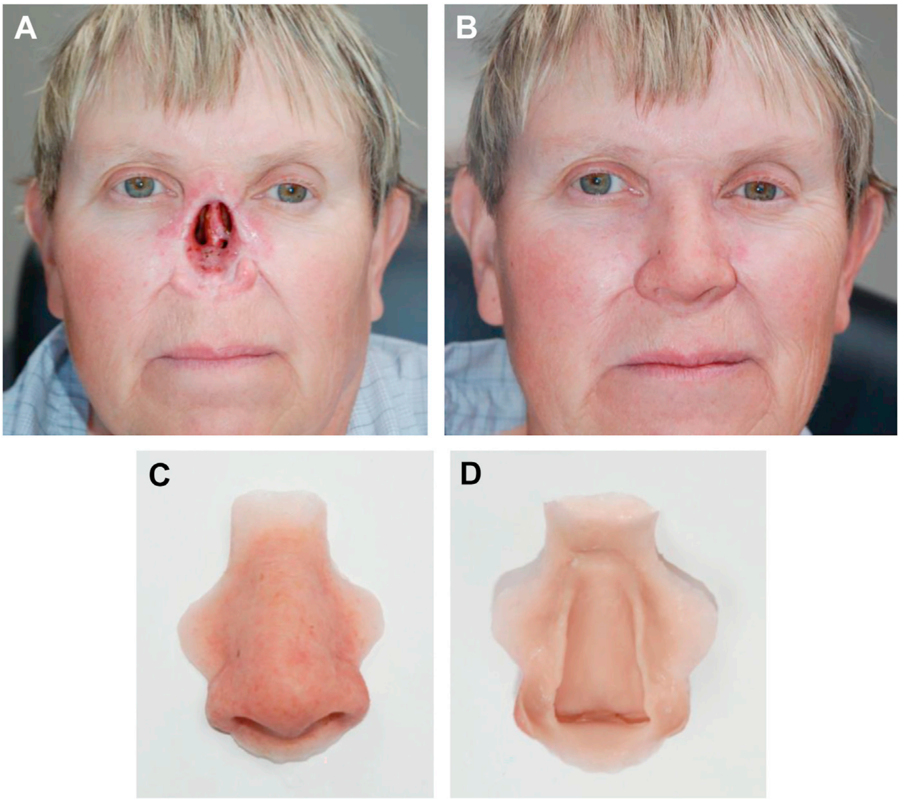

Fig. 7. (*A–D*): Adhesive-retained prosthesis.

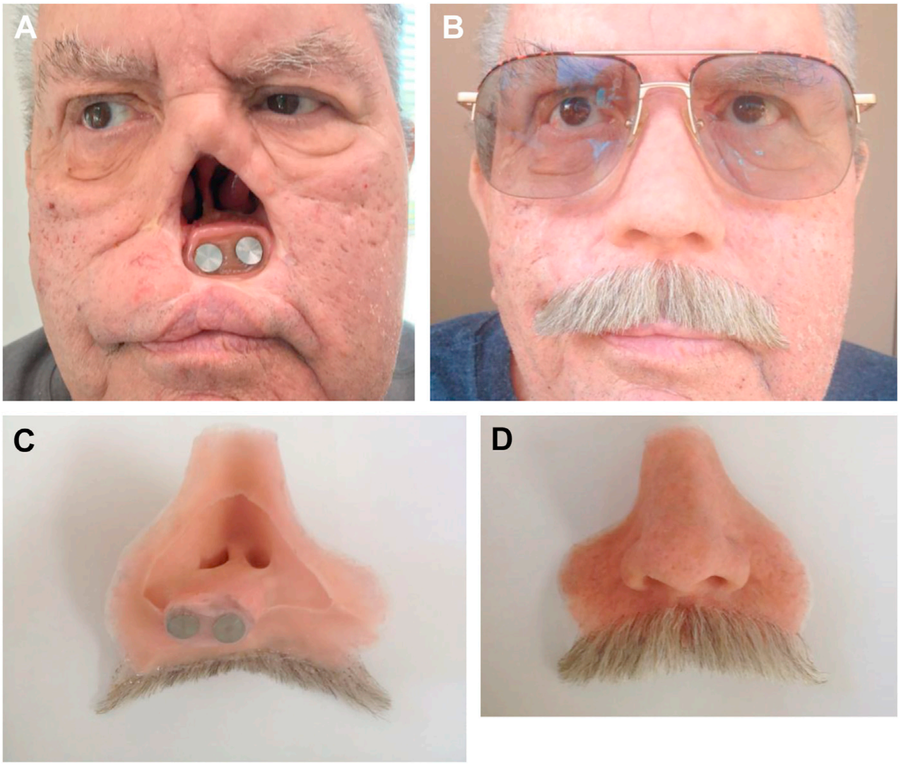

Fig. 8. (*A–D*): Magnets on intraoral obturator prosthesis used to for nasal prosthesis retention.

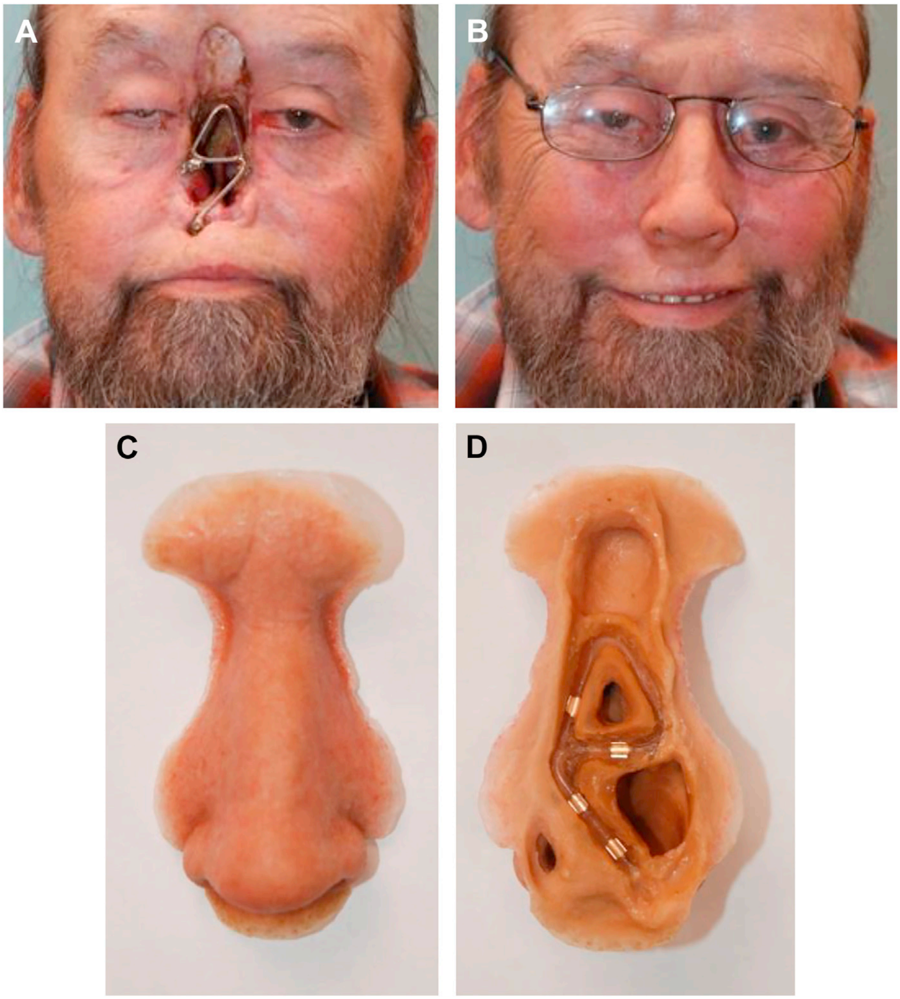

Fig. 9. (*A–D*): Implant-retained prosthesis utilizing an implant bar.

PROSTHETIC FABRICATION, MATERIALS, AND TECHNIQUES

The fabrication of a nasal prosthesis requires multiple appointments following appropriate skin healing from surgery. The first visit typically involves an impression of the midface using traditional dental impression materials. Dental stone is cast in the impression, creating an accurate model of the nasal defect, upon which the prosthesis is designed in wax (**Fig. 11**). The patient then returns for a second appointment to try on the wax prosthesis. Wax is used because it can be easily modified and allows the design of the prosthesis to be changed and approved by the patient. This wax pattern is finalized, textured, and then invested in a stone mold.[32] The wax is melted out of the stone mold, leaving the negative shape of the desired prosthesis. During these appointments, color matching of the patient's pertinent anatomy takes place. Silicone is mixed and then processed into this mold, and following silicone setting, the silicone prosthesis is recovered from the mold. Silicone can be intrinsically or extrinsically stained by the maxillofacial prosthodontist or anaplastologist (**Fig. 12**). The patient comes back for a subsequent appointment where the prosthesis is further customized with extrinsic staining and given to the patient. Digital technology can simplify this process, but still needs improvement (**Fig. 13**). Three dimensional facial scans, whether from a CT/CBCT scan or from a facial scanner, can be made of a patient's pre-op nasal contour and virtually sculpted, if the tumor distorts the shape of the nose. This can then be 3D printed, eliminating the need for hand sculpting a nasal wax pattern and can closely match the contours of the patient's pre-op nasal shape. Color matching has been digitally advanced with colorimeters like Spectromatch (Spectromatch Ltd, 27A

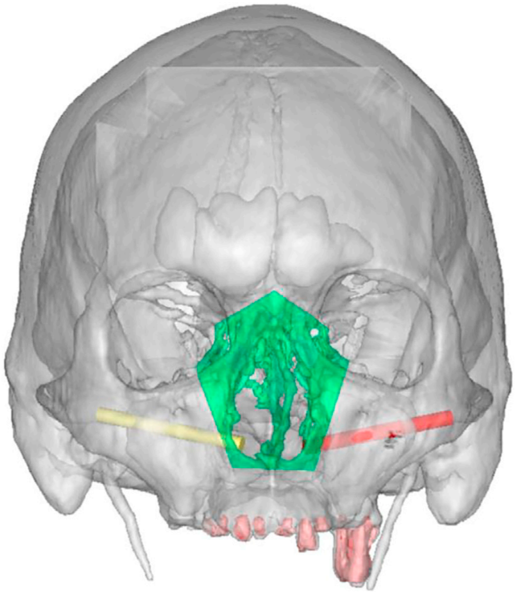

Fig. 10. Virtual surgical planning for rhinectomy and zygomatic implants.

Fig. 11. Wax up of nasal prosthesis.

Fig. 12. Intrinsic silicone staining.

Belvedere, Lansdown Road, Bath, BA1 5HR, UK) for base shade selection.

At the prosthesis delivery appointment, time is spent educating the patient on the correct care and maintenance of their prosthesis, including donning and doffing instructions, cleaning protocols, and potential complications. The patient is then seen for regular follow up to ensure the safe and effective use of the prosthesis.

COMPLICATIONS

Prosthetic complications are often related to issues with retention. When adhesive is used, determining the necessary type, distribution, and amount of adhesive to use for each individual takes some experimentation and trial and error. The presence of moisture from nasal drainage and condensation from air movement through the nasal prosthesis as well as constant midfacial muscle movement during speech and mastication create an environment that can be difficult for adhesives to overcome. Adhesive-retained nasal prostheses are typically remade every 1 to 2 years, due to silicone tearing or discoloration.[2] The frequency of remakes depends on the patient's hygiene, skin type, lifestyle, environment, and sun exposure.

Careful management of nasal prosthetic devices is also required in order to ensure the comfort and health of soft tissues in contact with the device. Modifications may be required to the tissue fitting surface of a nasal prosthesis if contact between the prosthesis and delicate tissues results in discomfort, pressure points, tissue breakdown, or irritation that causes excess nasal drainage. These issues may arise particularly with prostheses using anatomic retention and/or nasal stents, especially in defects not lined with skin grafts. The growth of microorganisms on the silicone surface is also sometimes seen with nasal prostheses. Microbial growth on a prosthesis can cause discoloration and possible tissue health concerns.

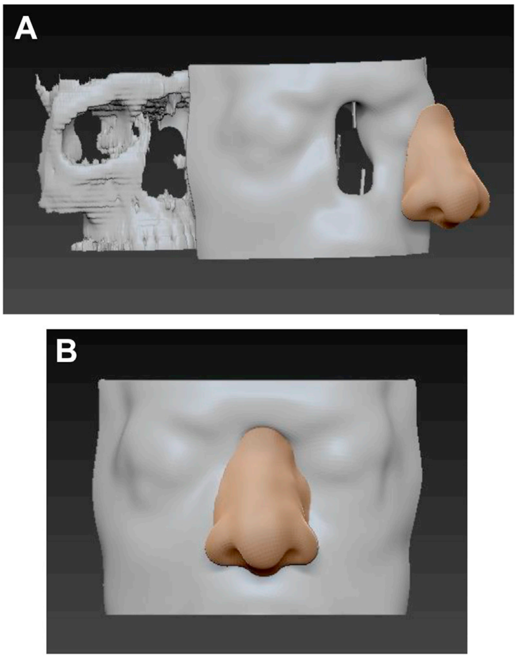

Fig. 13. (*A*, *B*): Digital design.

When microbial growth is present on a prosthesis, more frequent follow-up visits and replacement prostheses may be required.

For patients with implant-retained prostheses, the most common complications involve soft tissue reaction, most often due to lapses in hygiene.[33] Implant infection, implant failure, or implants placed in an unusable position are other possible complications. Implant components can break, lose retention, or detach from the prosthesis, so regular follow up visits are important.

Unsuccessful nasal prosthetic restoration can result from poorly designed prostheses, compromised surgical site preparation, improper implant placement, failed retention with adhesives, or patient non-compliance with care and maintenance of the device. All of these complications can be prevented or managed with good coordination and communication between patients and their surgeons, maxillofacial prosthodontists, anaplastologists, and other members of their healthcare team.

CLINICS CARE POINTS

- Proper patient selection and a skilled surgeon are critical for successful surgical reconstruction of nasal defects. A nasal prosthesis can restore normal nasal contours, function, and esthetics if a defect is properly prepared during tumor removal.
- The promising use of zygomatic implants may result in higher implant success rates even in patients who must undergo adjuvant radiation therapy. Further studies are needed.
- The most common complication with implant-retained prostheses are soft tissue reactions. Patients who are noncompliant or unable to perform diligent hygiene may not be good candidates for craniofacial implants.
- Digital technology is improving the workflow for fabricating prostheses and skin shade matching.
- A team approach is required from the beginning of treatment for patients who will undergo a rhinectomy and subsequent prosthetic reconstruction. The maxillofacial prosthodontist and/or anaplastologist should see the patient prior to tumor resection, collaborate with the surgeon to determine if any otherwise-healthy tissues should be removed along with the tumor, and aid in prosthetically driven implant planning.

ACKNOWLEDGMENTS

The authors would like to thank 3D Systems for providing anatomic modeling and zygomatic implant virtual planning. The authors would also like to thank Julie Brown, renowned certified anaplastologist, for her expertise and use of her images. She continually inspires us daily in the fabrication of facial prostheses.

DISCLOSURE

There are no financial disclosures or conflicts of interest.

REFERENCES

1. Beumer J III, Marunick MT, Espositio SJ. Maxillofacial rehabilitation: Prosthodontic and surgical management of cancer-related, Acquired, and congenital defects of the head and neck. 3rd edition. Hanover Park: Quintessence; 2011. p. 255–313.
2. Davis B, Reisberg DJ, Kirtane MV and de Souza CE. Prosthetic Rehabilitation: Intraoral and Extraoral Prostheses in Head and Neck Surgery, Otolaryngology-Head and Neck Surgery Series 2013, Thieme Medical and Scientific Publishers; Noida (India)Noida, India, 366–387.
3. Gormley M, Creaney G, Schache A, et al. Reviewing the epidemiology of head and neck cancer: definitions, trends and risk factors. Br Dent J 2022; 233(9):780–6.
4. Menick FJ. Nasal reconstruction. Plast Reconstr Surg 2010;125(4):138e–50e.

5. Plath M, Thielen HM, Baumann I, et al. Tumor Control and Quality of Life in Skin Cancer Patients With Extensive Multilayered Nasal Defects. Clin Exp Otorhinolaryngol 2020;13(2):164–72.
6. Malard O, Lanhouet J, Michel G, et al. Full-thickness nasal defect: place of prosthetic reconstruction. Eur Ann Otorhinolaryngol Head Neck Dis 2015;132(2):85–9.
7. Becker C, Becker AM, Pfeiffer J. Health-related quality of life in patients with nasal prosthesis. J Cranio-Maxillo-Fac Surg 2016;44(1):75–9.
8. Rosen EB, Golden M, Huryn JM. Fabrication of a provisional nasal prosthesis. J Prosthet Dent 2014; 112(5):1308–10.
9. Destruhaut F, Caire JM, Dubuc A, et al. Evolution of facial prosthetics: Conceptual history and biotechnological perspectives. Int J Maxillofac Prosthetics 2019;4:2–8.
10. Martin C. De la prosthèse immédiate à la résection des maxillaires. Paris: éditions Masson Ed; 1889.
11. Destruhaut F, Esclassan R, ToulouseE Vigarios E, et al. A history of prosthetic skin from the First World War until now. Actes, French Society for the History of Dental Art 2012;17:55–8.
12. Sigaux N, Amiel M, Piotrovitch d'Orlik S, et al. Albéric Pont, la grande guerre et les gueules cassées (Alberic Pont, the great war and the "broken faces"). Ann Chir Plast Esthet 2017;62:601–8.
13. Williams M, Tong DC, Ansell M. Plates for masking facial wounds. J Roy Army Med Corps 2014;160:51–3.
14. Wood FD. Masks for Facial Wounds. Lancet 1917; 189:949–51.
15. Baron P, Dussourt E. Anna Coleman Ladd (1878-1938), workshop designer of Studio for Portrait Masks in Paris. Cah Prot 2018 2018;182:32–51.
16. Colas A, Curtis J. silicone biomaterials: History and chemistry. Biomaterials science: An introduction to materials in medicine 2004; 2:80-85.
17. Andres CJ, Haug SP, Munoz CA, et al. Effects of environmental factors on maxillofacial elastomers: Part I-Literature review. J Prosthetic Dent 1992;68:327–30.
18. Tjellstrom A, Lindstrom J, Nylen O, et al. The bone-ancholored auricular episthesis. Laryngoscope 1981;91:811–5.
19. Federspil PA. Implant-retained craniofacial prostheses for facial defects. GMS Curr Top Otorhinolaryngol, Head Neck Surg 2009;8:03.
20. Straub JM, New J, Hamilton CD, et al. Radiation-induced fibrosis: mechanisms and implications for therapy. J Cancer Res Clin Oncol 2015;141(11):1985–94.
21. Chang TL, Garrett N, Roumanas E, et al. Treatment satisfaction with facial prostheses. J Prosthet Dent 2005;94(3):275–80.
22. Nemli SK, Aydin C, Yilmaz H, et al. Quality of life of patients with implant-retained maxillofacial prostheses: a prospective and retrospective study. J Prosthet Dent 2013;109(1):44–52.
23. Alberga J, Eggels I, Visser A, et al. Outcome of implants placed to retain craniofacial prostheses - A retrospective cohort study with a follow-up of up to 30 years. Clin Implant Dent Relat Res 2022;24(5):643–54.
24. Chrcanovic BR, Nilsson J, Thor A. Survival and complications of implants to support craniofacial prosthesis: A systematic review. J Cranio-Maxillo-Fac Surg 2016;44(10):1536–52.
25. Curi MM, Oliveira MF, Molina G, et al. Extraoral implants in the rehabilitation of craniofacial defects: implant and prosthesis survival rates and peri-implant soft tissue evaluation. J Oral Maxillofac Surg 2012;70(7):1551–7.
26. Rosen EB, Ahmed ZU, Huryn JM, et al. Prosthetic rehabilitation of the geriatric oncologic rhinectomy patient utilizing a craniofacial implant-retained nasal prosthesis. Clin Case Rep 2019;8(2):278–82.
27. Granström G, Tjellström A, Brånemark PI, et al. Bone-anchored reconstruction of the irradiated head and neck cancer patient. Otolaryngol Head Neck Surg 1993;108(4):334–43.
28. Chrcanovic BR, Albrektsson T, Wennerberg A. Dental implants in irradiated versus nonirradiated patients: A meta-analysis. Head Neck 2016;38(3): 448–81.
29. Scott N, Kittur MA, Evans PL, et al. The use of zygomatic implants for the retention of nasal prosthesis following rhinectomy: the Morriston experience. Int J Oral Maxillofac Surg 2016;45(8):1044–8.
30. Rosenstein J, Dym H. Zygomatic Implants: A Solution for the Atrophic Maxilla: 2021 Update. Dent Clin North Am 2021;65(1):229–39.
31. Aparicio C, Manresa C, Francisco K, et al. Zygomatic implants: indications, techniques and outcomes, and the zygomatic success code. Periodontol 2000 2014; 66(1):41–58.
32. Acharya V, Montgomery PC. A technique to orient a stone cast in the fabrication of a nasal prosthesis. J Prosthet Dent 2014;112(3):692–4.
33. Karakoca S, Aydin C, Yilmaz H, et al. Survival rates and periimplant soft tissue evaluation of extraoral implants over a mean follow-up period of three years. J Prosthet Dent 2008;100(6):458–64.