

Maxillofacial Prosthetics

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KEY POINTS

- Maxillofacial prosthetic is a branch of prosthodontics associated with restoration and/or replacement of stomatognathic and craniofacial structure with prostheses which may or may not be removed on a regular or elective basis. After cancer ablation surgery in the head and neck region, a maxillofacial prosthesis can rehabilitate patient's appearance and functions including mastication, swallow and speech
- When surgical construction of patient after cancer ablation surgery is limited. Patient's functions, esthetics can be restored by a maxillofacial prosthesis. Patient's quality of life and psychological status are improved.
- A maxillofacial prosthodontist works closely with the oncologic surgeon, physicians, and others cancer care team member to deliver the best treatment outcome for the patient.

SYNOPSIS

Treatment of cancer in head and neck region require a team approach. Maxillofacial prosthetics and oncologic dentistry involve in many phases of the treatment. After the cancer ablation surgery, if surgical reconstruction cannot not completely restore the surgical defect site, maxillofacial prosthesis play an important role to rehabilitate the patient's mastication, swallowing and speech. For chemo-radiation therapy, the outcome is enhanced by jaw positioning stent and fluoride carrier mouthpiece. These perioperative care by maxillofacial prosthetics improve the post-treatment outcome and ensure the patient's quality of life.

Introduction

Maxillofacial prosthetic is a branch of prosthodontics associated with restoration and/or replacement of stomatognathic and craniofacial structure with prostheses which may or may not be removed on a regular or elective basis¹. After cancer ablation surgery in the head and neck region, a maxillofacial prosthesis can rehabilitate patient's appearance and functions including mastication, swallow and speech. Not just only after surgical treatment, but on many other occasions the maxillofacial prosthodontist is requested to fabricate a device to support the ongoing cancer treatment. A positioned radiation stent for radiation therapy and a feeding appliance are good examples of those devices. In general, a maxillofacial prosthodontist works closely with the oncologic surgeon, physicians, and others cancer care team member to deliver the best treatment outcome for the patient.

Prosthetics Management of patient after maxillary resection surgery

Surgical excision of tumors in the maxilla is a principle reason for the surgery called maxillectomy or a maxillary resection surgery^{2,3}. Even though it depends on type and location of the tumor, cancer ablation surgery of the maxilla often involves hard palate, maxillary sinus, and nasal cavity. An alteration of the hard palate as the result of surgery can create a communication between the oral cavity and nasal cavity. Because of this oro-nasal communication, food bolus and liquid can escape the oral cavity to exit the nares. The failure to impound the air can cause a sound distortion (Hypernasality). Unintelligible of speech and potential inadequate nutrition of the patient may occur. Prosthetic intervention, with a

maxillary obturator prosthesis, is necessary to restore the contour of the hard palate and to recreate the functional separation of the oral cavity and nasal cavity and maxillary sinus⁴. This prosthetic intervention can be started as soon as at the time of the maxillary resection surgery and will be necessary for the remainder of the patient's life.

Prosthetic treatment planning

Treatment planning of prosthodontic rehabilitation for the patient undergoing maxillary resection surgery has to start prior to the surgery. The principle when treating maxillectomy patient preoperatively is an attempt to do everything that is possible in a limited time to increase the health status after surgery and maintaining the usefulness of the remaining teeth^{2,3}. A comprehensive oral and dental examination should be performed and a dental radiographic should be made. An accurate study cast which includes all important anatomies has to be obtained ***[Figure1: Pre-op study cast for maxillectomy patient]*** and mounted in an appropriated articulator⁵. It is preferred to have at least 2 sets of casts. One is preserved as a pretreatment record and other may be used to fabricate the surgical obturator or interim obturator. Irreversible hydrocolloid is generally the material of choice for making the impression for study casts. This material has a great property to capture anatomical details with short clinical working time and gentle to soft tissue, especially around a tumor area. When possible, dental prophylaxis or gross debridement by a dental hygienist is recommended. Minor operative dental procedures should be done. These are to minimize the risk of the dental and periodontal problems due to the difficulty of oral hygiene practice post surgically. The unsalvageable teeth may also be arranged to be removed at the time of surgery.

It is very important to discuss and explain to the patient about the plan for rehabilitation. Most of the patients are not familiar with the services that prosthodontist can be provided. The benefits, limitations, and sequences of the prosthodontic treatment should be informed to the patients and family. Patient 's compliance and acceptance are very important for the success of the treatment.

Phases of prosthetics rehabilitation for maxillary resection surgery can be classified into 3 phases^{4,5}:

- Surgical /Immediate obturation
- Post-surgical/Interim obturation
- Definitive obturation

Surgical /Immediate Obturation

Surgical obturation has many benefits for the either edentulous or dental patients who require any type of maxillectomy or palatalectomy. The benefits of surgical obturation include providing a matrix on which the surgical packing can be placed and reduced the risk of oral contamination to the wound. The prosthesis improves the patient's psychological status by enabling the patient to speak and swallow immediately after surgery. The ability to swallow immediately after surgery may eliminate the patient's need for or earlier removal of the

nasogastric tube. When utilizing the surgical obturator, the hospitalization period potentially reduces to 3 to 5 days after surgery⁵.

Communication between the prosthodontist and the surgeon is very important for designing and fabrication of the surgical obturator prosthesis. The goal of cancer ablation surgery is to eliminate all of the malignant tumor cells and leave clear margins at the resected site. However, for prosthodontic rehabilitation after maxillary resection surgery, maintaining as many structures (ex: hard palate, teeth) as possible is the key to improve prognosis. In general, the prognosis of the prosthodontic rehabilitation of edentulous patient varies with the defect size⁶. For the dentate patient, the more alveolar process and teeth preserved, the better will be the function of the prosthesis. The surgical incision line greatly influences the design and extension of the surgical obturator. One should design obturator with the most conservative line of resection. This method will allow the prosthesis to be used if the defect is larger than previously plan. If the most extensive line of resection is used for design, the surgical obturator may be too large and will require an adjustment in the operating room. In some institution that the prosthodontist cannot always be in the operating room to adjust and place the surgical obturator after the tumor resection, the surgeon preference is needed to appropriately prepare of the surgical obturator.

One of the general considerations for the surgeon when performing maxillectomy is to make the incision line through the socket of extracted teeth rather than at the interproximal area⁶.

The interproximal cut will result in resorption of the alveolar bone of the teeth adjacent to the defect. This will eventually compromise periodontal health and vitality of the tooth next to the defect which may likely lead to the loss of tooth. The tooth adjacent to the defect is an important abutment for the obturator prosthesis. If possible, the alveolar process which supports the tooth should be maintained.

There are several considerations for fabricating the surgical obturator. The surgical obturator should have a simple design, lightweight and inexpensive⁵. A clear heat processed acrylic resin or auto polymerizing acrylic resin is the material of choice for fabricating the surgical obturator⁴. The benefit of clear acrylic resin is a visualization of underlying tissue at the time of placement in the operating room and observation during the early healing period. For the edentulous patient, the peripheral extension should be made to the proper extension of a complete denture without overextension. Approximating the extension of the prosthesis into the soft palate and the pterygoid plate, especially in an edentulous patient, should be avoided. At the surgical defect or the skin graft-mucosa junction, the extension of the prosthesis should be terminated slightly short. The surgical pack will close any discrepancies in surgical defect margin and the margin of the surgical obturator⁴.

The surgical obturator prosthesis for a dentate patient should be perforated at the interproximal area to allow the prosthesis to be secured with wire to the teeth at the time of surgery. ***[Figure2: Processed surgical obturator with perforated holes ready for the surgery]***

Securing the surgical obturator prosthesis for the edentulous patient is more challenging. It requires the use of a palatal bone screw. A Titanium or stainless steel bone screw can be placed through the pre-drilled holes of the prosthesis at the anterior peak of palatal vault into the vomer. If the vomer is resected, two screws can be placed through the prosthesis into the lateral hard palate at the conflicting angle⁴.

In general, the original palatal contour should be reproduced, anterior teeth can be included in the surgical obturator for psychological and speech reasons. However, posterior occlusion should be avoided to minimize the risk of traumatization of the surgical defect area.

Post-surgical/Interim obturation

After the initial healing period, approximately 7 to 10 days postoperatively, the surgical obturator prosthesis and surgical pack are removed. A definitive prosthesis is not indicated until the surgical site is healed and dimensionally stable⁵. The complete healing time for the surgical site may be up to 3 to 4 months or more if radiation is included in the regimen. In this period, the interim obturator prosthesis is needed to intermediately restore function such as speech and swallowing as well as esthetics for the patient. The interim obturator also helps improving patient's psychological and emotional status.

For the completely edentulous patient, the prosthesis base used for surgical obturator can be modified to serve as an interim obturator prosthesis. The base plate is border molded and

relined using soft liner material (prosthesis polyethyl methacrylates acrylic resins). **[Figure3: Interim obturator]** The viscosity of the material can be altered by changing ratio of powder (polymer) and liquid (monomer). This material also has great handling properties and can be shaped manually⁴. The residual hard palate area and border area should be relined first for optimum stability of the base plate. The defect area can be impressed starting from the bony tissue border. The periphery of the of the defect is impressed by manually and arbitrary extending the soft liner material then adding the material incrementally. During impression of the defect site, the patient should be directed to perform exaggerated head movement and swallowing. This technique is an attempt to simulate a functional movement and should perform every time that the new incremental of material is added. After this functional impression, the base plate with impression material is flaked and processed with auto- or heat polymerizing acrylic resin and deliver to the patient within few hours.

The simple ways to evaluate the performance of the obturator are by speech and swallowing⁷. As 'n', 'm' and 'ng' sound are only speech sound in English that are formed when the air pass through the nasal cavity. Some authors suggested to listen to the 'm' sound and the 'b' sound.⁴ If the 'b' is clear and distinct then there is no air escaping. The phenomenon of air escape from the oral cavity to the nasal cavity during the speech is called "Hypernasal speech". Another method to evaluate the obturator prosthesis is by drinking water. With the prosthesis in place, the patient should be able to drink water without nasal leakage in an upright position.

The same general principles apply to the dentate patient. However, it is recommended to fabricate another prosthesis base from a duplication of the second set of casts. This acrylic resin base should incorporate retentive wire in strategic locations. Soft liner material can also be used to reline and make a functional impression of the defect site. The patient should be informed that over the healing period, the interim prosthesis is needed to be routinely revised to maintain the performance of prosthesis. Once the defect site is stable, the prosthetics rehabilitation process should continue. If the opposing mandibular teeth are presented, it is recommended to have a single posterior occlusal contact position to increase the stability of the prosthesis. Home care instructions should also be introduced to the patient in this phase including dental hygiene, defect cleaning and prosthesis care.

Definitive obturation

During the healing period, the patient sees the prosthodontist every 2-3 weeks for revising the interim prosthesis. By 3-4 months, most of the patient are mentally prepared and realized that mastication and speech will not be substantially compromised. It may be several months after surgery before the surgical area is completely stable without tissue change. This may be up to 6 to 12 months after completion of therapy depending on the size of the defect site^{4,5}. In the late interim phase, auxiliary treatments ex: endodontic and periodontics treatment that initiate during the interim phase should be completed. All remaining teeth should be re-evaluated. Preliminary impressions are made and study casts are properly mounted. The prosthodontics rehabilitation plan should be developed systematically and thoroughly due to the multiple

considerations which differ from a routine prosthodontic patient. Movement of the prosthesis will be significant during functioning. For the edentulous patient, without a dental implant, it is often impossible for the prosthesis to stay in place without using denture adhesive. Placement of dental implant can significantly improve the function of obturator prosthesis⁵. Suitable locations for the dental implant include the anterior maxilla and the maxillary tuberosity^{5,8}. The dental implant placement can be at the time of surgery or at some appropriate time thereafter. Radiation is the most common factor that could compromise the short-term and long-term survival rate of the dental implant in this patient population^{8,9}. The patient's quality of life, prosthesis performance, risks, and benefits are factors to consider for using the dental implant to support and stabilize the obturator prosthesis. However, with or without an additional support from the dental implant, the principle is to preserve the hard palate, residual ridge and healthy abutment teeth for the maximum support, stability, and retention of the prosthesis. ***[Figure 4: Definitive obturator]***

Combined surgical-prosthetic rehabilitation

With the advancement of surgical knowledge and technology, the planned surgical construction using vascularized free flap replacement of missing hard and soft tissue followed by prosthodontic reconstruction of missing teeth may be desirable especially in the young patient. Dental implant supported prostheses can be used to effectively restore function and esthetics for the patient.^{5,10} The patient selection for this combined surgical and prosthetic rehabilitation is very

important. The defect site must be proven to be free of disease and sufficient (more than 2 cm) in size.⁵ The common donor sites are an iliac crest, scapular and especially fibula.¹⁰ The careful prosthetic and surgical planning are required. Computer software using CT data cooperated with the modern 3D model fabrication technology (ex: Stereolithography model) can be used as a part of surgical planning. Dental implants can be placed simultaneously in the free vascularized graft at the time of surgery in one-stage. However, mal-angulation of the dental implants and compromise of flap vascularization can be the result if not planned meticulously. Two-stage surgery protocol is preferred by many institutions. This technique allows 6-12 months of healing and vascularization of the free fibular graft then dental implants are placed. Prosthetic rehabilitation will start 4-6 months later for an adequate time of healing and osseointegration of the dental implant.

Prosthetics reconstruction of the dentate patient with reasonable remaining teeth and hard palate can be achieved by a RPD-obturator prosthesis. A normal speech and swallowing can be restored as well as reasonable mastication. Creating a favorable defect (ex: skin graft of the defect, conservative incision line to preserve healthy periodontal structures of key abutments etc.) for the prosthesis is the key to success of the rehabilitation. This requires good communication and collaboration with the oncologic surgeon and maxillofacial prosthodontist prior to the tumor ablation surgery. For the edentulous patient, speech and swallowing can be restored but mastication is still a challenge. **[Figure5: Maxillary defect (Edentulous)]** Utilizing dental implant in the residual ridge significantly improves the performance of the prosthesis

especially mastication. Home care and oral hygiene are very important. Irrigation of defect with normal saline is recommended. The removable prosthesis should not be kept outside of the mouth for an extended period of time. The prosthesis should be in place after cleaning after each meal. Daily teeth and implants cleaning with the proper modalities should be reinforced to the patient for maintaining the health of remaining oral tissue.

Prosthetic Management of the Soft Palate Defect

The soft palate is a complex neuromuscular aponeurosis.¹¹ It consists of multiple muscles such as tensor veli palatini, palatoglossus, palatopharyngeus, levator veli palatini and musculus uvula muscles¹². These muscles are innervated by the pharyngeal plexus (Vagus Nerve, CN X) except for the tensor veli palatine, which is innervated by mandibular division of Trigeminal cranial nerve (CN V). The physiologic function in this region, also known as a velopharyngeal function, requires a simultaneous movement of the muscles in this area.^{13,14} One or a combination of structural and motor limitations within the velopharyngeal mechanism can result to velopharyngeal dysfunction. This velopharyngeal dysfunction can possibly lead to hypernasality and poor intelligibility of speech.^{13,15} In general, there are two terms that are used to describe velopharyngeal dysfunction based on physical and/or structural integrity. *Palatopharyngeal/ velopharyngeal insufficiency* is the term describing the velopharyngeal dysfunction when there is any tissue or a structural defect of the velum or pharyngeal wall which resulted in unaccomplished closure at the of the nasopharynx.^{11,16} When the soft palate and the pharyngeal structures are of adequate dimension but failed to close the nasopharynx

because muscular and/or neurological capacity, the term *palatopharyngeal/ velopharyngeal incompetency* applies.¹¹

The surgical excision of neoplastic disease in the soft palate area can include the soft palate and adjacent structures.^{13,17} The delicate functional balance between muscles and velopharyngeal mechanism will be effected after the surgery in various degrees depending on the extent of surgical resection and method of surgical closure.¹³ When the function of the palatopharyngeal area is altered due to the insufficient structures after the tumor resection, an obturator prosthesis is designed to close the opening between residual soft palate and the pharynx.¹¹ The goals of the pharyngeal obturator prosthesis, also known as speech bulb prosthesis or speech aid prosthesis, are to provide the adequate ability to control nasal emission during speech and to prevent the leakage of material into the nasal passage during swallowing^{5,14,18,19} Similar to the hard palate defect, the prosthetic treatment for the acquired soft palate defect patient can be approached as immediate/surgical obturation, interim/ delayed obturation, and definitive obturation. ***[Figure 6A: Interim obturator for oropharyngeal defect. The posterior part of the prosthesis was hollowed to decrease the weight., 6B: Interim obturator for oropharyngeal defect in the patient's mouth.]***

Surgical/ Immediate obturation

The immediate/ surgical obturation is most useful in the dentate or partially edentulous patient.^{14,18,19} In the edentulous patient or the patient with limited medial or lateral posterior border resection, the delayed obturation approach is preferred.¹⁹ The immediate obturator

prosthesis will provide support and retention of the surgical packing. The challenging in the fabrication of the immediate soft palate obturator prosthesis is a proper extension of the prosthesis. For example, the drape of the intact soft palate precludes the clinician from obtaining an impression of the nasopharynx in which normal palatopharyngeal closure occurs^{5,19} also, it is very difficult to delineate the surgical margins presurgically. Adjustments at surgery are generally required for the proper extension without excessive tissue contact as well as providing space for a nasogastric tube.

Post-surgical/ Interim obturation

7-10 days after the surgery, the prosthesis and surgical pack are removed. The tissue contact, especially at the lateral and posterior border, are checked. Then the soft-liner material is used to correct the palatopharyngeal extension area of the prosthesis. The patient is instructed to perform head movements and swallowing movements to mold the extension area to the proper dimension.¹⁹ Speech and swallowing are evaluated. The patient is followed up with sequential appointment until the definitive prosthesis can be fabricated.

Definitive Obturation

Construction of soft palate defect definitive prosthesis usually start with conventional removable prosthesis then the palatopharyngeal area is extended to the defect area.^{5,18,19} It is very important that the prosthesis should be carefully designed to accommodate the extra weight and movement of the defect area to provide adequate support, retention, and stability of the prosthesis. In the edentulous patient, the meatus design obturator has historically been

recommended.^{18,20} The prognosis of the definitive prosthesis is depended on the patient's ability to move residual pharyngeal complex during functioning. The chance of achieving normal speech is low if the patient exhibits little or no movement of the residual palatopharyngeal complex, and *hypernasal* speech will be resulted due to inability to control nasal emission.¹⁹

Prosthetics Rehabilitation of The Acquired mandibular defect

Prosthetics rehabilitation of the acquired mandibular defect resulting from oral cancer is very challenging. It requires a good understanding of anatomy and mandibular movement. The extent and location of defect especially the presence or lack of mandibular continuity are important factors for a favorable outcome.^{18,21,22}

Conventional Prosthesis

Continuity Defect

Resection of the mandibular body with overlying tissue while maintaining inferior border of the mandible and its continuity is called Marginal mandibulectomy.^{22,23} This surgical technique is indicated for head and neck cancer treatment including cancer of the lower lip, the floor of the mouth, retromolar trigone, gingiva, buccal mucosa and some skin cancer in facial area.²³ Soft tissues are used to reconstruct marginal mandibulectomy ex: skin graft, pedicle graft or microvascular graft depending on the extension of the resection. Prosthetic rehabilitation after marginal mandibulectomy is less complicated because the continuity of mandible is maintained and muscles of mastication are intact.^{5,21,22} Conventional removable partial denture type

protheses (RPDS) can enhance patient's esthetics, improve speech and provide effective mastication.^{21,24}

Due to the supporting area being compromised, the basic objectives of RPD design to control and to minimize movement of the prosthesis as well as maximum extension of denture base and stable occlusion of the prosthesis are recommended for minimal traumatization of the grafted tissue.¹⁸

Discontinuity Defects

Prognosis of prosthetic rehabilitation for the patient with a mandibular defect is quite variable. For many patients, reasonable mastication can be achieved while in some patient only esthetics can be improved.²¹ Mandibles lacking continuity are severely compromised biomechanically.²⁴ All jaw movement and positioning including resting position, opening, closing, and protruding are functioning with the remaining muscles around the single load bearing joint. There are other multiple factors that affect the movement of the discontinued mandible, for example locations of the defect, the number of the remaining teeth, wound healing and radiation scarring on the defect side.^{18,21,25} These result in a deviated jaw closing movement to the defect side and occlusal discrepancy in the dentate patient.^{18,21,25} A specially design removable prosthesis can be fabricated to manage these adverse outcomes after mandible and tongue surgery and improve function and esthetics for the patient. (pictures)

Combined surgical- prosthetic rehabilitation

Like the maxillary defect, after cancer resection surgery, an osseocutaneous free flap can be used to reconstruct the mandible.²⁵ The most advantageous donor site is fibula while iliac crest may also be used.²⁶ The fibular free-flap provides greatest bone length, the optimal dimension for dental implant and minimal donor site morbidity.^{26,27} Two surgical teams can work simultaneously at the donor site and recipient site. Occasionally, dental implants can also be placed in the same surgery. ***[Figure 7A: Mandibular defect reconstructed with fibular reconstruction-Intraoral view- due to the soft tissue approximation at the surgery, 2 dental implants were utilized to support the prosthesis, 7B: CBCT Panoramic view, 7C: CBCT lateral view]*** However, the delayed approach for dental implant placement is preferred in many institutions. This is to minimize the risk of complications including compromise of the pedicle's blood supply. One of the advantages of the delayed implant placement approach after the proper healing of the graft is to allow the surgeon to place the dental implant in the proper position and angulation for supporting the mandibular resected prosthesis.

Ancillary prosthesis for cancer therapy

Positioning stents during radiation therapy

During cancer therapy, the maxillofacial prosthodontist is often requested to fabricate a prosthetic device to support the cancer treatment. The design of the device depends on the modality of radiation therapy for the head and neck cancer patient. In the past, the device is designed to position the radioactive isotopes for brachytherapy.²⁸ However, the external beam radiation with the intensity-modulated radiation therapy (IMRT) technique has become the

treatment of choice for radiation delivery in the head and neck area over the past few years.^{28,29} The organ immobilization and ability to allow repeatable positioning of the patient on daily basis throughout 6-8 weeks of radiation therapy are the requirements to excellent treatment outcome of IMRT.^{28,29} **[Figure 8A: Radiation stent (tongue depression stent), 8B: Radiation stent in the working cast, 8C: Radiation stent in the patient's mouth]** Recently, in some leading cancer institution, the intensity-modulated proton therapy (IMPT) has also been used to treat head and neck cancer patient.³⁰ As well as IMRT, the IMPT is operated by computer and provides a more precise radiation delivery dosage. The positioning stent is also required for this radiation treatment. Depending on the location of the tumor and type of radiation therapy, the maxillofacial prosthodontist can design the positioning stent to serve the needs of the radiation oncologist.

Fluoride carrier tray

One of the most common complications during and after radiation therapy for head and neck cancer patient is salivary gland dysfunction.^{31–33} The ionizing radiation causes irreversible damage to the cells of the salivary glands especially serous salivary gland leaving remaining saliva thick and sticky. The patient with salivary gland hypofunction and salivary dysfunction usually have xerostomia which generally associates with dental caries.³⁴ This type of dental caries is so-called radiation caries. To prevent the radiation caries, a dentate patient who is undergoing and underwent head and neck radiation therapy, topical fluoride treatment is necessary.^{31,32,34,35} The patient is recommended to use a high concentration neutral fluoride

with a custom mouthpiece application during radiation therapy and continue this life-long daily topical fluoride treatment after radiation therapy.^{31,32,34–37}

Facial Prostheses

As a result of head and neck cancer surgical treatment, some patients require treatment with a facial prosthesis.^{38,39} When surgical construction alone cannot fulfill the patient needs, a facial prosthesis is used to obtain reasonable esthetics of the patient and may also improve function. A facial prosthesis is an artificial replacement of an eye, ear, nose or other portion of the face that restores normal appearance may improve function.¹ **[Figure 9: Orbital prosthesis, 10: Ocular prosthesis, 11: Nasal prosthesis, 12: Auricular Prosthesis]** The prosthesis is made of medical grade silicone rubber and is custom made to suit the fit and appearance of the individual patient^{33,40} Osseointegrated implants can be placed in strategic maxillofacial areas which can improve retention and acceptance of facial prostheses.⁴¹

Conclusion

Treatment of head and neck cancer patient requires a team approach. Maxillofacial Prosthetics are used to support the cancer treatment team during treatment and also improve the patient's post-cancer treatment quality of life.

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