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The Influence of Maxillary Obturators on Respiration and Speech: A Clinical Case

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ABSTRACT

The maxillary bones are the most important bones of the facial skeleton. They provide support to the base of the skull and are essential to the voice box, causing maxillary defects that occur following tumor resection or trauma to result in the loss of some functions such as phonation, deglutition, mastication, respiration, and aesthetics as well as loss of self-esteem. The aim of this paper is to show how prosthetic rehabilitation has multiple impacts on the phonatory and respiratory systems. (J CANCEROL. 2016;3:64-70)
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INTRODUCTION

The hard and soft palates create a physical barrier between the oral and nasal cavities, the maxillary sinuses, and the oropharynx. Its anatomic integrity is important to ensure proper function. In oncology patients, acquired maxillary defects result from the surgical resection of neoplasms that involve its structure and adjacent tissues in the midfacial area and which can be restored by means of a prosthetic device that is intended to close these acquired openings[1].

Respiration

The valves are structures that regulate the flow of air or fluids within the human body. In the nose, the cartilage and tissue of the nasal cavities, especially those of the inferior nasal conchae and the nasal septum, act as valves, regulating airflow; the anterior portion of the nasal cavities, from the nostrils to the nasal valve (NV), is the area where nasal airflow resistance is the greatest. The conchae protrude right into the middle of the inspired nasal airflow, thereby performing vital functions: controlling the airflow pattern and respiratory and airflow rates[2].

Secondary changes in maxillary morphology and nasal geometry resulting in communication between the oral and nasal cavities lead to changes in nasal airflow and respiratory function; resection of the maxilla is often accompanied by partial or total resection of the inferior nasal conchae, resulting in involvement of the nasal valve, which is strongly influenced by the shape of the inferior nasal conchae. This condition, coupled with the communication between cavities, results in nasal airflow dysfunction and affects the patient's respiratory function.

Components of respiratory function, such as airflow rate, airway resistance, and functional residual capacity, may be affected by the resection of the maxilla, which results in obvious reductions in the filtration, warming, and humidification of the air.

Airway resistance results from opposition to flow caused by the forces of friction; it is the ratio of driving pressure to the rate of air flow caused by the resistance to air flow provided by walls and ducts and it is also influenced by the hyperemia status of the nasal conchae. High nasal volumes and high nasal airflow show a significant correlation with high temperatures and a negative correlation with water gradients. Patients who have undergone maxillectomies frequently complain of nasal drying, crusting, and secretions accumulating after the maxillectomy produced by an inability to maintain moisture in the nasal cavity, which is dependent on an intact sinonasal mucosa. Loss of the inferior concha, enlargement of the respiratory airways over the nasal passage, and altered nasal resistance in the wider nasal airways may reduce the contact of the inspired air with the surrounding nasal respiratory mucosa[3].

The existence of nasal cavity resistance helps to create negative pressure in the chest during inspiration, which enlarges the pulmonary alveoli and expands the area for gas exchange. Patients with a maxillary defect undergo changes in the structure of the nasal cavity. Physiological dead space of the upper respiratory tract increases, resulting in a decrease in alveolar volume. Alveolar ventilation volume directly measures the volume of the exchange between the air and blood (V/Q ratio), so it follows that the alveolar ventilation volume of patients with maxillary defects may be below the normal range[4].

Phonation

The phonatory and respiratory systems combine to form a functional unit that includes the

CNS control centers, lungs, rib cage, and abdominal cavity, working in an organized, precise and sequenced manner and where the failure of one of its parts affects the others. Phonation is not the main function of these components, but in humans all these organs are able to work together to produce sounds.

During phonation, a process of transduction of aerodynamic energy is generated by the respiratory system into acoustic energy radiated at the lips that is heard as sound takes place.

Expiratory air from the lungs becomes fragmented at the larynx, which is a vibrator and regulator of frequency that produces harmonics from the vibration of the vocal cords, caused by the pressure of the air from the lungs flowing through. This sound acquires all its breadth and quality in the resonator tract that is constituted by the pharynx (hypopharynx, oropharynx, and nasopharynx), nostrils, and oral cavity[5].

It is important to have a proper breathing pattern in order to achieve adequate phonatory and respiratory coordination and thereby correct voice production. Sound should begin when expiration begins and the vocal cords come together to start the vibration cycle as, otherwise, the beginning of phonation would be uncoordinated and we would hear a loud or breathy smack caused by the glottis slapping together. A major impact on patients who undergo maxillectomy is the impairment of speech intelligibility. The opening between the oral and nasal cavities reduces intraoral air pressure during speech production resulting in articulatory imprecision, hypernasal speech, nasal air emission, and reduction of vocal volume and leads to impairment of speech intelligibility, which interferes with quality of life[6].

Absence of nasality in the voice depends on the integrity of various resonating cavities. Once the integrity of these cavities is lost, the voice is adversely affected[7].

CLINICAL CASE REPORT

An 81-year old female, with a known history of recurrent basal cell carcinoma (BCC) since 2011, a native and resident of Cuernavaca, Morelos, Mexico, married, Catholic, high school education, housewife.

Family health history

Mother and cousin died of skin cancer.

Personal medical history

Negative for alcohol use and smoking.

Surgeries

Excision of a tumor of the nasal tip in 2001 at the age of 68 with reconstruction using forehead flap; BCC reported verbally.

Onset of disease

Patient mentions having the following symptoms of the skin and surrounding areas: erosion, months of growth in the area of the nasal tip surgery scar. A 0.5 cm lesion was found during physical examination of the reconstruction site and dermatosis on the right cheek, clinically negative neck. An incisional biopsy was performed of the nasal and right cheek lesion; the former was reported to be ulcerated BCC and the latter was reported to be solid-type BCC. Patient was treated by dermatology with topical 5% imiquimod for skin of the left cheek and by radiotherapy (RT) with 51 Gy in 17 fractions. The patient presented with late RT-related changes in the irradiated areas, with a recurrent lesion on the lower left lateral side wall of the nasal pyramid that was treated conservatively with imiquimod and, following failure, was assessed for surgical treatment. A CT

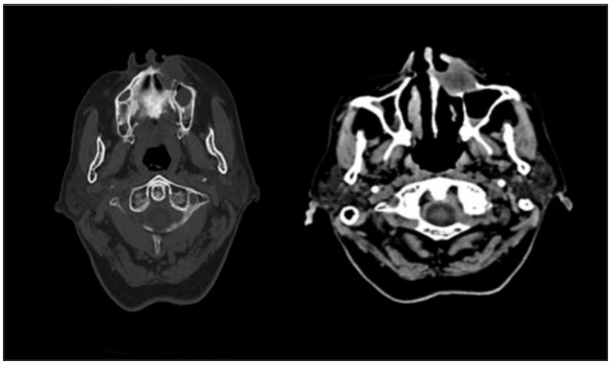

Figure 1. Computed tomography scan.

scan of the area showed mucosal thickening and secretion in the maxillary sinuses. Heterogeneous enhancement revealed a solid tumor in the sphenoid sinus, with its epicenter in the left nasolabial fold, and which was destroying the walls in the lacrimal recess, maxillary sinus, nasolacrimal duct, and alveolar recess extending into the adjacent soft tissues. It affected the ascending ramus of the ipsilateral maxilla and partially obliterated the common nasal meatus (Fig. 1). Left partial maxillectomy and total rhinectomy were performed.

Surgical finding

An infiltrating tumor in the left nasal ala, extending to the nasal vestibule, infiltrating the anterior medial wall of the maxillary antrum as well as the superior alveolar process.

Histopathology report

Specimen from a total rhinectomy and left partial maxillectomy: solid type BCC, adenoidal with morphea showing ulceration and abscesses, located in the skin of the nasal ala and extending to the nasal cavity, gingival mucosa, periodontal space, and the medial and anterior walls of the maxillary antrum.

The patient was referred to the Maxillofacial Prosthetics Unit by the Head and Neck Unit and the Radiation Therapy Units for final rehabilitation of the combined defects: nasal and intraoral class IV according to Aramany's classification of maxillary defects (Fig. 2). Treatment was initiated. First, the condition of the remaining teeth and of the oral mucosa were evaluated, impressions were made according to conventional procedures in order to cast the metallic framework and construction of the definitive obturator, whose purpose is to separate the oral and nasal cavities and to add volume to the nasal prosthesis, was initiated. After the obturator was ready, work was started on making the nasal prosthesis: a model was made and

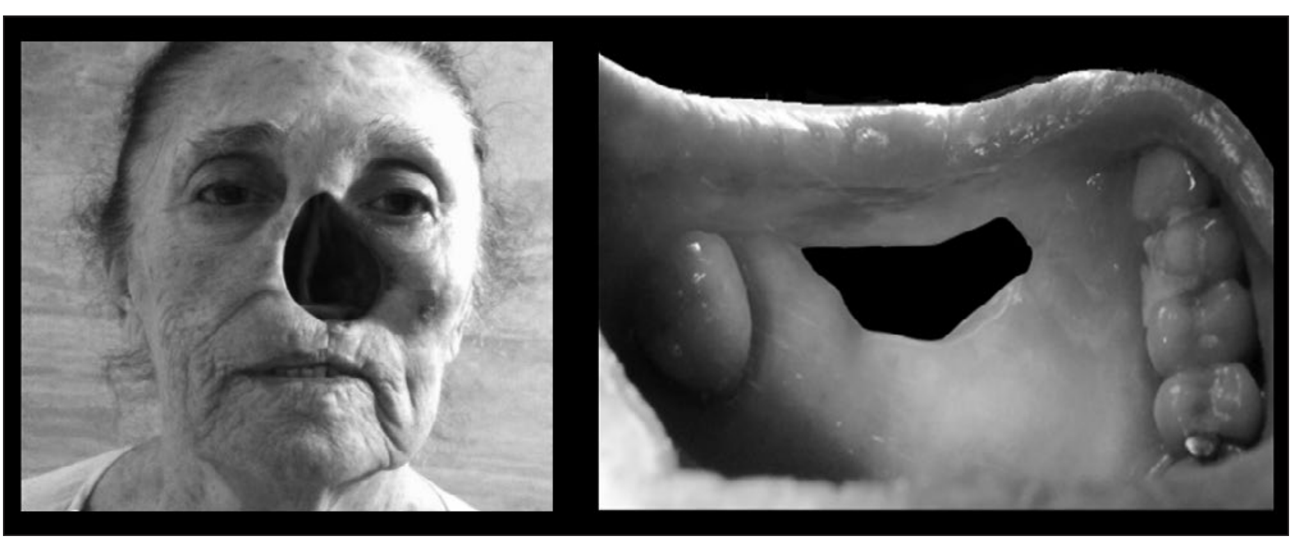

Figure 2. Patient with nasal defect and class IV maxillary defect according to the Aramany classification.

Figure 2. Prosthetic rehabilitation; **A**. Patient with nasal and obturator prostheses placed in position; **B**. Occlusal view of obturator in place; **C**. Frontal and lateral view of obturator.

adjusted to the facial defect, then intrinsic coloring was done using silicone material, and when the base color was developed, extrinsic coloring was added (Fig. 3).

RESULTS

After undergoing a total rhinectomy and partial maxillectomy, components of the respiratory function and speech have been affected. On the one hand, the nasal valve is affected by the loss of the inferior concha, which has resulted in a modification to the airflow pattern of inspired air from laminar flow (orderly flow) to turbulent flow. A greater amount of air fills the cavity, but this air does not get filtered and humidified so the passages are neither hydrated nor clean so this results in the development of paradoxical nasal obstruction: despite more air being inspired, the lungs have to work harder to get it, in addition to the loss of resistance to air flow provided by the nasal walls.

Phonatory-respiratory coordination results from the harmonious integration of myoelastic expiratory pressure in the larynx and the muscular pressure that occurs during articulation. The oral cavity is just as important for resonance as the pharynx; loss of continuity of the palate produced by a Class IV defect will cause problems with F, V, Z, T, D sounds.

The shutter at the top will be responsible for performing the functions and guide runny nose, performing the inferior turbinate, narrowing the nasal valve, preventing dysfunction nasal airflow, and increasing contact of the inspired air with the nasal mucosa surrounding and reestablishing close normal parameters, the volume of air flow, and the functional residual volume. The bottom will be in charge of replacing the continuity palate, helping improved phonetic articulation modes; walls facial silicone prosthesis will resist the inflow of air helping in conjunction with the shutter maxilla inspired air pass a pattern of turbulent flow to a laminar flow pattern.

The upper part of the obturator will now have to provide the function of directing nasal airflow that was formerly performed by the inferior concha by narrowing the nasal valve, preventing dysfunction of nasal airflow, and increasing contact between inspired air and the surrounding nasal mucosa, as well as restoring airflow rate and functional residual capacity parameters to near normal. The lower part will be responsible for replacing continuity of the palate, helping to improve the phonetic manner of articulation; the walls of the facial silicone prosthesis will oppose resistance to air flowing in, working together with the maxillary obturator so that the flow of inspired air transforms from a turbulent flow pattern to a laminar flow pattern.

DISCUSSION

Airflow dynamics are recognized as being an important factor for the functioning of the human nose in conditioning and filtering inspired air, and yet these dynamics are poorly understood. Despite considerable research on airflow dynamics by otolaryngologists, respiratory physiologists, and toxicologists, there are still major disagreements about the nature of airflow in the human nose. In particular, there is little consensus about the character of nasal airflow regimes (laminar or turbulent) and about the main pathways of airflow through the internal chamber. However, it is known that in healthy patients, the relative projection of the inferior concha is the only variable that significantly affects the flow rate[8]. By adjusting it to the total or partial recession of the inferior concha that is carried out in patients with maxillary cancers, we can talk about a major change in the airflow dynamics of patients who have undergone maxillectomies. We know next to nothing about the impact that prostheses have on the components of respiratory function, and no spirometry tests or other respiratory function tests are conducted on patients who have defects that involve airway components.

On the other hand, improved phonatory ability after a maxillectomy has been demonstrated. Speech tends to become hypernasal and is often unintelligible. Measurements of nasality and speech intelligibility can be used to evaluate the effectiveness of oral-nasal communication[9]. Although the acoustic characteristics associated with nasality are not totally eliminated, they are significantly reduced with a prosthesis[10]. The results of speech resonance have shown that when a prosthesis is used, there is a reduction in hypernasality in the majority of patients (69.6%), according to some studies in the literature. However, the success of prosthetic treatment may be limited by factors such as radiation therapy, the extent of a maxillectomy, and speech therapy[11].

CONCLUSIONS

For prosthetic rehabilitation in cancer patients who have different types of defects, the priority should always be to provide a potential solution that will allow the quality of life of the patient to improve, keeping in mind that the meaning of this concept varies from one person to another as each one of us has our own ideas as to what constitutes quality of living; we can only offer that which is in our power to provide: to restore vital functions such as respiration, deglutition, phonation, and self-esteem.

We should integrate all our knowledge in prosthetic rehabilitation. Every case is different with varying degrees of difficulty, but we must always bear in mind that rehabilitation requires a holistic approach, taking on the challenge of restoring the patient's functions to near normal physiological parameters and considering that the best way to determine the success of prosthetic treatment is by the changes in the day-to-day life of the patient who, together with the prosthetic rehabilitation, is able to develop skills for coping with and mastering new ways of living.

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