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Recent Advances In Head And Neck Cancer Reconstruction:A Review

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ABSTRACT
The term "cancer" is used for a large group of diseases that are characterized by growth of abnormal cells beyond their usual boundaries. Middle-aged and older individuals are most prone to oral cancers, although these have also been found in younger adults, "Oral cancer" can be divided into three categories namely carcinomas of the oral cavity proper, carcinomas of the vermilion of the lip, and carcinomas arising in the oropharynx. Intraoral and oropharyngeal tumors are more commonly found in men as compared to women, with a male:female ratio of over 2:1. However, the difference in this ratio has become less noticeable over the past half century, possibly because of the fact that women have been more equally exposing themselves to known oral carcinogens. Treatment of cancer includes excision of tumor and neck dissection, apart from adjuvant chemotherapy and radiotherapy. However, it results in anatomical defect, functional loss, cosmetic disfigurement and the psychosocial effects which can be devastating to the patient. Reconstructive surgery plays an important role in improving the quality of life by restoring anatomical defect, achieving functional rehabilitation and aesthetic outcome. There are various recent advances in the reconstruction of head and neck cancers, such as, free tissue transfer, double free flaps, triple advancement flap, tissue engineering, computer aided surgery, computer aided navigation technology, prototyping, 3D printed models, in house virtual surgical planning and robot-assisted reconstruction.

Keywords: Cancer, Head and Neck, Reconstruction, Recent advances.

INTRODUCTION

The term "cancer" is used for a large group of diseases that are characterized by growth of abnormal cells beyond their usual boundaries. These cells can invade adjoining parts of the body and/or spread to other organs. It is the second leading cause of death across the world. The most common types of cancers in men are those of the lung, prostate, colorectal, stomach and liver, while in women these are breast, colorectal, lung, cervix and thyroid cancers.[1]

Oral cancer is a serious problem in various parts of the world. Oral and pharyngeal cancer, when grouped together, is the sixth most common type of cancer in the world, with the annual estimated incidence of around 275,000 for oral and 130,300 for pharyngeal cancers excluding nasopharynx. Two-thirds of these cases occur in developing countries. In high-risk countries like Sri Lanka, India, Pakistan and Bangladesh, oral cancer constitutes the most common cancer in men, and may contribute up to 25% of all new cases of cancer.[2]

Smokers have five to nine times greater risk for developing oral cancer as compared to non-smokers. Extremely heavy smokers may have increased risk, which is as much as 17 times greater. Patients with treated oral cancers who continue to smoke are at two to six times greater risk for developing a secondary malignancy of the upper aerodigestive tract as compared to those who cease to smoke.[3] The use of tobacco is the world's leading preventable cause of death. More than 5 million people are killed annually. The most common form of tobacco-caused cancer is that of the lung, followed by tumours of the larynx, pancreas, kidney and bladder.[4] Consumption of alcohol is a major risk factor for cancers of the upper aerodigestive tract. Patients who are both heavy smokers and heavy drinkers can have over one hundred times greater risk of developing a malignancy because of the synergistic effect of alcohol and smoking.. Marijuana use may also be partly responsible for the rise in oral cancers among young adults.

Other causes include betel quid chewing which often results in oral submucous fibrosis that can have a malignant transformation. Human Papilloma Virus(HPV) may also be associated with oral and oropharyngeal cancers. Dietary factors, such as a low intake of fruits and vegetables, may also increase the rsik of cancer. Combination of iron deficiency anemia, dysphagia and esophageal webs (known as Plummer-Vinson or Paterson-Kelly syndrome) is associated with an elevated risk for development of carcinoma of the oral cavity, oropharynx, and esophagus. Erosive form of oral lichen planus may also be associated with an increased cancer risk.. Kidney transplant patients receiving immunosuppressive medication have been reported with carcinomas of the lips, and oral carcinomas have been reported in young AIDS patients.[3]

Treatment of cancer includes excision of tumor and neck dissection, apart from adjuvant chemotherapy and radiotherapy. However, it results in anatomical defect, functional loss, cosmetic disfigurement and the psychosocial effects which can be devastating to the patient. Reconstructive surgery plays an important role in improving the quality of life by restoring anatomical defect, achieving functional rehabilitation and aesthetic outcome.

2. History of Reconstructive Surgery

Development of plastic surgery is very well documented since 3000 BC, when Edwin Smith Surgical Papyrus, from ancient Egypt, described first surgical management of facial trauma. Reduction of nasal fracture was done, followed by nasal cleaning, packing and splinting with linen. Shushruta, in 6th century BC, first described the first operative procedure for nasal reconstruction by the transfer of skin from forehead and cheek. Before the 1950s, reconstruction was performed only when no early local recurrence developed.[5] Later in the early 1950s, defects were repaired using a forehead flap or temporal flap combined with split-thickness skin graft.[6] In the late 1950s, the first free flap procedure was performed. It involved the removal of tissue from the donor site and transplantation in another site of the body with anastomosis of the vessels.[7,8] In 1963, McGregor introduced temporalis muscle flap for reconstruction of midface and lower face defect.[9] In 1965, deltopectoral flap was introduced by Bakamjian for coverage of the lower third of the face as well as of the oral and esophageal defects.[10] Advances in head and neck reconstruction emerged in the 1960s when the myocutaneous pedicle flap was introduced. In 1979, Ariyan described the use of pectoralis major myocutaneous flap for lower third of face.[11] In 1981, Yang described the free radial forearm flap.[12] In 1982, reconstruction ladder was introduced by Mathes and Nahai for closure of simple to complex wound.[13] Today it includes the use of negative-pressure wound therapy, dermal matrices and perforator flaps.[14] Thereafter, the use of microvascular tissue transfer has revolutionized the field of head and neck cancer reconstruction.[15] In the 1990s, free flap reconstruction was the dominant technique for cancer defect reconstruction.[16]

3. Recent Advances

Newer and newer modalities are being developed for best aesthetic and functions. Some of the major advances in the head and neck cancer reconstruction include sensate free tissue transfer; osseo integrated implant and dental rehabilitation, motorized tissue transfer and vascularized growth center transfer for pediatric mandible reconstruction. Navigation, use of three-dimensional imaging, stereo lithic model and custom made implant for reconstruction are advocated because they promise improvement in aesthetics. Robotic surgeries have obviated the need of doing mandibulotomy by providing access for resection of tumours and reconstruction with free flap in deep oropharynx. Research is being done in stem cell and tissue engineering to regenerate tissues and avoid the need of autologous tissue flaps. Composite facial anatomical units can be reconstructed with allotransplant in a single surgery because of the use of excellent immunosuppressant drugs.[17]

3.1. Free tissue transfer

Microvascular free tissue transfer is often at the top of the reconstructive ladder and is usually reserved for complex composite tissue defects in previously treated fields. It is mostly used for reconstruction of the head and neck because of mucosal malignant disease. It is also used in the reconstruction of cutaneous or scalp lesions that have undergone previous multiple treatments. It is considered a versatile modality because it enables us to harvest composite tissue that matches the tissue defect in composition, surface area, and volume. Moreno et al in 2009[18] compared the functional outcomes of microvascular free-flap reconstruction with palatal obturation in 113 patients undergoing maxillectomy. Although functional results were comparable in small-to-medium-sized palatal defects, reconstruction with free flaps provided better speech and swallowing results than the latter in extensive and anterior defects.

Phillips et al in 2005[19] used fibula epiphyseal transfer to permit growth of the reconstructed mandible in children. They reported good growth potential in patients over 8 years of age, while those under 8 years of age showed impaired growth. Wong and Wei in2010[[20] concluded that microsurgical free flap is the standard of care for patients with large, composite defects after tumor resections. Although workhorse flaps like anterolateral thigh, radial forearm, fibula, and jejunum flaps used today are more versatile, donor-site morbidity is at the same time much reduced. Bourget et al in 2011[21] reported head and neck free flap reconstruction in previously irradiated patients to be highly successful. However, the risks of reoperation and complications are higher. The use of a reconstruction plate only to bridge a mandibular bone defect should be avoided in irradiated patients as it carries a higher complication rate. Aggressive treatment of infections should be done in irradiated patients.

3.2. Double free flaps

Single flaps may be inadequate for some defects that are either too large or necessitate the use of composite tissues. In such cases double free flaps are used. It has a low failure rate[22] and is more flexible and versatile. It allows allow easier in setting and better restoration of the 3-dimensional anatomical boundaries,[23] It can be helpful in case of advanced 'inoperable' tumours such as T4b.[24] However, there are certain limitations such as increased patient morbidity, increased intraoperative time, risk of complications, and its use is limited to primary cancers.[25] Tsue et al[26] found that the operating time for double flaps can be 3 hours shorter than that for a one free and one pedicled combination. However, Guillemaud et al[27] found that there is no significant difference in the duration of surgery and complication rate when comparing double free and one free and one pedicled surgeries.

3.3. Triple advancement flap

It is also known as Mercedes flap. It is used for the repair of circular or oval defects on the forehead, temple, and preauricular cheek areas. It is particularly useful for the lateral upper forehead and the temple next to the lateral canthus.[28] This flap is advantageous in that the tension vector for wound closure is split in different directions. This facilitates a tension-reduced closure in such a way that distortion to important structures is minimized. Wide subcutaneous mobilization can sometimes be avoided with the use of this technique. It is possible to position the closure lines in horizontal forehead lines, hiding within the scalp or off the face, thus leading to better cosmetic results.

3.4. Tissue engineering

Tissue engineering technique and stem cell therapy permits regeneration, replacement or repair of tissues for specific purposes. The success of tissue engineering is decided by three components: scaffold, signalling molecule and cells. All or some of these components are introduced for the regeneration of tissues. This is followed by *in-vitro* growth and maturation, to produce tissue or organs.[29] Kusumoto et al reported that for the fabrication of tissue engineered bone, an adequate number of cells with osteogenic capacity, appropriate scaffold for seeding cells, and factors to stimulate osteogenesis are required. But the blood supply is required for its transfer to a distant site. Fabrication of bone in latissimus dorsi muscle has been made possible and then it has been transferred as free bone muscle flap. [30]

Cartilage cannot repair or regenerate and its reconstruction is challenging on account of scarcity of suitable donor sites. Prosthetic materials used have their own associated problems. Tissue engineering cartilage is quite simple because it consists of only one cell type, the chondrocyte, does not require neovascularization, survives on the diffusion fluid for nutrition and excretion of waste products. [31]

3.5. Computer-aided surgery

The use of computer-aided surgery (CAS) for head and neck cancer reconstruction started in the late 2000s. It has been used in many complex craniomaxillofacial reconstruction procedures such as reconstruction of semgemtal mandibular defects after oncologic ablative surgery.[32-38] Advantages include increased reconstruction accuracy,[36,39] reduced ischemia time and operating time,[37,38] reduced surgical learning curve,[34] and reduced cost of the treatment.[38] However, there are certain limitations such as inability to determine the tumor margin[39] and more time is required for preparation of an operation.[40]

3.6. Computer aided navigation technology

Navigation technology has been used in procedures, such as TMJ arthroplasty, tumor resection, deformity correction, craniomaxillofacial reconstruction, implantation, and removal of foreign bodies.[41-45] Advantages include accuracy, minimal trauma, shorter duration of surgery, reduced complications,reduced chances of recurrence and excellent success rate. These are mainly used by neurosurgeons for the removal of brain tumours that can be seen on computed tomography or magnetic resonance imaging but cannot be easily distinguished from normal brain tissue.[46]

3.7. Prototyping

Rapid prototyping (RP) is a new technology used to assist the surgeon in the visual and tactile aspects of surgery, provide diagnostic accuracy and increase the success of surgical planning. In this way it improves outcomes and reduces complications, risks, operative time and the overall cost of treatment.[47-49] It is a constructive,additive process used for obtaining physical prototypes from a digital three dimensional model, based on which RP systems build prototypes by successively adding fine layers of specific materials[50,51]

3.8.3D printed models

The technique for complex reconstructions in the craniofacial region may be improved with advanced preoperative planning using 3D printed models, which are generated with patient-specific geometrical data from computed tomography (CT) scans. The advantages include reduced operative time and cost, improved patient understanding, resident education, and refininement of surgical predictability and outcomes [52]. There is decreased patient morbidity and an improved quality of life after head and neck reconstruction. Satisfactory esthetic and functional outcomes have been reported in the literature.[53] However, good cooperation between the radiologist, a team of engineers preparing 3-D model printing as well as the surgeons is required in modern reconstructive surgery.[54]

3.9. In house virtual surgical planning

Virtual surgical planning is a recent adjunct that allows the surgeons to plan resection and reconstruction prior to operation. It reduces operative time and decreases surgeon stress during the operation. However, it requires technicians with appropriate skills, materials, software and technology, and is expensive, and hence outsourced to an external company.[55]

3.10. Robot-assisted reconstruction

Transantral robotic endoscopic surgery provides adequate access to the anterior and central skull base and also permits for three-dimensional, two-handed, tremor-free endoscopic dissection and precise closure of dural defects.[56] The robot-assisted reconstruction (RAS) has a valuable role to play in the head and neck reconstructive surgery, with flap inset having the most obvious role.[57] Transoral robotic surgery(TORS) is helpful in management of

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residual and recurrent oropharyngeal cancer. Advantages of TORS over open surgery and transoral laser microsurgery include en bloc resections, facility for intraoperative ultrasound imaging, and inset of free flaps without mandibular split.[58] Free-tissue transfer for TORS possess promising 1-year functional outcomes and the complication profile is the same as other microvascular reconstructive procedures.[59] However, there are certain limitations of TORS such as cost related to each procedure, time and efficiency, paucity of safety evidence, no haptic feedback which is essential for microsurgery, inability to perform two team operation when both teams need the robot simultaneously, and a steep learning curve.[60]

4. Conclusion

All these recent advances in head and neck cancer reconstruction aim at further refinement that enables a surgeon to restore normalcy and enable complete oncologic resection without leaving any residual tissue that can lead to recurrence, and to improve the quality of life of the patients. All techniques have their own benefits and limitations.

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