Current concepts and novel techniques in the prosthodontic management of head and neck cancer patients

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Key points

Highlights that with the rising incidence of HPV infections, there is a looming epidemic in head and neck cancer, especially oropharyngeal cancer.

Shows that the planning and management of HNC is a team effort by a multidisciplinary team.

Suggests that the introduction of digital technologies and surgical design and simulation has revolutionalised the management of head and neck cancer, especially jaw reconstruction and oral rehabilitation, and in facial prosthetics.

Abstract

'The face is the mirror of the mind', so said St Jerome. Patients affected by head and neck cancer have to deal not only with the effects of the disease but also with the effects of the treatment for the disease. This is one cancer which is literally and figuratively 'in your face'! And it is a disease which is difficult to hide. This article attempts to summarise head and neck cancer and its treatment modalities as well as the effects of treatment and the defects it creates. It will also attempt to explore and elaborate on the novel prosthodontic management techniques in advanced jaw reconstruction and extraoral anatomical defects. The concept of functional assessment and rehabilitation in head and neck cancer patient management will also be briefly explained.

Introduction

The term 'head and neck cancer' (HNC) refers to a group of tumours that arise in five primary sites – oral cavity, pharynx, salivary glands, paranasal sinuses and larynx.[1] HNC is the eighth most common cancer in the UK accounting for 3% of all new cancers cases,[2] and the sixth leading cancer by incidence worldwide.[3] In the UK, 70% of the HNC cases are in males and 30% are in females.[2] The most common histological type is squamous cell carcinoma – about 90%, with the remaining neoplasms being salivary gland tumours and mesenchymal lesions of the soft tissues and paranasal sinuses.[3,4,5]

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The effects on the lives of patients with HNC can be devastating with treatment effect disfiguring and causing significant functional defects. Due to the complexity of the anatomical structures and the functions affected, the management can present significant challenges to the healthcare system, because of the wide variety of disciplines involved and relatively low number and distribution of the patients requiring the specialised treatment and support. Also due to the nature of the disease, it needs close surveillance for a number of years, and patients who have had treatment may require rehabilitation and care on an ongoing basis for the long term.

Risk factors for HNC[1,6,7]

'Usual suspects':

1. Tobacco (various forms – smoking [cigarettes, cigars, etc] smokeless tobacco (snuff, betel quid, chewing tobacco etc)[8,9]
2. Alcohol – tobacco and alcohol are known to have a synergistic effect and users of both alcohol and tobacco are at a greater risk of HNC than people who use either alcohol or tobacco alone[10,11]
3. Others – poor oral health, occupational exposure, radiation exposure, diet and nutrition, immunosuppression, ethnicity and genetic predisposition, Epstein-Barr virus.[12]

'New kid on the block':

1. Human papilloma virus (HPV) –HPV with HPV-16 being the predominant subtype, is an increasingly relevant causative agent in oropharyngeal (OPSCC) and oral squamous cell carcinoma.[6] The incidence of OPSCC is increasing significantly and HPV is now responsible for over 70% of OPSCCs in Europe and the USA.[13] The incidence in the UK has doubled from 1990 to 2006 and has further doubled in incidence from 2006 and 2010. HPV associated tumours tend to occur in younger individuals and where the usual risk factors of alcohol and tobacco is lacking.[14] Given that the incidence rates for OPSCC continue to increase dramatically, largely among men in several countries, there is an argument as to whether this constitutes an 'epidemic'.[15] It has also been said that prophylactic HPV vaccine, while it holds considerable promise in reversing these

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trends, will only happen to occur after 2060! The issue of an 'epidemic' is relevant as HPV-related OPSCC has a good prognosis and they are more in younger individuals and so will have more years to live, but will have to deal with the burden of the disease and the various treatments for the disease, for longer.

Symptoms HNC patients usually arrive with:[1,16]

1. Oral ulcer
2. Red or white patch on oral mucosa
3. Oral swelling
4. Unexplained tooth mobility
5. Unusual bleeding or pain in mouth
6. Problem with denture fit
7. Neck lump
8. Sore throat or tongue
9. Pain and/or difficulty swallowing
10. Hoarse voice/croaky voice/hot potato voice
11. Pain in the ear
12. Nose bleeds
13. Blocked nose/sinuses
14. Pain in upper back teeth
15. Trouble with the eye
16. Numbness or paralysis of face.

Patients who present with symptoms suggestive of oral cancer such as the following should be referred to a specialist centre using the suspected cancer pathway referral for an appointment within two weeks:[17]

1. Unexplained ulceration in the oral cavity lasting more than three weeks
2. A persistent and unexplained lump in the neck
3. A lump on the lip or in the oral cavity consistent with oral cancer
4. A red or red and white patch in the oral cavity consistent with erythroplakia or erythroleukoplakia.

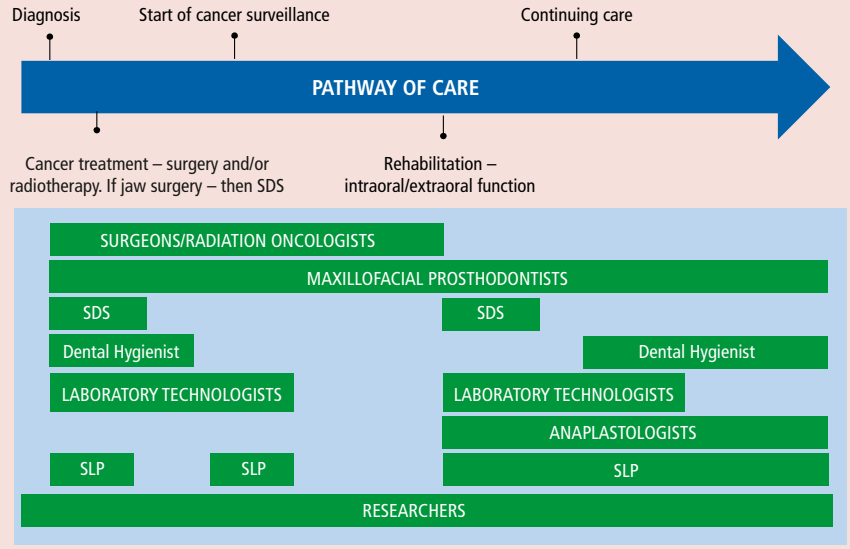
General dental practitioners are and should be on the frontline for diagnosing oral cancer and they are in a unique position and have the necessary training to be able to catch this disease early, thus providing a better prognosis.

What does HNC and its treatment affect?

HNC and the effects of treatments for HNC[18,19,20] impact patients in a multitude of ways and can have adverse long-term effects on the patient's subsequent quality of life:

1. Anatomical defect – surgery involves removal of the cancerous tissues resulting in an anatomical defect with an ensuing aesthetic deficiency, unless it is reconstructed. Radiotherapy may also cause anatomical loss of cancerous tissues and can affect the dentition as well
2. Physiological or functional deficiency – loss of anatomical structures will result in a functional deficit with difficulty in swallowing, speech, mastication, taste, smell, sight, hearing etc
3. Psychological issues – although these are quite common issues with HNC patients, they are the least discussed effects of HNC and its treatment. Patients typically undergo feelings of guilt, anger, depression, alienation, denial, social introversion, helplessness to name a few.

Fig. 1 Pathway of care



SLP - Speech and Language Pathologist
SDS - Surgical Design Simulationist

Role of the multidisciplinary team in the management of the HNC patient

The management of HNC is complex and requires special expertise from a range of healthcare professionals because of the association of anatomically complex and diverse areas and also due to the vital functions affected by both the disease and its treatment. The management of HNC needs to be carried out by a multidisciplinary group of clinicians meeting on a regular basis to improve the quality of care for these patients. Given this complexity, in the UK, the management of HNC is carried out by a multidisciplinary team (MDT). All patients with HNC should be managed by an MDT and each MDT must have a comprehensive range of professionals with special expertise.[21] It has been opined that when fewer specialists see more patients it tends to enhance their expertise. This is likely to enhance outcomes in all groups of patients and particularly in HNC given the smaller numbers.[21] Studies have shown that special training of MDT led to better team dynamics and communication, improved patient satisfaction and improved clinical outcomes.[22,23]

The consultant in restorative dentistry is a core member within the HNC MDT and manages patients with complex dental health issues before, during and after their cancer treatment which may include issues such as oral mucositis and ulceration, oral candidiasis, trismus, xerostomia and rampant caries. These patients also have a high risk of developing osteoradionecrosis. The consultant takes the lead in providing oral rehabilitation which may include the use of osseointegrated implants to provide for oral or facial prostheses. Where patients require maxillary obturation, the consultant will arrange for fabrication of a surgical obturator and ideally should be present during surgery. The consultant should also liaise with the patient's general dental practitioner for ongoing general dental care and oral prophylaxis with support from the consultant when required.[24]

Figure 1 gives you an overview of the pathway of care for HNC patients and some of the multidisciplinary team involved in their care at our institute.

HNC treatment modalities

HNC treatment modalities can broadly be classified as:

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Fig. 2 a – f – Patient with left maxillary nerve sheath tumour treated with left maxillectomy and restored with a definitive obturator; a &b – Images illustrating the hard palate defect and the loss of dentition on maxillary left quadrant; c & d – Definitive obturator with cast base and heat cured silicone bung to obturate maxillary defect; e & f – Definitive obturator in-situ

1. Surgery is the well-established mode of initial definitive management for a majority of HNC. The aim of surgery with curative intent in HNC is complete microscopic surgical excision.[25] Clear excision margins are a positive prognostic factor and a consideration for post-operative adjuvant therapy.[26,27] In recent times, there have been prominent advances in surgery in the form of transoral access techniques for oropharyngeal, supraglottic and glottis cancers via transoral laser microsurgery (TLM) and transoral robotic surgery (TORS). The advantages of these surgical techniques from the prosthodontic perspective are that it obviates the need for transmandibular approach in cancer access surgery, which invariably requires the sacrifice of a mandibular tooth in the dentate patients. It must also be mentioned that surgical defects are now more likely to be reconstructed. Surgical reconstruction may be with pedicle flaps or soft tissue microvascular free flaps obtained from anterolateral thigh flap or radial forearm free flap and the choice will be dependent on the bulk required or, it can be a composite flap consisting of both hard and soft tissue. For mandibular reconstruction, the fibula free flap is a popular choice as it provides the maximum length and bone volume to achieve a satisfactory reconstruction and also to achieve both a primary or secondary osseointegrated implant installation.[28] Other composite free flaps available are the scapular flap, radial forearm osteocutaneous flap or the deep circumflex iliac artery flap. The choice of a particular composite free flap will depend on the location and length of mandibular reconstruction, as well as the need for soft tissue for mucosal or skin coverage at the site of resection, among others[29]
2. Radiotherapy (RT) – introduction of ionising radiation, following the discovery of radium, became an important means of nonsurgical treatment of HNC. Although RT is one of the most frequently used therapeutic modalities in HNC, in the majority of patients with advanced cancer, it is employed as an adjuvant therapy and offered as a post-surgical treatment, as single modality treatment is associated with poor outcomes. RT has benefited from advances in imaging, computer software and developments in radiation delivery technology in recent years.[30] Gone are the days of conventional 2D RT, nowadays RT treatment is more targeted using 3D images and increasingly complex computer algorithms. Newer forms of RT in use are – intensity modulated radiotherapy (IMRT); RapidArc radiation therapy and proton beam therapy. RT traditionally used to be associated with xerostomia, however, IMRT has shown to reduce radiation induced xerostomia.[31,32] But there are other effects of radiotherapy particularly to the oral cavity and dentition, which can affect quality of life for HNC patients[18,19,20]
3. Chemotherapy in the management of HNC was considered to be palliative in the 1950s to 70s. Chemotherapy alone cannot cure HNC.[33] It is used in conjunction with other treatments, namely surgery and RT to improve outcomes in terms of local control, organ preservation and to decrease the incidence of subclinical micro-metastatic spread. The introduction

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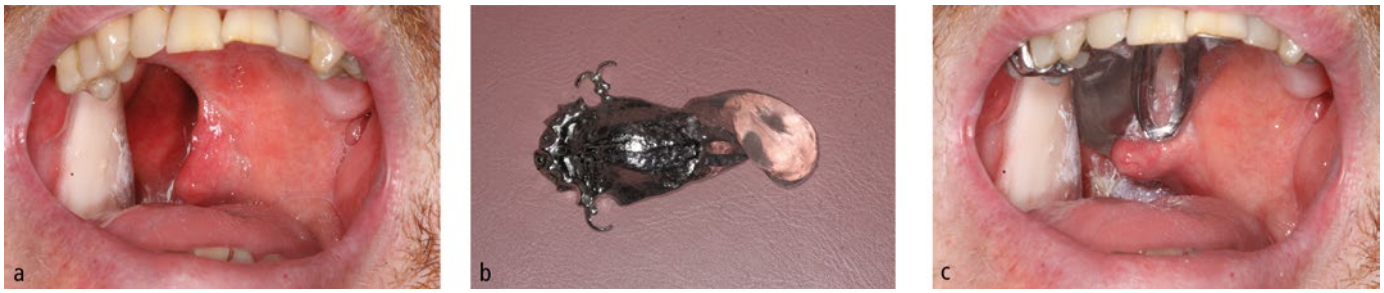

Fig. 3 Images illustrate soft palate defect and pharyngeal obturator used in management; a – Soft palate defect; b – Pharyngeal obturator; c – Pharyngeal obturator *in situ*

Fig. 4 Images illustrate soft palate defect and pharyngeal obturator used in management; a – Soft palate defect; b – Pharyngeal obturator; c – Pharyngeal obturator *in situ*

of newer chemotherapeutic drugs such as Cisplatin, when given concomitantly with RT, was associated with increase in survival.[34,35] When chemotherapeutic agents are given with RT, it can have a radio sensitising effect making cancer cells more susceptible to RT. Targeted biological agents such as cetuximab with concurrent administration during RT has shown to increase overall survival and locoregional control.[36] In the case of HPV-related oropharyngeal cancer, there is increasing evidence that there are better outcomes with chemoradiotherapy and studies are underway to examine if less intense treatment with both chemo and RT could be given to achieve the same outcome but with less toxicity.

Prosthodontic management

Oral rehabilitation of congenital and acquired maxillofacial defects is managed by maxillofacial prosthodontists. Maxillofacial prosthodontics is 'the branch of prosthodontics concerned with the restoration and/or replacement of stomatognathic and craniofacial structures with prostheses that may or may not be removed on a regular or elective basis'.[37] In the UK, the consultant in restorative dentistry is the core member of the MDT of the HNC team who provides specialist restorative and maxillofacial prosthodontic services.[21]

Intraoral defects due to HNC treatment can be broadly classified:

1. Maxillary arch – Defects of the maxilla can be managed either prosthodontically or surgically. Prosthodontic rehabilitation is usually predictable and effective

a. Hard palate – maxillectomy in its various forms is performed to resect tumours of the maxilla. There are many classifications for maxillectomy defects from a surgical and prosthodontic perspective.[38,39,40,41] Management of these defects include both surgical and prosthodontic rehabilitation. Surgical management may involve closure with an autologous soft tissue flap – however, this makes any further restorative treatment challenging due to the poor support provided by the soft tissue for a prosthesis. The surgical rehabilitation using autologous composite tissue transfer is explained in the next section. The classic management of a maxillectomy defect amenable to prosthodontic obturation involves a three staged approach involving a surgical, interim and definitive obturator[42] (Fig. 2)

b. Soft palate – HNC and its management which involves the soft palate can result in loss of integrity of the velopharyngeal complex. Velopharyngeal deficit can be broadly categorised into velopharyngeal insufficiency when there is loss of tissues as a result of tumour resection; or velopharyngeal incompetence due to a neurological disorder. In HNC, velopharyngeal insufficiency occurs more commonly, although velopharyngeal incompetence cannot be completely ruled out. Deficit in velopharyngeal integrity can result in issues with speech and swallowing. In speech, the main issues are with articulation and resonance. Resonance refers to the quality of one's voice as affected by the resonating chambers of the pharynx, oral cavity and nasal cavity. When there is a disproportionate sound passage between the oral and nasal cavity due to a velopharyngeal deficit, it affects resonance and results in altered speech. A common condition which affects resonance is a blocked nose due to nasal congestion where there is no air passing out through the nose and is termed hyponasal. In velopharyngeal insufficiency, there is excess air escape through the nose and is termed hypernasal. Prosthodontic management is with an obturator prosthesis termed pharyngeal obturator (PO). It is different from an obturator for the hard palate defect

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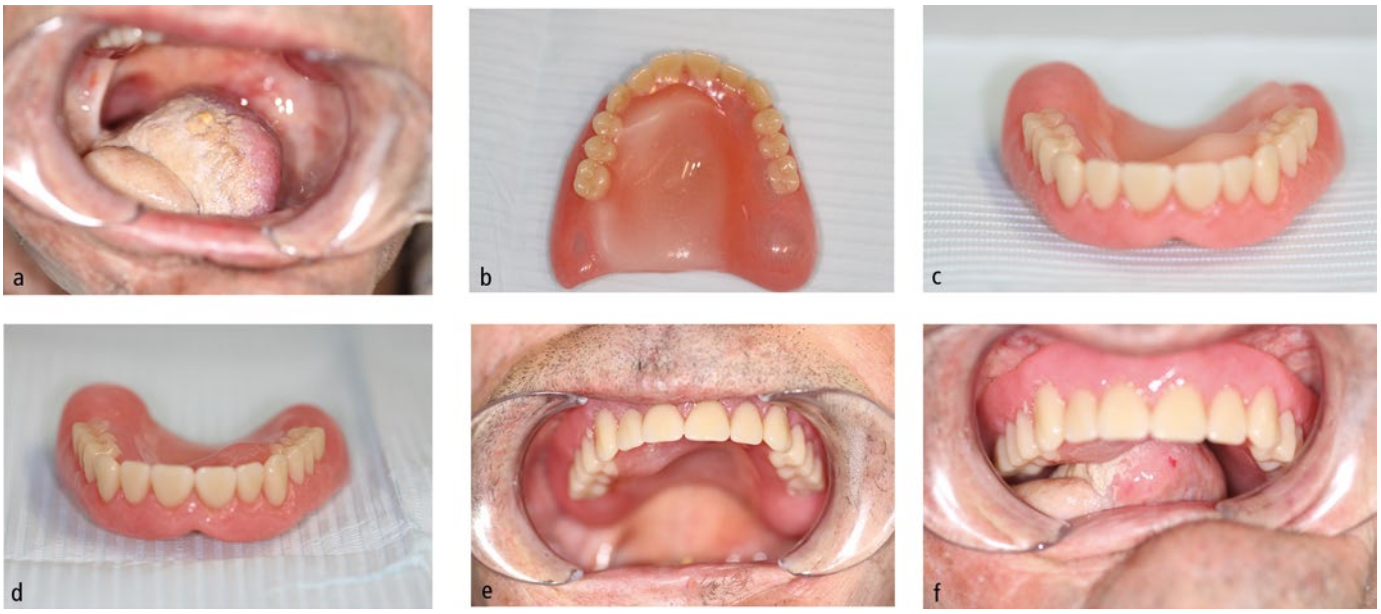

Fig. 5 Palatal augmentation prosthesis – patient diagnosed with right tongue squamous cell carcinoma and underwent right hemiglossectomy with left radial forearm free flap reconstruction; a – Post surgical picture with reduced volume and mobility of right side of tongue; b & c – Maxillary complete denture with viscogel used to capture tongue movement and to augment right side of palate; d – Augmented area processed in acrylic; e – Palatal augmentation prosthesis in-situ; f – Palatal augmentation prosthesis providing contact to right side of tongue during function

in that there is very little movement of the tissues bordering the hard palate defect, however, a PO must be made to function with surrounding functional tissues. The PO must allow for air passage for nasal breathing and nasal emission for speech, but provide sufficient obturation to prevent leakage of food/fluid during swallowing and avoid hypernasality (Fig 3 & Fig 4)

3. Mandibular arch – surgical resections of the mandible can result in discontinuity defect with resultant altered mandibular movement.[43] Rehabilitation can be challenging based on the extent of the resection and surgical reconstruction and is less predictable. Prosthodontic management of the deviated mandible can be tried with a mandibular guidance appliance/guide flange, however, in the author's experience these have not been successful. The most effective course of action in a discontinuity defect is the use of autologous composite tissue transfer along with provision of implants for oral rehabilitation and this is elaborated in the next section
4. Glossectomy – the ability to function – swallow, speech, and chew, is affected to varying degrees in resection of the anterior, lateral, base or total tongue. The tongue can move in all directions and contact the palate in carrying out its function. Partial or complete contact between the

Table 1 Five levels of approach to jaw reconstruction (courtesy of Dr John Wolfaardt)

Increasing levels of accuracy and sophistication ↑	V	Navigation and robotics – no need for physical models as digital planning and robot will assist surgeon in resection and reconstruction
	IV	Planned functional reconstruction – fully guided and occlusion based – 3D printed models, resection guides, occlusal transfer templates – all planned based on occlusion
	III	Guided anatomical reconstruction – digitally planned and guided – use of 3D printed models, resection guides
	II	Planned anatomical reconstruction – digitally planned but unguided – use of 3D printed models
	I	Anatomical reconstruction – intraoperative intuitive surgery

Table 2 Approaches to jaw reconstruction rehabilitation and extraoral prosthetic rehabilitation utilising digital technologies

1	Standard digital – planned functional reconstruction - level IV	Primary or secondary reconstruction Delayed implant installation & delayed implant loading Used in benign and malignant tumours
2	Modified Rohner – planned functional reconstruction - level IV	Primary implant installation in fibula Primary reconstruction with prefabricated fibula with implants and immediate implant loading Used in benign tumours, trauma, reconstruction in HNC treated cases requiring bone reconstruction
3	Alberta Reconstructive Technique (ART) – planned functional reconstruction – level IV	Primary reconstruction Immediate implant installation but delayed implant loading Used in malignant tumours, trauma
4	Extraoral prosthesis – digitally planned and partially guided	Delayed implant installation and delayed loading. Custom abutvments with magnets in nasal and orbital prostheses and bar retained retention in auricular prosthesis

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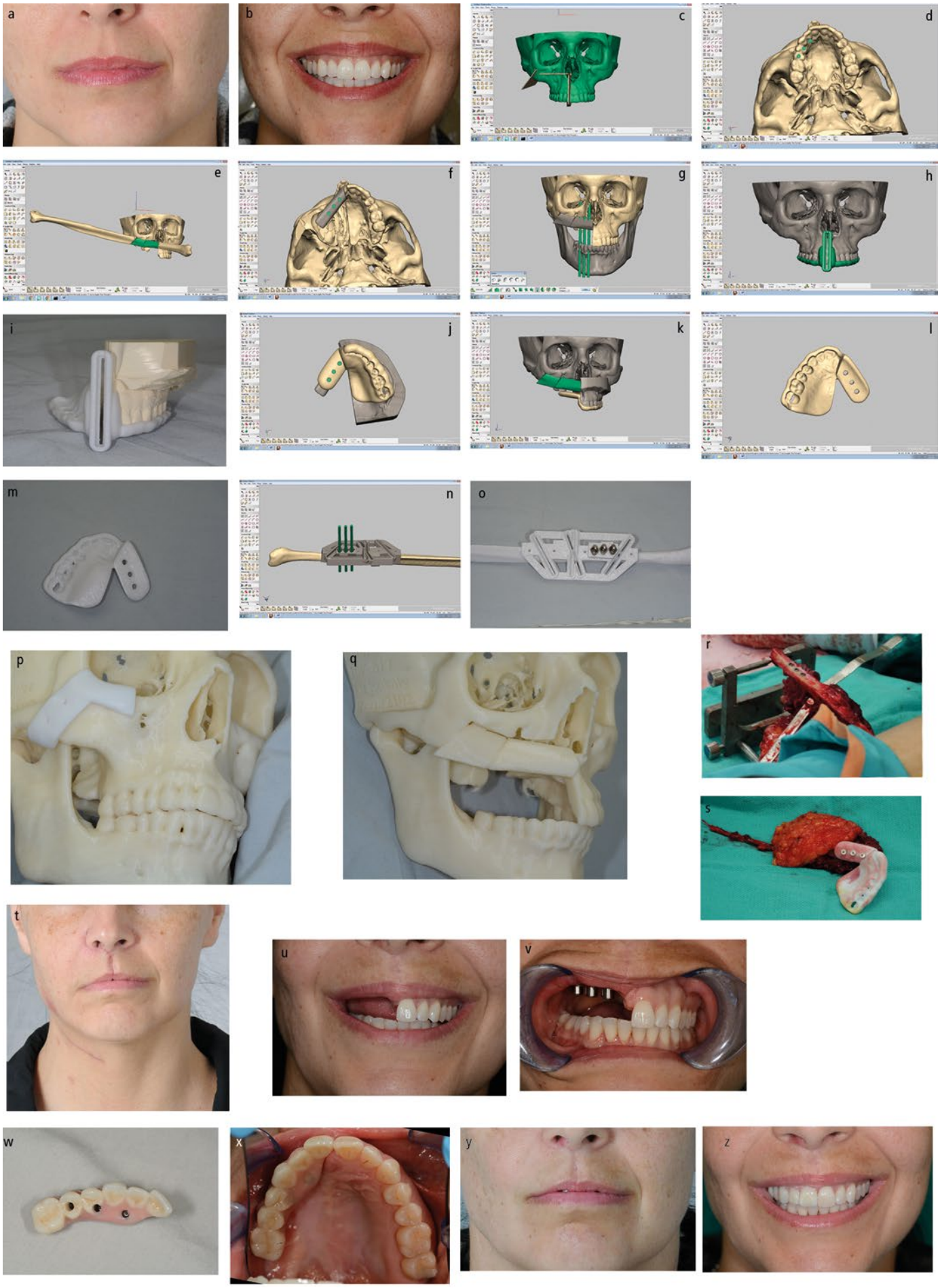

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Fig. 6 Advanced jaw reconstruction of maxilla – patient diagnosed with clear cell carcinoma of right maxilla – treated with right maxillectomy and reconstruction with left fibular free flap using Alberta Reconstruction Technique. Time from cancer surgery to completion of oral rehabilitation – 15 months; a & b – Pre-op; c – First step in surgical design and simulation (SDS) is finalising the resection margins – this is done in a joint meeting with the surgeon, maxillofacial prosthodontist (MFP) and the surgical design simulationist (SDS); d – Once the dental defect is ascertained, the MFP decides on the restoration and positions the osseointegrated implants (OI) accordingly; e – The SDS then virtually positions the left fibula in the maxillary virtual defect; f & g – The MFP then finalises the position of the implants and the position of the fibula segments are is confirmed; h & i – The anterior resection guide is virtually designed by the SDS and 3D printed; j – m – The maxillary reconstruction fibula segment which incorporates the OI needs to be oriented in the maxillary surgical defect accurately as per the plan. To achieve this, an occlusal transfer template (OTT) is designed. This utilises the remaining dentition in orienting the fibula segment as per the plan. Once the plan is finalised, it is 3D printed. n & o – The planned position of the OI in the maxilla has to be transferred to the fibula during cancer surgery. This is achieved by design and 3D printing of an implant osteotomy guide. The implant osteotomy guide also incorporates the fibula sectioning guide as seen in Figure 6o; p – shows the zygomatic and maxillary resection plane to assist the surgeon in carrying out the surgical resection as per the virtual surgery plans; q – Shows the reconstructed 3D printed skull; r – During ART surgery – shows the left fibula on the fibula bench with the OI in position. After this, the sectioning of the fibula is carried out with the fibula sectioning guide as shown in Figure 6o; s – The maxillary reconstruction fibula segment is then attached to the occlusal transfer template. This picture shows the composite fibula flap attached to the occlusal transfer template before transfer to the maxillary surgical defect; t – One month post ART surgery; u – Eight months later and before Stage II ART surgery; v – Two months after Stage II ART surgery; w & x – shows the maxillary implant retained interim prosthesis and after delivery. Compare the actual position of the implants in relation to the virtually planned positions of the implants in Figure 6d; y & z – With the interim implant prosthesis

tongue and palate results in some of the functions associated with the tongue. So when the tongue is not able to go up to meet the palate to carry out its function, due to various degrees of glossectomy, the palate must be made to come down to meet with the tongue! In partial glossectomy cases fabrication of a palatal augmentation prosthesis allows the remaining tongue to contact the palate by bringing the palate inferiorly (Fig. 5). In collaboration with a speech and language pathologist, these prostheses have a high rate of success.

Advanced jaw reconstruction using surgical design and simulation

The approach to jaw reconstruction can be broadly classified into five levels with increasing levels of accuracy and sophistication (Table 1).

The surgical management of HNC has traditionally involved the 3 Rs – resection, reconstruction and rehabilitation. This is all the more important in HNCs affecting the jaws and typically these stages are carried out in a phased manner while taking into consideration issues such as recurrence, disease management skills, cancer surveillance and funding among others. There is a general, albeit misguided, regime that oral rehabilitation must take place once it has been confirmed that the patient is free from cancer or about two years after cancer treatment! It has been the author's experience that when using a phased manner along with the above considerations, the treatment period from diagnosis to oral rehabilitation can take anywhere from four to five years or more. This is an unacceptable state of affairs as the five year survival rate for HNC patients is around 55%.[44] That would mean a poor quality of life for the remainder of their life for the unfortunate 45% who will not have their oral rehabilitation completed in that time!

The use of bone-containing microvascular flap transfer techniques in the surgical management of HNC affecting the jaws has revolutionised the management and significantly improved jaw reconstruction. Microvascular surgical reconstruction was, and in some centres still is, based on intraoperative intuitive decision making that produces a spatial design challenge in achieving accurate osteotomy, optimal insertion and positioning of the bone flaps for functional oral rehabilitation with osseointegrated implants.

To overcome this for HNC patients undergoing jaw surgery at our institute, we have developed the Alberta Reconstruction Technique (ART),[45] which is a surgical technique to resect, reconstruct and partially rehabilitate – all in one surgery – and employing surgical design and simulation (Table 2). In conventional bone-containing flap transfer using intraoperative intuitive decision making, the position of the reconstruction bone is based on anatomical constraints of the resected bone. For example, for mandibular reconstruction, it is proposed that the most important anatomical consideration is positioning of the bone graft along the lower border of the mandible to maintain facial form. Once this has been carried out, osseointegrated implants for oral rehabilitation have to be placed where the bone is and then the replacement dentition will have to conform to the position of the implant, which at times may be less than ideal. If one were to visualise the 3D position of the mandibular dentition in relation to the lower border of the mandible, the discrepancy in the relation is easy to comprehend. With the ART technique, the planning process is reversed: first, the position of the dentition to be restored is planned. Based on the planned dentition, the implant positions are determined. Subsequently, the position of the reconstruction bone is planned based on the position of the implants.

With the introduction of advanced jaw reconstruction, using digital technologies, surgical design and simulation (SDS), rapid prototyping (RP) and a team approach in planning and management in HNC, the surgery has been raised to new levels of precision. In an effort to shorten the management continuum for these patients, advanced jaw reconstruction has led to a reduction in time to oral rehabilitation. Chuka *et al.*[46] had compared implant utilisation and time to prosthetic rehabilitation between conventional and advanced jaw reconstruction. They concluded that there was a reduction of nearly 21% of implant wastage. More importantly, they also concluded that there was a significant reduction in the time taken to complete oral rehabilitation from 4.5 years using the conventional jaw reconstruction techniques to around nine months using advanced jaw reconstruction techniques. HNC patients, who have their oral rehabilitation completed earlier, can enjoy a better quality of life for the remaining years of their life – however long (or short) that may be. Figures 6 & 7) show two examples of this technique employed in maxillary and mandibular reconstruction respectively.

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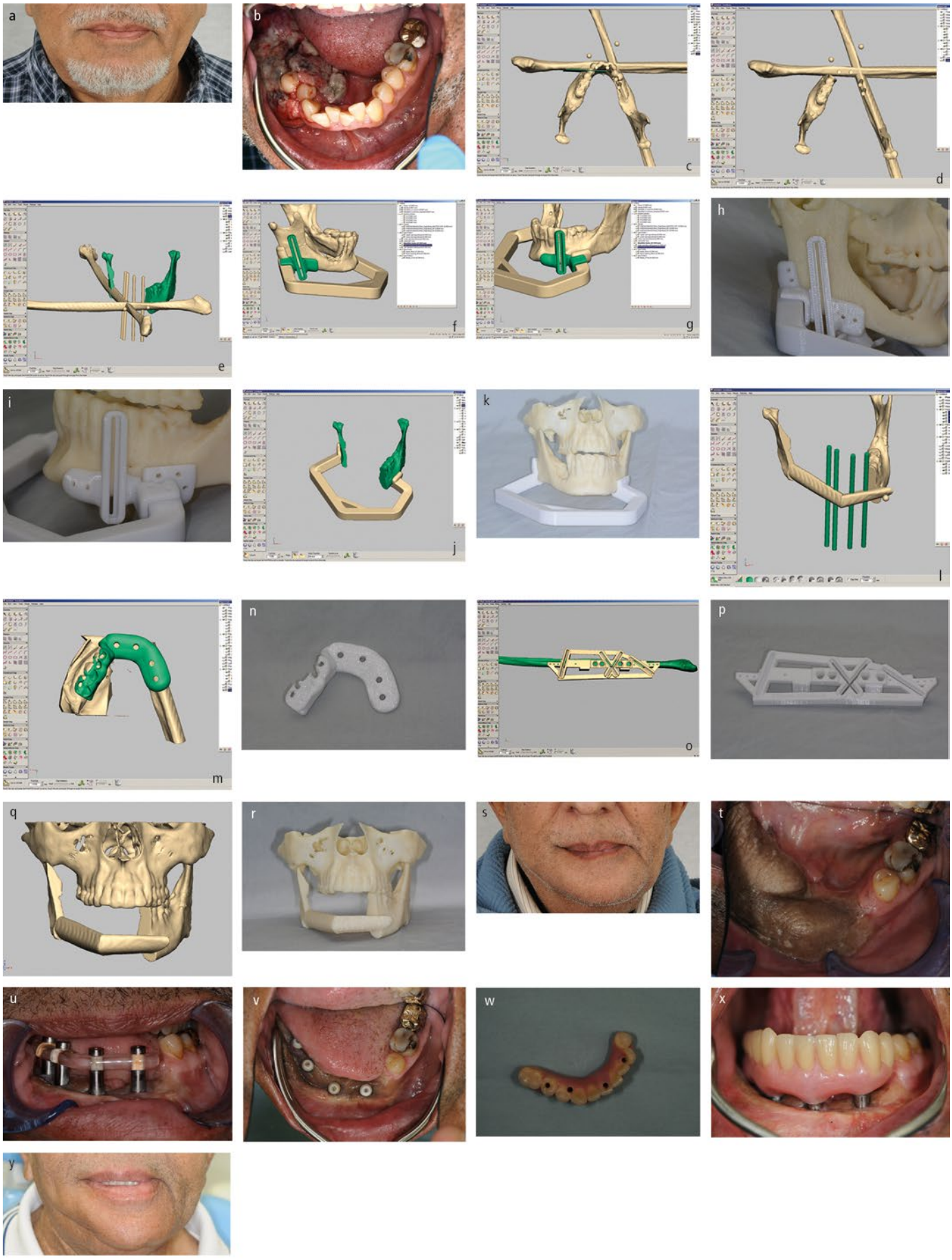

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Fig. 7 Advanced jaw reconstruction of mandible – patient diagnosed with squamous cell carcinoma of right mandible – treated with right and anterior mandibular resection and reconstruction with right fibular free flap using ART technique. Time from cancer surgery to completion of oral rehabilitation – 14 months; a & b – pre-op and shows carcinoma on right mandible; c – Once the resection margins are confirmed with the surgeon, the maxillofacial prosthodontist (MFP) considers the osseointegrated implant (OI) positions in relation to the dentition; d & e – The implant positions are further refined based on the reconstruction; f – i – Once the mandibular resection margins are confirmed, the mandibular resection guides are designed by the surgical design simulationist (SDS) and 3D printed; j & k – Mandibular resection is challenging in that the position of the remaining mandibular segments have to be maintained in the preoperative 3D position. To achieve this, an external mandibular fixator is designed to hold the remaining segments of the mandible in the preoperative position. Once designed, it is 3D printed; l – n – After finalising the position of the OI and the reconstruction fibula segments, an occlusal transfer template is designed and 3D printed. The occlusal transfer template allows planned positioning of the fibula segments in the mandibular resection site using the occlusion as the guide; o & p – The finalised OI positions are then transferred to the right fibula bone and the implant osteotomy and the fibula sectioning guide is designed and 3D printed; q & r – Virtual plan of the final reconstruction and the 3D printed reconstructed skull; s – one month post ART surgery.; t – Nine months later and before Stage II ART surgery; u – One month post Stage II ART surgery with surgical stent in-situ; v – Occlusal view of implant abutments with healing caps; w – The mandibular implant-retained interim prosthesis. Compare the actual position of the implants as evident from the screw access channels to the virtually planned positions of the implants in Fig. 7c; x & y – with the interim implant prosthesis *in-situ*

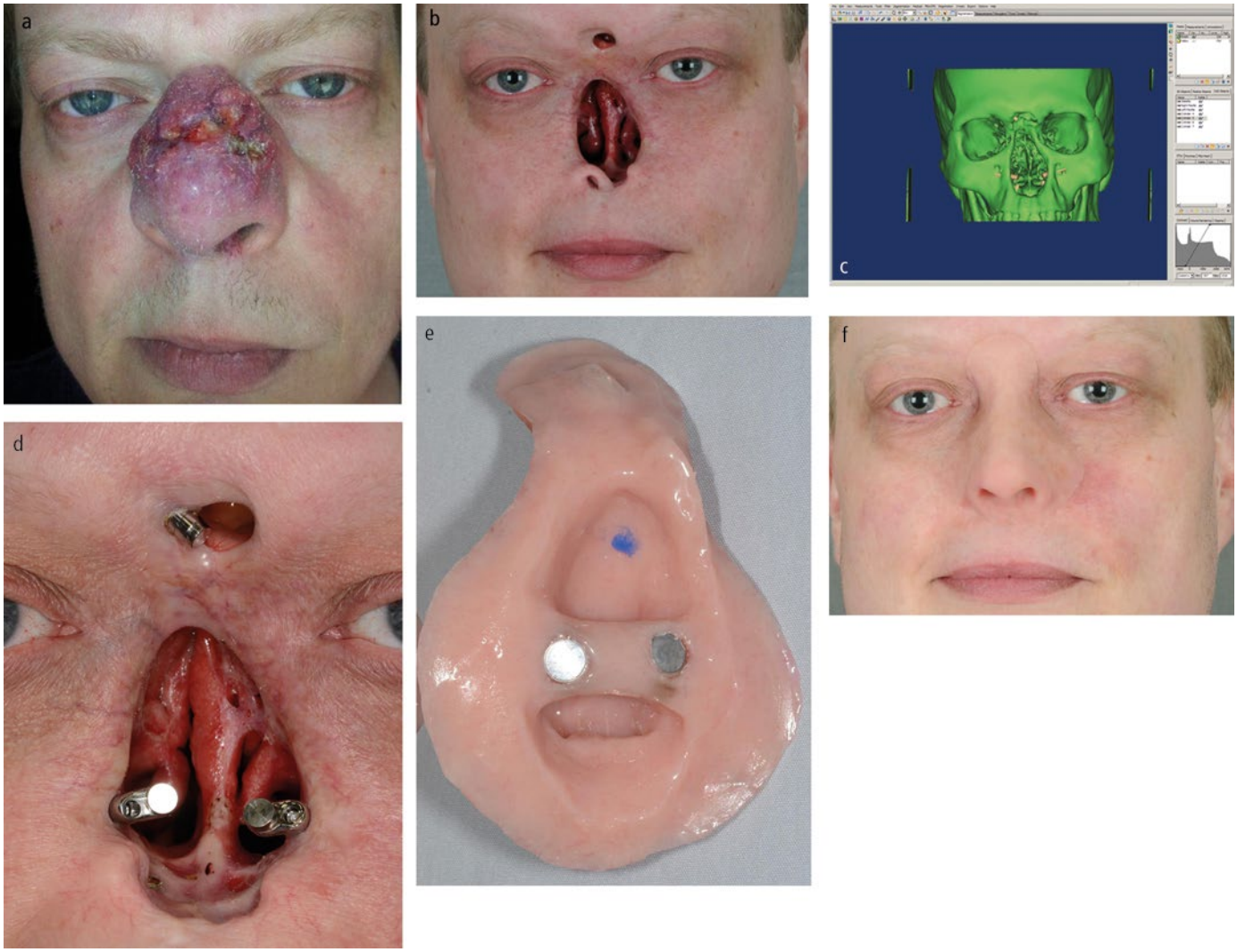

Fig. 8 Implant retained nasal prosthesis for nasal defect; a – extensive sinonasal squamous carcinoma; b – after radical rhinectomy; c – osseointegrated implant installation simulation planning – using the clock face positioning system – 5 implants were planned in 3 ,5, 7, 9 & 11 o'clock positions. Implants planned for 5 & 7 o' clock positions in the maxilla were intraoral regular platform implants. Implants planned in 3 & 9 o'clock positions were zygomatic implants. Implant planned at 11 o'clock position in the glabellar region was an intraoral narrow platform implant; d – Custom abutments on implants with magnetic keeper. The two maxillary implants (5 & 7 o' clock) were not used and put to sleep; e – Nasal prosthesis with magnet attachments; f – patient with nasal prosthesis

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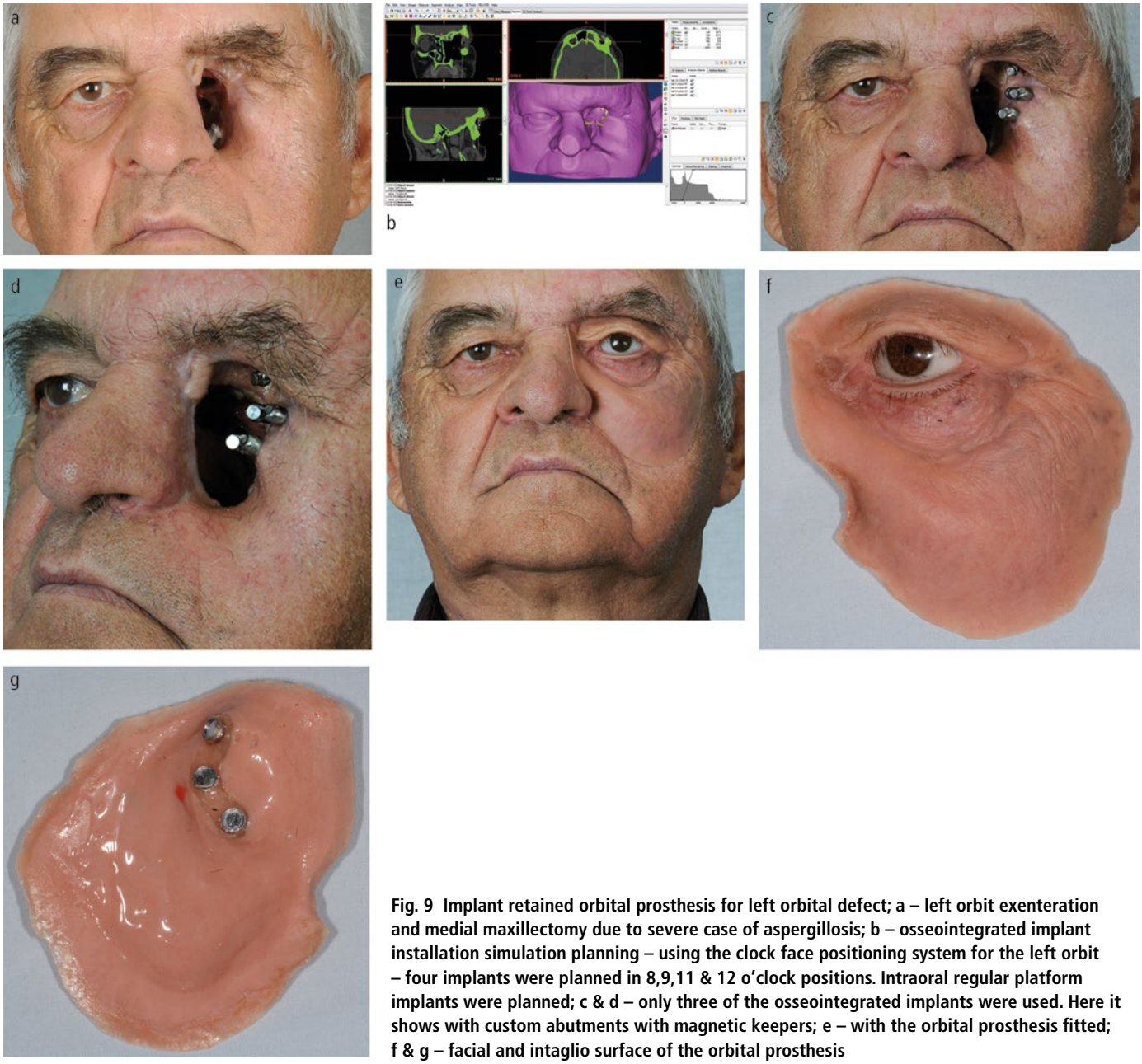

Fig. 9 Implant retained orbital prosthesis for left orbital defect; a – left orbit exenteration and medial maxillectomy due to severe case of aspergillosis; b – osseointegrated implant installation simulation planning – using the clock face positioning system for the left orbit – four implants were planned in 8,9,11 & 12 o'clock positions. Intraoral regular platform implants were planned; c & d – only three of the osseointegrated implants were used. Here it shows with custom abutments with magnetic keepers; e – with the orbital prosthesis fitted; f & g – facial and intaglio surface of the orbital prosthesis

Extraoral anatomical defects

Trauma, tumours and their treatment, or congenital and development deformities can all result in facial defects. Management of these defects include surgical reconstruction, facial prosthesis or a combination.

Facial prosthetics have come a long way in dealing with facial disfigurement.[47] It has its limitations and one of the primary limitations is the challenge faced in retention of the prosthesis.. Traditional techniques of retention include mechanical retention such as use of spectacle frames to support an auricular or nasal prosthesis; or the use of adhesives. However, both these techniques have their disadvantages as the retention provided is not reliable and there are issues with positioning of the prosthesis.[47,48]

With osseointegrated implants now being used more commonly for retaining facial prostheses, the retention issue has been resolved to a great extent.[49] Implant angulation had been one of the major challenges in using osseointegrated implants in the facial region, however, this has largely been resolved with the use of custom abutments.[50] Facial prostheses retained by osseointegrated implants classically consist of three components: the soft tissue prosthesis typically made of silicone; a rigid substructure which supports the silicone and houses the retentive elements; and the retentive elements. The retentive elements can be magnets, bar and clip, or a precision attachment.[51]

The planning and fabrication of these prostheses has to be a multidisciplinary effort. In our institute, facial prosthetic patients are managed by a multidisciplinary team comprised of maxillofacial prosthodontists, anaplastologists, plastic surgeons and laboratory technologists. As pictures speak a thousand words, a series of clinical and planning pictures illustrates the management of three facial prosthetic patients (nasal, orbital and auricular) using osseointegrated implants – these include intraoral, extraoral and zygomatic implants (Fig 8, Fig 9 & Fig 10).

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Fig. 10 Implant retained auricular prosthesis for loss of left auricle; a – basal cell carcinoma of left ear; b – left auriculectomy and closure with a local rotation flap; c – osseointegrated implant installation simulation planning – using the clock face positioning system for the left auricle – two implants were planned at the 9 & 11 o'clock positions; d – two extraoral osseointegrated implants placed; e – round bar retention construct; f & g – external and intaglio surfaces of the auricular prostheses; h – auricular prosthesis in position

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Functional rehabilitation

As has been mentioned previously, HNC and its treatment will affect function including speech, mastication and swallowing. All HNC patients must undergo a pre-treatment functional assessment to have a baseline record and functional assessments must be carried out at all stages of the treatment pathway.[52] At our institute, functional assessments are carried out by speech and language pathologists.

One of the main goals of cancer rehabilitation is to achieve the best possible functional outcome and quality of life.[53] This requires a multidisciplinary approach and although the importance of this is widely known, it has been the author's experience that it is more often honoured in the breach than in the observance!

So let us try and see this from the patient's perspective. When patients are referred for oral rehabilitation (OR) a majority of them arrive with an expectation that OR will provide a solution for their functional deficit, namely issues with swallowing, chewing and/or speech. Frequently, clinicians involved in providing OR do not necessarily take into consideration the functional deficits caused by HNC and its treatment. This can result in less than ideal management as the OR has not been able to live up to the patient's expectation of improving functions such as swallowing and speech, although it may have improved chewing. At times, OR could potentially make the functional deficit worse, creating a less than ideal outcome.

In a multidisciplinary environment, before start of OR, and in collaboration with the speech and language pathologist (SLP) a functional impact statement needs to be established. A functional impact statement provides a forecast of what the functional deficit is and how OR may favourably or adversely affect function. At times, it may be that although OR may improve the chewing efficiency, it may not necessarily provide any significant improvement to swallowing or speech function and could, at times, actually worsen these functions, to an extent. If this is expected in advance, the patient can be informed and an explanation provided rather than an excuse when things do not work out after OR. For example, OR can increase the vertical dimension in an edentulous patient and this could make swallowing and speech more onerous for patients who have had treatment for tongue cancer. From a medico-legal perspective, it is imperative that any treatment that does adversely affect the outcome has to be carried out with informed consent from the patient. Aspiration of food/fluids into the lungs due to impaired swallowing made worse with OR can be a life-altering to life-threatening scenario and one which has to be avoided.

Functional rehabilitation measures are an important tool to compare various resection and reconstruction surgeries and radiotherapy treatment modalities. These measures can also be used to compare the functional outcomes between different reconstruction and rehabilitation techniques in HNC. In a recent study, the speech and resonance outcomes were compared among three treatment modalities for maxillary defects: maxillary obturators; standard fibular free flap reconstruction not involving digital planning; and digitally planned surgical design and simulation fibular flap reconstruction.[54] It was found that there were significant differences in the speech and resonance scores between these three modalities with patients treated with digital reconstruction having better speech outcomes across all measured speech variables than the other two treatment groups.

With this increasing knowledge about functional rehabilitation and its importance in improving QOL for HNC patients, there is the emergence of a novel concept – termed – 'prehabilitation'. Essentially, this means preparing the HNC patient for cancer treatment and its aftermath. This can range from educating the patient about possible outcomes, to carrying out prophylactic exercises to optimise function.[55,56]

The future

As has been exemplified, HNC and the effect of its treatment can cause anatomic and functional defects which can be managed using prosthetic techniques and surgically using autologous grafts or a combination. But if one's own cells could be cultured to replace/reconstruct the missing structures, that would be Holy Grail of reconstruction/replacement. Research in stem cell and tissue engineering is progressing to regenerate tissues and to avoid the need for autologous grafts. Tissue engineering involves regeneration of new tissue and basically three components are required: scaffolds, signalling molecules and cells.[57]

With the advances in regenerative medicine techniques, these could have the potential to restore the missing structures while minimising the risks associated with the traditional reconstruction techniques.[58,59,60] At the pace of current research, it is likely that regenerative techniques in replacing/reconstruction may become a reality, sooner rather than later!

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